Engineering ENTERPRISE

THE ALUMNI MAGAZINE FOR ISyE AT GEORGIA INSTITUTE OF TECHNOLOGY

Summer 2004

- Healthcare Delivery Systems in the United States
- Perspectives on Healthcare
- An In-depth Look at the ISyE Health Systems Graduate Program at Georgia Tech

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ISyE	Georgia Institute of Technology
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EDITORIAL

Managing Editor	Ruth Gregory ISyE / Georgia Tech Atlanta, GA 30332-0205 Tel: (404) 385-2627 Fax: (404) 894-2301 ruth.gregory@isye.gatech.edu
Contributing Editors	Sarah Banick sbanick@mindspring.com

ART DIRECTION & PRODUCTION

Art Director	Alan Brubaker, ext. 218 albrubaker@lionhrtpub.com
Publication Designer	Donna Browning, ext. 226 donnam@lionhrtpub.com

SALES & MARKETING

Advertising Sales	Marvin Diamond, ext. 208 marvin@lionhrtpub.com

CIRCULATION

Circulation Manager	Maria Bennett, ext. 219 bennett@lionhrtpub.com

ADVERTISING OFFICE

LIONHEART PUBLISHING INC.
506 Roswell Street, Ste. 220
Marietta, GA 30060, USA
(770) 431-0867
Fax: (770) 432-6969
E-mail: marvin@lionhrtpub.com

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Health Systems

by William B. Rouse

As Professor François Sainfort indicates in this issue, healthcare is the largest industry in the U.S. in terms of percentage of GDP (14 percent) – and it's growing by double-digit percentages every year. Consider these projections. If GDP grows by a reasonable 3 percent per year while healthcare costs grow by 10percent per year, within 20 years healthcare will account for 50 percent of GDP. At 20 percent growth per year — which has occurred in many recent years — healthcare costs will exceed 100 percent of the GDP in less than 10 years!

Healthcare is a very large, complex, and inefficient industry. The complications of the underlying issues are enormous. Fragmentation and competing interests are laced throughout the system. There are no ultimate decision makers other than arduous political processes. Yet, given the above projections, we have no choice but find ways to manage the complexity and gain significant efficiencies.

Professor Sainfort argues that this provides tremendous opportunities for industrial and systems engineering. This perspective is certainly supported by Bill George, interviewed in this issue. Bill is one of our many alumni CEOs who has achieved great success. He is now sharing his experiences and insights with aspiring executives at Harvard Business School.

In this interview, Bill outlines his ideas on transformational leadership. His most notable success was as CEO of Medtronic, a high-tech leader in the healthcare industry. Bill also discusses healthcare as an overall system, including issues of competition, measurement, and incentives. He provides a strong dose of articulate, clear thinking.

Several articles in this issue describe the Health Systems Program in ISyE. This program was founded in 1958 and has approximately 600 alumni. In more than 40 years of evolution, the program has grown to have three major themes:

- Biological and Biomedical Operations Research
- Healthcare Delivery Operations Research and Management
- Knowledge Management and Information Technology

These areas dovetail nicely with the College of Engineering's major initiatives in Bioinformatics, Quantitative Medicine, and Computational Biology; as well as Nanomedicine.

This issue of *Engineering Enterprise* describes the research of many ISyE faculty members in areas ranging from cancer treatment to visual impairments to dental services. The scope of these efforts ranges from individual patients, to delivery processes, to overall system models. It is very clear that the breadth of ISyE competencies is well aligned with problems and opportunities in healthcare.

Nevertheless, healthcare is a big challenge with enormous consequences for everyone. We will need lots of ingenuity and initiative to succeed with this challenge. Fortunately, Georgia Tech engineers are well endowed with these attributes. Frankly, they will need all the talent they and others can muster to gain success in this undertaking.

William B. Rouse is the H. Milton and Carolyn J. Stewart Chair and Professor of the School of Industrial and Systems Engineering at the Georgia Institute of Technology.

Four Logistics Leaders Chosen for EMIL International Scholarships

By Terri Herod, *EMIL Managing Director*

Georgia Institute of Technology's Executive Masters in International Logistics (EMIL) program has awarded $20,000 scholarships to four top professionals in international logistics. This year's winners are: Alec Ang, Singapore, Supply Chain Logistics Director, Asia Pacific, DHL International; Heidi Cerrud, Panama, Procurement Officer-Regional Logistics Unit International Federation of Red Cross and Red Crescent Societies; Bublu Sarbani Thakur-Weigold, Germany, Supply Chain Management Consultant, Innovation Diffusion, Hewlett-Packard; and Gabriella Toro, Venezuela, Lean Manufacturing Coordinator, Dana Venezuela.

The scholarship winners were selected based on their demonstrated career success, a clear potential for leadership, and a desire to participate in and make a contribution to EMIL's intense 18-month educational experience. Each applicant is required to reside and work in either Asia Pacific, Latin America, or Europe; and to have been admitted to the EMIL program as a degree-seeking student.

Alec Ang

Alec Ang has worked for 10 years as a senior manager at DHL in the Asian logistics market, progressing from planning analyst to GCS supply chain logistics director. He holds bachelor's and master's degrees in Business Administration. In addition to obtaining global experience through EMIL, Ang said he is looking forward to building "a strong network of logistics and supply chain professionals comprised of fellow students, faculty, and guest speakers."

Heidi Cerrud

As a Panamanian, Cerrud offers the unique perspective of a logistics professional who works in a country that is a key route for logistics transportation. Her work with the International Federation of Red Cross and Red Crescent Societies, the world's largest humanitarian organization, gives her a special interest in developing supply chain efficiencies and cost reduction with logistics plans for emergencies. "Through the EMIL Program, I expect to grow as a logistician, better enabling me to support Red Cross/Red Crescent relief operations to disaster victims," said Cerrud.

Bublu Sarbani Thakur-Weigold

Born in India, educated in a French high school in Canada and then at MIT, Sarbani has spent the last 15 years living and working in Germany; so her perspective is truly an international one. Almost 10 years of experience in SAP consulting, first with Andersen Consulting and then with Hewlett-Packard, have given her a rich overview of European companies. She also brings a strong intellectual and practical grasp of how HP refines its global supply chain. "The EMIL program is an ideal opportunity to validate and refresh my present Supply Chain knowledge," she commented, "and gain a glimpse into international operations that go beyond HP, the electronics industry, and Europe."

Gabriela Toro

With seven years of logistics experience in the Latin American automotive industry, Toro brings a solid professional background to the EMIL program. She holds a bachelor's degree from the Technological University for the Center of the Country, a teach-and-learn system in which teams of students participate in field projects. Throughout her career, she has continued to expand her global knowledge of logistics, including completing an international lean manufacturing training program. "I see EMIL as an opportunity to advance myself in what I really love," said Toro, "achieving breakthroughs by changing traditional logistic systems and positioning ourselves for a better tomorrow."

"These EMIL Scholarship winners have each demonstrated exceptional dedication and industry expertise over the course of their careers," said John Vande Vate, EMIL Executive Director. "It's this continued cross-pollination of professional expertise and international perspectives that makes EMIL the most unique logistics master's program in the world."

EMIL is an 18-month master's degree program that allows participants to remain on the job while they learn practical techniques for decreasing logistics costs and improving supply chain efficiencies. The courses are structured around faculty lectures, industry speakers, case studies, group projects, and company presentations. In addition, international residences give EMIL participants the opportunity to meet with government officials and other key players worldwide to discuss customs issues, taxes, and trade agreements that impact the supply chain.

EMIL participants represent a professional elite in logistics. A full 50 percent of them have an MBA; 15 percent are vice presidents, 45 percent are at the director level, and most have 10 to 15 years of on-the-job experience. "They are truly the logistics leaders of the future," remarked Vande Vate. "The real-world experience they gain in EMIL will shape the direction of international logistics for years to come."

The Logistics Institute – An Update

The Logistics Institute is pleased to update the *Engineering Enterprise* readership on four topics, the first of which is Georgia Tech's new Global Learning & Conference Center – Warm Hospitality, Cool Technology – and how TLI is benefiting from having world-class conference facilities comparable to its world-class educational resources. Since the GLCC opened last August, TLI has hosted two major conferences, two Supply Chain Executive Forum meetings, and 13 short courses. Participants gave the hotel, meeting rooms, and A/V systems rave reviews.

TLI is also leveraging GLCC's state-of-the-art technology capabilities to introduce distance learning into its professional education program. An Internet-based seminar, Fridays with Frazelle, was introduced in September 2003 and is receiving favorable reviews from participants around the world. In this two-hour monthly "webinar," Dr. Ed Frazelle lectures via an interactive audio link while participants view his slides and lecture notes on their Internet-enabled computers. On May 13, TLI transmitted its first broadcast of a short course from the GLCC classroom to Internet viewers using streaming video technologies. TLI is also offering computer enabled "e-courses" on several logistics topics via DVD and websites for students who wish to study at their own convenience.

Under the leadership of Dr. John Langley, the Supply Chain Executive Forum continues to grow and have impact on the industry. Its most recent April meeting focused on the unique challenges of retail logistics with keynote speaker Dr. Marshall Fisher from the Wharton School of Business at the University of Pennsylvania.

We are delighted to welcome BMW North America as our newest *Leaders in Logistics* member company. Under the leadership of Jeff Stephens, a Georgia Tech ISyE alumnus, BMW has established a very active partnership with TLI: recruiting ISyE graduates, sending BMW logisticians to TLI professional education programs, and hosting plant tours for TLI groups. Dr. John Vande Vate and his graduate students have just initiated a new research project focusing on BMW's global inventory management systems.

During the past two years, TLI's economic development activities have been rapidly expanding. As many of you are aware, TLI Asia Pacific is a five-year-old partnership among Georgia Tech, the National University of Singapore, and Singapore's public and private sectors, with governmental leadership provided by the Singapore Economic Development Board. The mission of this partnership is to educate future logistics professionals in the Asia Pacific region while also discovering or creating new knowledge – through surveys, case studies, and analytical analysis and research – that is relevant to the economic development of Singapore. The dual master's degree in logistics, where students take courses at both Georgia Tech and NUS, is now well established within this highly successful partnership. We anticipate the next five-year plan for TLI Asia Pacific to be announced soon.

In addition, TLI has become actively engaged in economic development for Georgia and the nation. This includes both research and education, by providing leadership for the Maritime Logistics Innovation Center in Savannah and by partnering with the Metro Atlanta Chamber of Commerce to conduct research relevant to the needs of the large and growing logistics community in metro Atlanta, which includes the air cargo part of Atlanta's international airport. Initial research attention will be focused on the security and efficiency of the transportation system with special attention to international trade, seaport and airport security, and their economic interrelationships and impacts. Specific topics will include seaport and airport container and cargo security, as well as the transportation and new forms of information technology that can enable a secure and efficient transportation system (e.g., RFID). We envision that the scope of this activity will eventually broaden to include other issues important to Georgia and the nation, such as the state of the physical infrastructure, the use of information technology to improve infrastructure and vehicle management and operations, environmental impact, safety, and congestion mitigation.

During the past two years, TLI's economic development activities have been rapidly expanding.

We always enjoy hearing from the *Engineering Enterprise* readership. Please let us know if we can provide you further information on any of the above topics or any other topics that you might find of interest when you go to our website, www.tli.gatech.edu.

Alumni News

Northern Light Group, LLC, has been named to the list of *KMWorld's* 100 Companies That Matter in Knowledge Management. The company's chief executive is **David Seuss, BIE 1972.** Northern Light, based in Cambridge, Massachusetts, uses search, classification, and content integration technology and services to facilitate the creation of user-friendly search solutions of diverse content and enormous scale.

Major General **Ronald Johnson, MSOR 1985**, is currently deployed in Iraq where he serves as the U.S. Deputy Director of the Program Management Office, Coalition Provision Authority (CPA), responsible for the management of the $18.4 billion reconstruction of the country. He also serves as commanding general of the Gulf Region Division of USACE.

Recently, General Johnson along with the Iraqi Minister of Electricity, Ahyam al Sammarae; and Scott Redd, deputy director for the CPA, ceremoniously started the first of eight 23-megawatt gas turbine generators at the Baiji Thermal Power Station, 220 kilometers north of Baghdad. In his remarks to those attending, Johnson paid honor to "all of the Iraqi engineers, all of the men and women who work with us to bring progress and improvement to the people of Iraq."

The Restore Iraqi Electricity Directorate, as part of the Gulf Region Division, continues to work with local Iraqi power plant managers on projects such as Baiji Mobile as an asset of Combined

ISyE Students Help Design New Jake's Location

When Georgia Tech students visit the new Jake's ice cream shop on 10th Street, they should feel right at home. That's because not only was the shop designed with the students in mind, it was partially designed by ISyE students.

Jake's, with five locations in Metro Atlanta, is known for its comfy spaces with overstuffed sofas, working fireplaces, and soft lighting. In addition to award-winning ice cream, Jake's serves soups, salads, and sandwiches. The stores encourage patrons to linger and converse, relax, or study.

To provide some background, there really is a Jake – Jake Rothschild – and one evening last winter he met ISyE assistant professor Julie Swann, who frequents Jake's. He told her about the new Georgia Tech location, and before long Swann was mulling over a project for her Manufacturing Systems students. Rothschild agreed immediately and by April the 110 students in Swann's and Professor Jane Ammons' classes, organized in teams of four or five, were developing designs for the interior of the new location.

"They started off with a blueprint and some discussions with employees, the general manager, and the manager of operations," says Swann. "Jake's folks had some ideas on what they wanted, but students had to make the decisions about where the equipment should be located and where they could propose new equipment. They all tried to think about the customer flow of the facility." Students had two weeks to provide several alternative blueprints and layouts, along with justified recommendations.

"One of the big things that is different about real projects is having to deal with the client's interests," Swann added. "In class you're given data – they had to figure out what they needed, search for it, and figure out what the most important objectives and constraints were. Students got frustrated with that sometimes, but I think that's part of the real learning experience. Figuring out how to apply these mathematical techniques in class to the fuzzy, real world project also takes some development on their part."

Rothschild is very happy with the results of his design project. "I'd do it again in a heartbeat," he says. "The students and faculty were so easy to work with. The deadline sensitivity was amazing, and their commitment to detail was great."

Georgia Tech students actually helped put Jake's in business, he says. "They were our early customers at the [original] Highland Avenue store. They were coming in droves, probably within three or four months of our opening, so we've always had an incredible affinity for the kids that go to school there. When we found the location right across the street from campus, it seemed like a natural fit."

"Jake's has always been community minded," he adds, "and this was a wonderful head start in getting into the Georgia Tech community. We're honored we were allowed to work as closely as we did for such a nominal fee [ice cream] and in a short period of time. It all worked out just perfectly."

Three student teams were chosen as winners. These teams include, in no particular order, 1) Dean Cannon, Greg Hunt, and Ben Maloch; 2) George Hasegawa, Michael Johnston, Kunal Khosla, and Sowmya Sundareswaran; and 3) Miquel Diaz, Phillip Gillespie, Dan Hutchison, and Julia Mariano Pereira.

The Jake's project was different from the traditional senior design projects because it was short and had a quick deliverable. Swann says she and other faculty members are always interested in offering their classes these types of experiences. Alumni or friends should contact Paul Griffin, associate chair for Undergraduate Studies, if they believe they have a workable project.

Every student participating received a scoop of Jake's ice cream, and members of the three winning teams took home a pint. Most importantly, they'll have the satisfaction of knowing they had a hand in designing what is sure to become a Georgia Tech student hangout.

Joint Task Force-7 and the CPA to position Iraqi people for success in rebuilding their electrical grid.

The power site at Baiji originally consisted of six thermal transfer engines. Only five are currently operational. Prior to the Gulf War, the Saddam Hussein regime attempted to install two 159 MW gas turbine generating sets under the Food for Oil Program. Neither unit was fully commissioned and placed on line.

The Baiji Mobile project consists of installing eight 23-MW dual fuel – diesel and gas – turbine generators at the thermal transfer plant. The initial fuel for these generators will be diesel for at least 30 days before switching over to gas. Once connected to the national grid, all eight will supplement the grid's power supply at the 132 Kilovolt or 400 Kilovolt line, adding 184 MW, or an extra half hour of electricity for every home, every shop, every factory in Iraq.

Portions of this update have been reprinted directly from the GRD Update*, a publication of the Gulf Region Division, Iraq. (Edition IV, 8 March 2004).*

Faculty and Staff News

ISyE IT staff have been awarded the APC Real-time InfraStruXure Award from APC InfraStruXure. Staff members used the company's technology to build a state-of-the-art computer server room, along with one of the largest and fastest supercomputing clusters in the Southeast. According to Systems Development Engineer **Bennett Gaston**, "Our computer network is one of the most advanced on campus, and we continue to provide our students the ability to work with one of the most diverse sets of analytical optimization/modeling software packages anywhere in the world." Staff members received a plaque at a special awards dinner.

Professor **Jane Ammons** has been named Associate Dean for Faculty Affairs within the College of Engineering. She will retain her appointment with ISyE and split her duties evenly between the two positions.

Doug Bodner has been promoted to senior research engineer.

Russ and Sammie Chandler Chair and Professor **William Cook** was mentioned in an article in the *Wall Street Journal* in April. Cook is known for his groundbreaking work on the well-known traveling salesman problem.

Brandi Vidakovic and **Sigrun Andadóttir** have been appointed full professors in ISyE upon recommendation by President Wayne Clough.

ISyE faculty and staffed teamed up for the third year to participate in the Susan Komen Race for the Cure, held in May. Proceeds from the 5K race/walk go to the breast cancer research programs of the Susan B. Komen Foundation. ISyE participants included **Jane Ammons, Carmella Bell, Doug Bodner, Marcia Chandler, Trudy Cron, Sheila Devezin, Patti Parker, Lorraine Shaw,** and **Yvonne Smith.**

Ming Yuan joins Statistics Faculty

Ming Yuan will join ISyE as an assistant professor in industrial and systems engineering in January, 2005. School Chair Bill Rouse announced that Yuan will further enhance the School's growing strength in statistics. "I am very excited to join Georgia Tech," Yuan said from Wisconsin.

Yuan recently received his Ph.D. in statistics from the University of Wisconsin in Madison. He also holds an M.S. in computer science from the University of Wisconsin; an M.S. in probability and statistics from the University of Science & Technology of China; and a B.S. in electrical engineering and information science, also at the University of Science & Technology of China.

Yuan's research interests include nonparametric statistical methods, Bayesian statistics, data mining, bioinformatics, survival analysis, and financial statistics. He has worked as both a research assistant and a teaching assistant while pursuing his Ph.D. Yuan is a student member of the American Statistical Association, the Institute of Mathematical Statistics, the International Biometrics Society, and the Society of Industrial and Applied Mathematics.

Student News

Roberto Castro, BIE 2007, had a great freshman year, finishing with a 4.0 both semesters while playing on Tech's golf team. Castro earned honorable mention from the Golf Coaches Association of America, which recently announced its PING All-America teams. Castro, from Alpharetta, Georgia, was also named All-Atlantic Coast Conference and ACC Rookie of the Year.

Stacey Lee, BIE 2003, represented Michigan in the 2004 Miss USA pageant in April. Lee, who also earned a bachelor's in math from Clark Atlanta University through Tech's dual-degree program, now works as a corporate auditor for General Motors in Detroit.

continued on page 21

Healthcare DELIVERY SYSTEMS in the United States

By François Sainfort, Ph.D.

William W. George Professor of Health Systems, Associate Dean for Interdisciplinary Programs

INTRODUCTION

U.S. healthcare expenditures are expected to be more than $1.4 trillion in 2004, representing 14 percent of the Gross Domestic Product (GDP) and making healthcare the largest industry in the United States. This figure corresponds to $41,000 expended per second and more than $4,400 spent per capita per year. Despite such large spending and the largest amount per capita in the world, many Americans remain uninsured and do not have access to healthcare services. Furthermore, the industry employs more than 10 million people in settings ranging from nursing homes to academic medical centers. While our country has the most formidable medical workforce in the world, and develops and uses the most modern medical technologies, the World Health Organization (WHO) (2000) recently ranked the overall performance of the U.S. healthcare systems 37th out of 191 countries worldwide. While one may argue with the set of criteria employed by WHO to compare international healthcare systems, as described in a report yet to be released (forthcoming, 2004) by the National Academy of Engineering in collaboration with the Institute of Medicine, it remains true that "the industry has devoted relatively little technical talent and intellectual effort to optimizing its operations (particularly at higher levels of systems – hospitals, regional networks, etc.), or to measuring its performance in terms of quality and productivity. This neglect has contributed to the development of a high-cost delivery system with poor operational processes and performance measures that provides highly uneven quality of care and limited coverage/reach of quality care. It has also contributed to the development of a great cultural divide between physicians focused on patient relationships and improvements in individual quality-of-care and healthcare administrators focused on cost control and the productivity of the business; a divide that has undermined the performance of both parties."

CHARACTERISTICS OF THE HEALTHCARE INDUSTRY

The healthcare industry is a very large, complex, and inefficient industry. Growing costs are a critical concern. In addition, the Institute of Medicine (2001) puts forth four key underlying reasons for inadequate quality of care in the U.S. healthcare system today: (1) the growing complexity of science and technology, (2) the increase in chronic conditions, (3) a poorly organized delivery system, and (4) constraints on exploiting the revolution in information technology. In addition, a growing trend toward consumerism is building up as a major force in shaping the future organization of the healthcare industry. The six trends, detailed further below, are shaping the future of healthcare in the United States.

Growing costs concerns:

Until the 1980s or 1990s, while healthcare costs escalated in absolute terms and relative to GDP, most Americans seemed to think they were getting value for money. That perception has changed. Americans might be willing to see healthcare costs rise more or less continuously relative to other expenditures, provided that genuinely better health – longer lives and better quality of life – resulted; and provided that costs were shared in ways viewed as equitable. Today, approximately 90 percent of insured individuals are enrolled in managed care plans. Ten years ago it was hoped that managed care would be the answer to both cost control and quality improvement by creating a competitive set of intermediaries. The current healthcare system is not meeting these expectations, however, and costs continue to rise at a double digit rate, as shown in Figure 1.

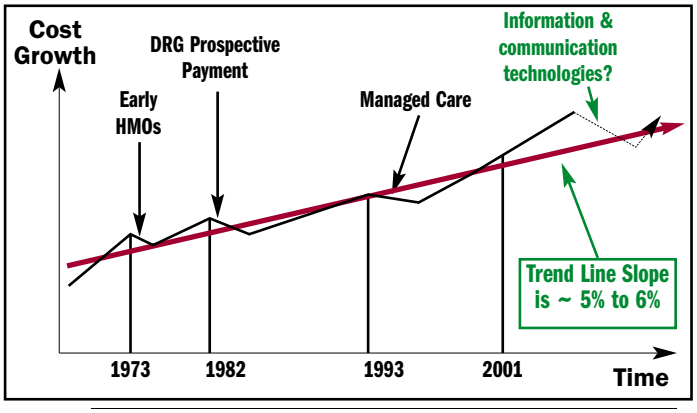

Figure 1: Growing Cost Concerns

Complexity of Science and Technology:

The sheer volume of new healthcare science and technologies – the knowledge, skills, interventions, treatments, drugs, and devices – is very large today and has advanced much more rapidly that our ability to use and deliver them in a safe, effective, and efficient way. Government, as well as private, investments in pharmaceutical, medical, and biomedical research and development have increased steadily.

Medicine itself is a high-technology, science-based profession, constantly enriched by inflows of knowledge from the biological sciences, new drugs and treatments, and engineered innovations from the medical equipment industry. Indeed, few would dispute the scientific and technological leadership of U.S. companies, research universities, and teaching hospitals in the areas of human therapeutics; medical instruments, devices, and equipment; and medical research and training. The industry achieved primacy in these areas by focusing resources on life and physical sciences, and the engineering of devices, instruments, and equipment in service to individual patients (i.e., customized service). With this focus, the industry excelled in providing the highest quality care at a high cost to those who can afford it.

The healthcare delivery system, however, has not kept up with phenomenal advancements in science and technology and with the proliferation of knowledge, treatments, drugs, and devices. With current advances in genomics (offering promise in diagnosis as well as, possibly, treatment), sensor technologies (offering promise in automated detection, measurement, and monitoring), nanotechnologies (offering promise in diagnosis, treatment, and control), and information and communication technologies (enabling remote delivery, telemedicine, e-health, and patient empowerment), the complexity of science and technology in healthcare is only going to increase.

Chronic Conditions:

As noted by the Institute of Medicine (2001), "because of changing mortality patterns, those age 65 and over constitute an increasingly large number and proportion of the U.S. population," as shown in Figure 2. Individuals age 65 and over consume 35 percent of all healthcare services provided in the U.S., yet constitute only 13 percent of the U.S. population. This percentage is expected to grow to 25 percent of the population by 2050.

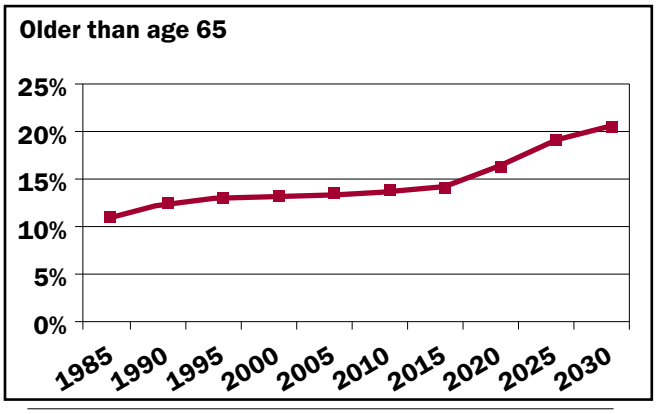

Figure 2: The Elderly as a Percentage of the Population

As a consequence, there is an increase in both the incidence and prevalence of chronic conditions. Hoffman et al. (1996) estimate that patients with chronic conditions make up 80 percent of all hospital bed days, 83 percent of prescription drug use, and 55 percent of emergency room visits. As opposed to acute illnesses, effectively treating chronic conditions requires disease management and control over long periods of time; collaborative processes between providers and patient; as well as patient involvement, self-management, and empowerment.

Organization of the Delivery System:

The healthcare delivery system in the United States is a highly complex system that is nonlinear, dynamic, and uncertain. The system is further complicated by a large number of agents and multiple stakeholders, each with multiple, sometimes conflicting, goals, aspirations, and objectives. As a result, the entire system leads to a lack of accountability; it has frequently misaligned reward as well as incentive structures, and it suffers from inefficiencies embedded in multiple layers of processes. The healthcare "product" or "service" is often ill-defined or difficult to define and evaluate. The processes involved in delivering healthcare services are complex, ill-specified, and difficult to measure, monitor, and control. Health outcomes are difficult to measure, manage, and analyze. The system experiences growing cost pressures, faces potential insurance premium increases, and is extremely fragmented. In a recent article, Porter and Olmsted Teisberg (2004), eloquently put forth that competition is the root of the problem with the U.S. healthcare performance. They pointed that the current healthcare system has:

- The wrong level of competition
- The wrong objective
- The wrong forms of competition
- The wrong geographic market
- The wrong strategies and structure
- The wrong information
- The wrong incentives for payers
- The wrong incentives for providers

They propose that a reform should be designed to address these fundamental issues and allow a well-structured competitive market to improve the system. In addition, Wagner et al. (1996) identify five elements needed to improve patients' outcomes in an increasing population afflicted by chronic conditions:

- Evidence-based, planned care
- Reorganization of practices to meet the needs of patients who require more time and/or resources, and closer follow-up
- Systematic attention to patients' need for information and behavioral change
- Ready access to necessary clinical knowledge and expertise
- Supportive information systems

Regarding this last point, the Institute of Medicine points to the fact that "healthcare organizations are only beginning to apply information technology to manage and improve patient care. A great deal of medical information is stored on paper. Communication among clinicians and with patients does not generally make use of the Internet or other contemporary information technology. Hospitals and physician groups operate independently of one another, often providing care without the benefit of complete information on the patient's condition or medical history, services provided in other settings, or medications prescribed by other providers."

The revolution in information technology holds great promise in a number of areas for consumers, patients, clinicians, and all organizations involved in the delivery of health care services.

Information Technology:

The revolution in information technology holds great promise in a number of areas for consumers, patients, clinicians, and all organizations involved in the delivery of healthcare services. A recent report by the National Research Council of The National Academies (2000) identified six major information technology applications domains in healthcare: consumer health, clinical care, administrative and financial transactions, public health, professional education, and research. While many applications are currently in use (such as online search for medical information by patients), others, such as remote and virtual surgery and simulation of surgical procedures, are in early stages of development (Institute of Medicine, 2001). While the Internet (and intranets) are a driving force of recent changes in the information technology landscape, not all healthcare applications are web-based. Many applications (administrative billing systems, computerized physician order entry systems, etc.) remain on legacy systems, often built around older mainframe systems.

With respect to consumers/patients and providers, the Committee on the Quality of Healthcare in America identified five key areas in which information technology could contribute to an improved delivery system (Institute of Medicine, 2001):

- Access to medical knowledge base
- Computer-aided decision support systems
- Collection and sharing of clinical information
- Reduction in medical errors
- Enhanced patient and clinician communication

Consumerism:

The Internet and other developments in information and communication technologies are contributing to greater consumerism with stronger demands from individuals for information and convenience. People are more demanding and they want timely and easy access to medical information, the latest in technology, and the latest in customer service. Patients are starting to have access to tools that can lead to empowerment and shared decision making regarding their own healthcare.

There are, however, many technical, organizational, behavioral, and social challenges and barriers to greater use of information technology. Technological challenges include the design of optimal, effective, flexible human-computer interfaces, as well as issues of privacy and security of information.

The Healthcare Regulatory Environment:

As Kumar and Chandra (2001) mention, the healthcare industry has "unique" legislative challenges. Among them, two in particular have implications on the field of healthcare informatics: 1) the Health Insurance Portability and Accountability Act (HIPAA); and 2) health information and other business data security. The Health Insurance Portability and Accountability Act was passed and signed into law in 1996 and is designed to improve the portability of health insurance coverage in the group and individual markets, limit healthcare fraud and abuse, and simplify the administration of health insurance. The act has serious implications for healthcare providers and information managers. Of all its mandates, administrative simplification is perhaps the most critical for healthcare information managers, who are faced with everything from establishing standardized financial and clinical electronic data interchange (EDI) code sets to adopting, assigning, and using unique numerical identifiers for each healthcare provider, payer, patient, and employer. Both HIPAA and the increasingly growing role of the Internet contribute to creating an even greater and critical concern for data security and privacy.

OPPORTUNITIES FOR INDUSTRIAL AND SYSTEMS ENGINEERING

The characteristics of the healthcare system in the U.S. and the major forces accentuating the problems provide virtually unlimited opportunities for industrial and systems engineering to contribute and make significant changes to the system. Healthcare is a notably complex system; but it has evolved, compared to other industries, with little shaping by the visible hands of either management or engineering. Indeed, only recently, with the rise of managed care, which has brought rapid change to the sector, has healthcare come to be viewed as an "industry."

Engineering is unique in employing tools and methods suited to both analysis and design.

Engineering is unique in employing tools and methods suited to both analysis and design. Most of these methods are quantitative; many are based on mathematical models. So are those of science, economics, and "management science." But engineering, with architecture and related planning professions, is alone in focusing on the design of new systems, often systems of great complexity, to meet socially defined criteria. The next critical task in healthcare is to re-engineer its systems. It is an objective to which engineering methods are especially suited: building foundations for ongoing, cumulative increases in performance with respect to the quality of care, its accessibility, and its cost. This will entail developing better metrics; identifying tools, techniques, and methods of proven effectiveness in other settings that hold promise in healthcare; and developing quantitative models that will permit the examination and optimization of system performance (really a system of systems) through which healthcare providers convert inputs into outputs. Reengineering the delivery of healthcare services through innovative development, application, and use of proven and novel operations research and management sciences methods, theories, and tools coupled with modern and novel information and communication technology solutions can result in tremendous cost savings and improved access to healthcare services, as well as improved quality of life for all citizens.

While a number of excellent studies have been and are being performed to illustrate the application of operations research in healthcare delivery, as exemplified by the brand new *Handbook of Operations Research and Healthcare* (Brandeau, Sainfort, Pierskalla, 2004), the field of operations research in healthcare has been very fragmented and has suffered from a lack of infrastructure, hindering necessary innovations in this critical industry – the largest in the United States, touching virtually all lives in the country.

Engineers do not have good knowledge of healthcare systems. Public health, population health, and health services researchers do not have good knowledge of operations research and systems analysis methods and theories. Information and decision support technology experts have hardware and software capabilities but need the "content" of the necessary applications to be developed. The School of Industrial and Systems Engineering at Georgia Tech, through its talented faculty and students, and through its Health Systems Engineering graduate program, is uniquely positioned to have a tremendous impact on healthcare delivery systems in the United States. And we've only just begun.

(For further information on the ISyE Health Systems graduate program and its expert faculty, see pp. 16-20).

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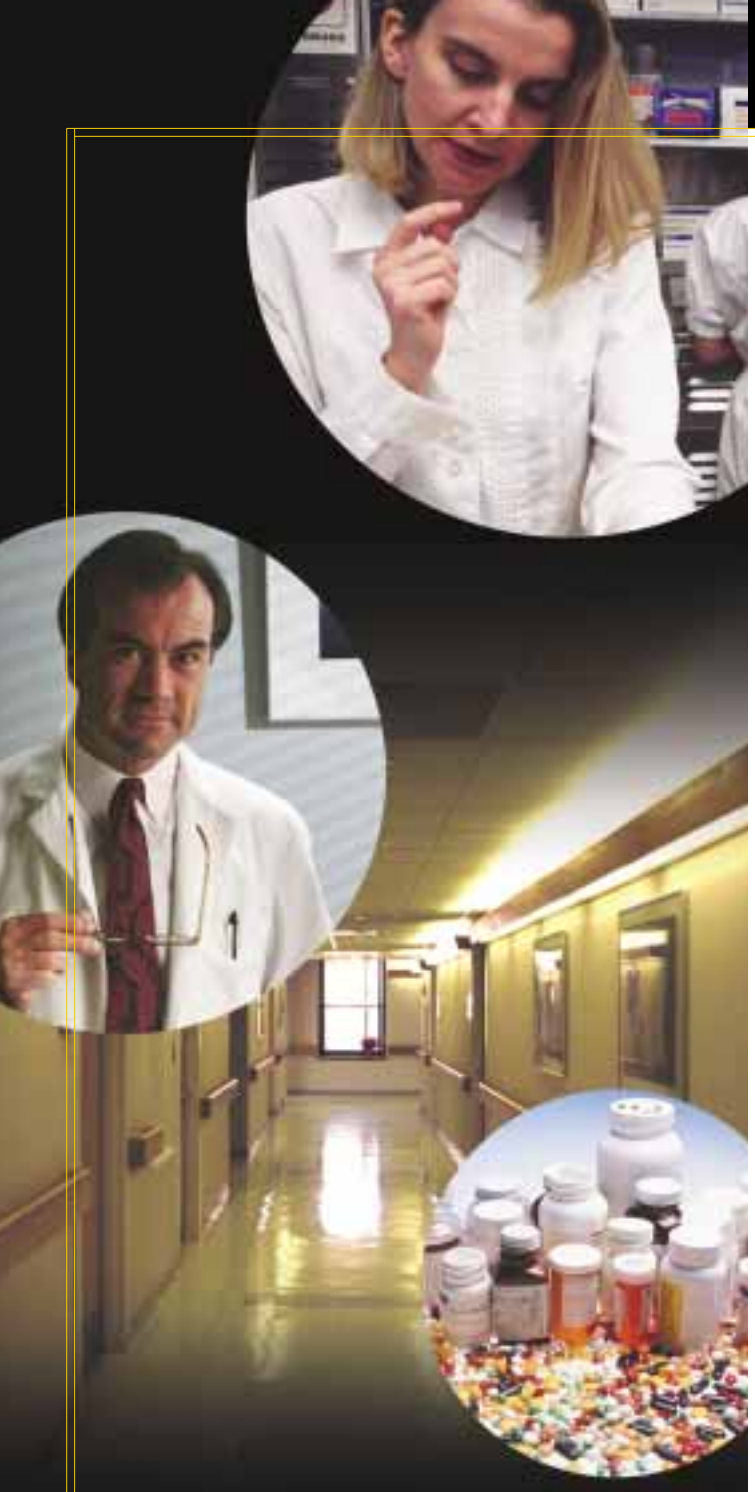


PERSPECTIVES ON

HEALTHCARE

AN INTERVIEW WITH BILL GEORGE

William (Bill) W. George is the former chairman and chief executive officer of Medtronic, Inc. He joined Medtronic in 1989 as president and chief operating officer, and was elected chief executive officer in 1991, serving in that capacity through 2001. He was chairman of the Board from 1996 to 2002. Under his leadership, Medtronic's market capitalization grew from $1.1 billion to $60 billion, averaging 35 percent growth per year. Prior to joining Medtronic, he spent ten years as an executive with Honeywell, serving as president of Space & Aviation Systems and Honeywell Europe, and ten years with Litton Industries, primarily as president of Litton Microwave Cooking.

George received his BSIE with high honors from Georgia Tech, and his MBA with high distinction from Harvard University, where he was a Baker Scholar. He has been named Executive-of-the-Year by the Academy of Management (2001) and Director-of-the-Year by National Association of Corporate Directors (2001-02). He has received a Legend in Leadership Award from Yale University and Alumni Achievement Award from Harvard Business School.

George is senior lecturer at the Harvard Business School, where he is teaching *Leadership and Corporate Accountability*. He is the author of "Authentic Leadership: Rediscovering the Secrets to Creating Lasting Value," and was recently named one of "The 25 Most Influential Business People of the Last 25 Years" by PBS Nightly News. Prior to joining the Harvard faculty in January 2004, George was professor of Leadership and Governance at IMD International in Lausanne, Switzerland and Executive-in-Residence at Yale University's School of Management.

EE: How did you get from ISyE into the healthcare industry?

George: That was a long journey. I went into engineering originally as a path to management of high tech companies. I selected industrial engineering when I enrolled in Georgia Tech in the 1960s because I wanted a broad engineering education. I did not see myself as a circuit designer, an electrical engineer, or a mechanical engineer. Industrial engineering was perfect for me. At Tech, I got very excited about IE, operations research, and had summer jobs in industrial engineering for Proctor & Gamble, Lear Jets, and a local machine tool manufacturer. Then my path took me directly into business. I got an MBA, which was consistent with my desire to get into management of high tech companies.

I spent ten years with Litton Industries in the microwave business, creating consumer microwave products from 1969 to 1978. Then I joined Honeywell, another high tech company, with the idea that I would be there for the rest of my career. I had the opportunity to run most of Honeywell's businesses involving its European operations. In 1978, the opportunity to join Medtronic came along for the third time. After thinking about it some time, I decided that I wanted to get into the field of medical technology, even though I knew very little about medicine.

EE: Did that seem like a big leap at the time?

George: The medicine part seemed like a big leap. The technology was very similar to what I was doing at Honeywell and Litton, so it was a natural. If I hadn't had a technological background I would not have been nearly as effective in any of the three companies. I have always felt comfortable dialoging with circuit designers and engineers and the creators of new technology. To learn the medical business, I spend my first six months at Medtronic in operating rooms and cath labs, working with many of the top doctors around the world, watching how they do procedures.

EE: Interesting that the company could let you do that.

George: My boss, the CEO, was 63 at the time with a fixed date for retirement two years later. We knew the path we were on. He had come from Pillsbury and was not very comfortable interacting with the doctors. I gained that comfort by getting out there with them and taking a combination of engineering knowledge and expertise and just observation in working with them to learn a lot about what the critical elements of medical technology and procedures are. They are very different from pharmaceuticals, where it's just the gestation of a pill. There are tremendous variabilities and outcomes in the cath lab or surgical suite based on the surgeon's skill and equipment employed – how comfortable the doctor is with the equipment will determine how effective that procedure is to the patient.

EE: I would think your experience of how Honeywell operated in their market would be rather different than Medtronic.

George: It's certainly different, but also very similar. You have people who are trying to serve consumers – patients in this case – and trying to understand what the needs are of the recipient of your product, and the user of your product, in this case the doctor. It is understanding what works or doesn't work, translating that back to the engineers, and having them come up with new products that better meet those needs.

EE: We talked a few months ago about transformational leadership. You talked about that being a long-term commitment, and I'm interested in how you think about that in the context of your role at Medtronic.

George: In any innovative, high tech business, it is essential that the leader be "hands on" with the crucial point of intersection of the marketplace and technology – the decision of which innovations to fund, and how to keep your organization innovative. I don't think one can preside – go to meetings, sit at the back of the room, say thank you very much, listen carefully - and not engage. First of all, this turns off engineers and the technical people. And they really love having top executives coming into the labs and engaging them. Just like the doctor's love having you in the marketplace with them. They feel that someone is listening to their ideas. I think this engagement is extremely important. That's what Bill Hewlett and Dave Packard did at HP. They were great role models for me. Andy Grove of Intel was very engaged, passionately so. The same with Bill Gates. All those people are extremely engaged in the business. In the pharmaceutical industry, we've seen many leaders come up who are now more withdrawn, and I think many are struggling. Many of them are struggling for innovations, and they don't understand why they're not getting results.

If I hadn't had a **TECHNOLOGICAL BACKGROUND** I would not have been nearly as **EFFECTIVE** in any of the **THREE COMPANIES.**

EE: Do you think it makes a difference if you're selling a commodity vs. a proprietary product?

George: Yes. I think it makes a difference if you've decided that innovation is not important in your company.

EE: Couldn't you be innovating in the service side of your business?

George: Yes, innovating in terms of services, processes, or cost reductions. You have to be engaged in those, too. But I do think in true innovation, no matter how good your system for innovation is, there is no substitution for the involvement of senior executives in that process, if you want it to be effective. It doesn't matter how much money you spend, senior executives must be involved in order to make it work.

EE: Is it more than engagement? Do you have to set the tone, the vision, the values or…?

George: Yes, you clearly have to set the mission and convey the passion. Are we trying to create the world's greatest software, like Microsoft is doing, or are we trying to develop the world's greatest circuit technology, like Intel is trying to do, or are we trying to restore people to full health, like Medtronic tries to do? That mission must be conveyed to people clearly and articulately with passion. I think drawing the circle wider for that mission to bring customers into your mission is also a good idea. Bring all employees, whether they work in the IT department or the accounting department, to be a part of the mission, so it's not just the inventors.

EE: What would you say were the greatest innovations at Medtronic while you were leading it?

George: There was a whole series of incurable neurological diseases we wanted to stamp out. And we developed a treatment for Parkinson's that transforms people's lives with an electrode in the brain that takes

We look at both the **POTENTIAL** of our **TECHNOLOGY** and the **DISEASES** that are not well served **TODAY**.

away all the symptoms of Parkinson's. We started with the tremor indication, but then moved to other symptoms such as spasticity, rigidity, and immobility, all these other factors that made life miserable for Parkinson's patients. It really opens up their lives to a much more normal life.

EE: How do you decide which one of these areas – Parkinson's, Alzheimer's, heart disease – to pay attention do?

George: We look at both the potential of our technology and the diseases that are not well served today. We never got into orthopedic implants – hips and knees – because we felt the market was well served by existing manufacturers. Neurological disease is underserved because there are no solutions. Then we went through very formal screening processes to determine where we should be investing. After that, you have to engage in a kind of freeform innovation process where you put a lot of irons in the fire and let them try to heat up and see which one is really good. In other words, at the early stage things are inexpensive and you're not doing any clinical trials. You're just trying to come up with ideas that can be converted to a product and see what people come up with. We gave them a lot of freedom, kept the teams small, and let them go out and try some ideas. It is important not to build up the big venture bureaucracy with the administration, the management, the processes, and all that. Just let them go do it.

EE: The idea they are trying – you know it has the potential to hit these markets you're interested in?

George: Yes. Back in 1994, we got $450 million of funding from Siemens for a patent violation, and we asked for that funding be paid every quarter for ten years. Instead of taking it as profit, we told the stock market we would use it to fund new ventures. At that point, our R&D funding, although it was increasing at 20-25 percent a year, was being absorbed by existing businesses. There was no money left over for creative, freeform innovation. The innovation teams built up about a dozen innovation projects.

One of those projects was heart failure. At the time, all the doctors were telling us, forget it, because we don't believe in treating heart failure with anything other than drugs. We just don't believe in implanting some device for a disease like heart failure. Then we developed some breakthrough therapies that hit the market in 2001 and are now a $1 billion business. It might be a $2 billion business in a few years as it's just now taking off. It's been a miraculous treatment for heart failure, and it will result in huge reductions in cost to the healthcare system. We chose that because it was such a high cost to the healthcare system.

EE: One of the questions that often comes up is, "Do leaders make the times or do the times make the leaders?" It's always struck me that the leaders are the ones that can recognize and take advantage of the times. It seems that you had an opportunity there and you just took advantage of it in a very different way rather than just letting it flow to the bottom line.

George: We did so because we believe innovation is our future. We had one team look at market opportunities, another team looked at what our technology could produce, and then we tried to mesh the two. You could say Alzheimer's has a huge unmet patient need, but no one has a clue how we can use any of our technologies to treat Alzheimer's so we didn't fund that area. We funded about a dozen things. Of that first dozen things, five or six or seven of them failed. We had another approach to heart failure called cardiomyoplasty that involved massive surgery and taking the back muscle and wrapping it around the heart. We spent a lot of money on human trials, but we eventually shut it down because the procedures didn't prove out and we found a superior approach.

EE: Did you really only need one or two things to work out well?

George: Yes, but it sure is nice when four or five work out. I think that some of them are going to be the classic grand slam homeruns, like heart failure, and some of them are going to be homeruns like the Parkinson's disease therapy. We came out with a device for implantable diagnostics and it missed the market; but when we modified the device, it started to move the market. Now, it has led to clear thinking inside the company about how to pursue implantable diagnostics. If you could electronically diagnose people, they could live at home, and this is leading to a whole new way of thinking about healthcare. One of the technical innovations that came out of this was wireless telemetry. Instead of putting a magnet on the device to measure EKGs and the heart rhythms, we can do it all wireless and just send it out over the Internet. The doctor gets it at the office and sees whether there are any problems or not. It can be in real time, 24 hours a day if you want. Now that's a big breakthrough.

EE: In managing your resources, how do you deal with things that you've been marketing and selling for a long time, but there is just not much growth left there? How do you reallocate resources in those cases?

George: A good example would be the cardiac surgery market, where procedures are not growing as fast. The market was well served with the coronary artery bypass. We created a team about a year later, and said, see if you can radicalize this treat-

ment. We now have a radical procedure, called "beating heart" surgery, where the patient is treated without any kind of bypass procedure. There is still a need to open up the chest, but you don't have the bypass procedure which has been standard for 50 years. We're now using it in about 25 percent of cases in the U.S. It's a far superior procedure.

EE: So when areas get mature, you basically….

George: You turn them into immature technology opportunities. Companies make money when there is a technological change or a market change. If the markets mature and the technology is mature, it's going to commoditize and no one is going to make any money. Think about the automobile market, classically. If all the cars are the same, the price will fall and no one will make any money. To a high tech company, that is not very interesting, and in fact, that's our greatest fear. We have a process we call "Reinventing Medtronic." Every five years the company would reinvent itself so that when you look back, it looks like a totally different company. One of the goals we set, which we have fulfilled for the last seven years now, is that 67 percent of the revenues come from products introduced in the last 24 months. That's a staggering figure. Intel and Hewlett-Packard and 3M have 25-30 percent of their revenues coming from products introduced in the last five years.

EE: The Industrial Research Institute publishes a table with this metric, and your percentage would make Medtronic one of the outliers.

George: Think about the pressure on people to turn the product line so that you have 70 percent of your revenue coming from new products every two years.

EE: Do you retire products?

George: All the time. That's the whole idea of reinventing yourself.

EE: That's not really our strong suit here at the university.

George: The bigger the company is, the harder it is. Large companies don't reinvent themselves. All they do is incremental engineering to replace the products they have. What they are doing is getting more engineering elegance. That used to be the bane of my existence. At Medtronic, we shut some major products down because they didn't do anything but the basics.

EE: Let's broaden the view a bit. We recently talked a little bit about the whole healthcare system. Last month Michael Porter's article "Redefining Competition in Healthcare" came out in* Harvard Business Review *(June 2004). You commented that you liked the article.

George: I liked his analysis. Porter advocates that we make decisions based upon the quality of the provider's outcomes. So we should chose the doctors based upon the highest quality physicians, not the lowest cost. He is correct. The highest quality physician will ultimately be the lowest cost. People don't believe that, but it is true. It's the old thing about quality – when is the most cost-effective time to catch your defects? It's as early as possible in the process. If you catch a defect like a defective drug, when it is already in the body of 200,000 people, you've got a heck of a problem. He's correct, but the question is how do you get the doctors and the hospital to provide that kind of data? Right now they are extremely resistant to doing that, and frankly do not agree on the right measures of quality. How do we make that economically attractive? Right now there is no incentive for doctors to do that.

If the **MARKETS** mature and the **TECHNOLOGY** is mature, it's going to **COMMODITIZE** and no one is going to make any **MONEY**.

EE: It's interesting to think about having those metrics, not for a particular procedure at a particular hospital, but for particular individuals. That sounds to me like a tall order.

George: In this case, the individual is the primary source of variability. Let's consider an absurd example. You're buying a car, which is made by one person. And the quality of your car is totally dependent on that one person, and there is a huge variability among the workers that build cars. Let's say they sign their names at the end. You would want to get data on who was producing top quality cars because one of them has a 60 percent probability of being error free for the first two years, and the other one has a 95 percent probability. You'd like to know that if they are all built by one person. When you're talking about doctors, there is huge variability in quality of outcome.

EE: I see that part of it, but a few years ago I went for my 50,000 mile check up, and in that day I managed to fill out my medical history form five times.

George: Exactly, the whole system is absurd.

EE: But that's not just an issue of the quality of the doctor, is it?

George: What you described is the easy issue. You just give people a Smartcard and fill out your medical history. You make the decision to turn it over. You just made the decision to turn it over five times in writing, so wouldn't you just as soon have a card, like your insurance card, with all your information on it? But the problem is you don't want your employer to know about these things in your medical history. You're embarrassed about something in your medical history, and you don't want this in the newspapers.

EE: The other problem is I don't want to show up for one step of this whole process, and the people say, "Oh, we don't take that card."

George: It has to be like your Social Security number; everyone has to take it. You can do it with insurance cards, but then you get into the privacy requirements as people don't want all that information out there. That's why the system is so totally dysfunctional. The better quality doctors wind up with less business. That's been carefully studied. Let's take angioplasty, putting in stents. One of the concerns is the possibility of restenosis. Patients who don't experience restenosis don't have to go back to the doctor, so this doctor gets less business. For the doctor who puts in stents and the patients get restenosis, the patients will be back every six months.

EE: If you can get people to buy a car that needs a lot of maintenance you can make a lot of money on the service.

George: In fact, that's what they did. That was the whole process that many American auto dealers tried – to make a lot of money off service. However, the Japanese made cars error-free, and that's why the Japanese auto sold so well.

EE: What do you see as scenarios for getting out of the path we're on in healthcare right now? Michael Porter portrayed one way we could fix it, and I think you raised the issue of practicality. How would you make that happen?

George: You start with what is the core problem. There are two cost cause problems. The first relates to the Indian story of the blind man and the elephant. You've got all these brilliant people looking at the elephant, i.e. the healthcare system, from different perspectives and they see it through their own perceptions. Physicians see it one way, policy people in Washington are going to see it another way, hospitals are going to see it a third way. I just talked last Friday to 2,000 people at the American Health Insurance Plan Association – the association of all the health plans – they see it a different way. We have all these people interacting with the system who see it in totally different ways. That's problem one.

The second root cause is that healthcare is the only consumer good that you don't pay for directly. By not paying for it, you don't feel the economic responsibility, or worse yet, you feel you're paying for it through your premiums, which are not rated by your experience. You feel, I might as well get my money's worth from all those premium dollars I'm paying, so I'm going to use the system. The economics are fundamentally flawed at the core level. Until you fix that problem, the demand/supply curve will never be in line. So then what that leads to is someone who can stand above the system and look at it and redesign it in a systematic form. However, there is no model of the healthcare system and how it works. There are lots of models of the economy, of everything else, but not models of the healthcare system, at least not yet.

EE: Do you think a university could play that role?

George: Yes, they should, but it's a massive role. You may need lots of funding from a government entity like NSF or NIH or CMS – someone who is prepared to say, we aren't getting there the way we are going. All we're doing is paying for more and more high cost procedures. We have no vehicle not to pay for those. On the other hand, you're squeezing the reimbursement which just causes people to have more procedures. Instead of reimbursing the $2000 for a particular procedure, you tell them you're only going to reimburse $1500. You'll just see a 25 percent increase in the number of procedures because doctors need to balance out their income.

EE: We were talking with one of your co-alums, the CEO of a health insurer about this problem, and asked if he found it as complex. He said no, it's simple. We just keep raising the rates. Is there any point at which the economy just can't deal with this?

George: Sure. They've raised rates double-digits for five consecutive years. What's the inflationary rate, 3 percent? You can't live with that forever. General Motors has a huge unfunded healthcare liability just for its retirees.

EE: Actually, we talked about this problem of modeling the healthcare system when several GM executives visited Tech, and they said they might be interested in investing in this.

George: That would be a big investment. That's a huge job.

EE: Would it be fair to say that if any one of the primary proponents, i.e. the doctors, the hospitals, or the insurance companies or whoever, were the leaders on such as initiative, they would always be viewed a little cautiously?

George: Everyone right now is looking out for his or her own skin in the healthcare game. There are so many proponents or advocates of new, systematic changes that haven't worked, or they have adverse consequences, that their first response is defensive. You would think that the pharmaceutical industry would be thrilled over the possibility of the U.S. government now paying seniors for their drugs – logically?? But initially they were opposed to it. They are afraid that this would result in lower prices for their drugs for seniors, which could have an effect on the pricing of all their drugs. So they got a provision in the Congressional law that got passed that says that the federal government, which is the largest purchaser of pharmaceuticals in the world, is not able to negotiate on price with its suppliers. Think about that.

EE: My mother in her later years had high blood pressure and they tried one medicine after another, and finally on the seventh medicine, they got it under control. So I said to the doctor, "Now that you know what works, can't she just take one prescription?" He said, "That's not the way it works. We don't actually know why her blood pressure is under control, we just know these seven prescriptions together seem to work." I said, "Why don't you take the composition of the seven, whatever it is, and put together one pill?" He said, "The problem is that the seven different pills are sold by different drug companies."

George: The problem you are posing is an unbelievably big challenge. You're challenging basic medical research standards, the so-called gold standard of the clinical trial, which tests one drug against a placebo. Drugs are rarely tested in combination with each other. However, there's another solution to the problem you're highlighting. Let's understand medically what is causing your mother's high blood pressure. All the studies done in healthcare are based on correlations, not based on causal relationships. No one knows why these seven finally caused the cessation of your mother's high blood pressure. The better solution to the problem is to figure out what's causing the high blood pressure and find out what the drug needs to do to correct it, and design it to do that.

EE: What do you see as the overall university role, in general, and Georgia Tech's role in this whole process?

George: Georgia Tech is one of the top two or three or four technological institutions in the U.S. It has a very major role to play in fostering innovation and creativity with a sound underlying scientific and engineering base. Taking scientific principles and engineering principles, and being a great supporter of creativity are Georgia Tech's role.

EE: How well do you think we're doing at that?

George: Increasingly well. In the past decade, Georgia Tech has become a major player on the national stage. It has emerged that way from two factors. One is the growth of Georgia Tech's graduate education and second is the growth of its research budget.

EE: Part of what happens here also is the university has to be willing to play a role on the national stage, not just stay in the lab.

George: Purdue is a great institution; I would say it was at least comparable, and probably ahead of Georgia Tech when I was in school. Why has Georgia Tech gone so far ahead of Purdue? Maybe it is due to Wayne Clough. The State of Georgia has become a big supporter of Georgia Tech as a way to build its economy. When I was in school, the legislature almost had a distain for these things; now they support it for the growth of Georgia. I'm very positive about this. The commitment is far greater than other states, proportionately.

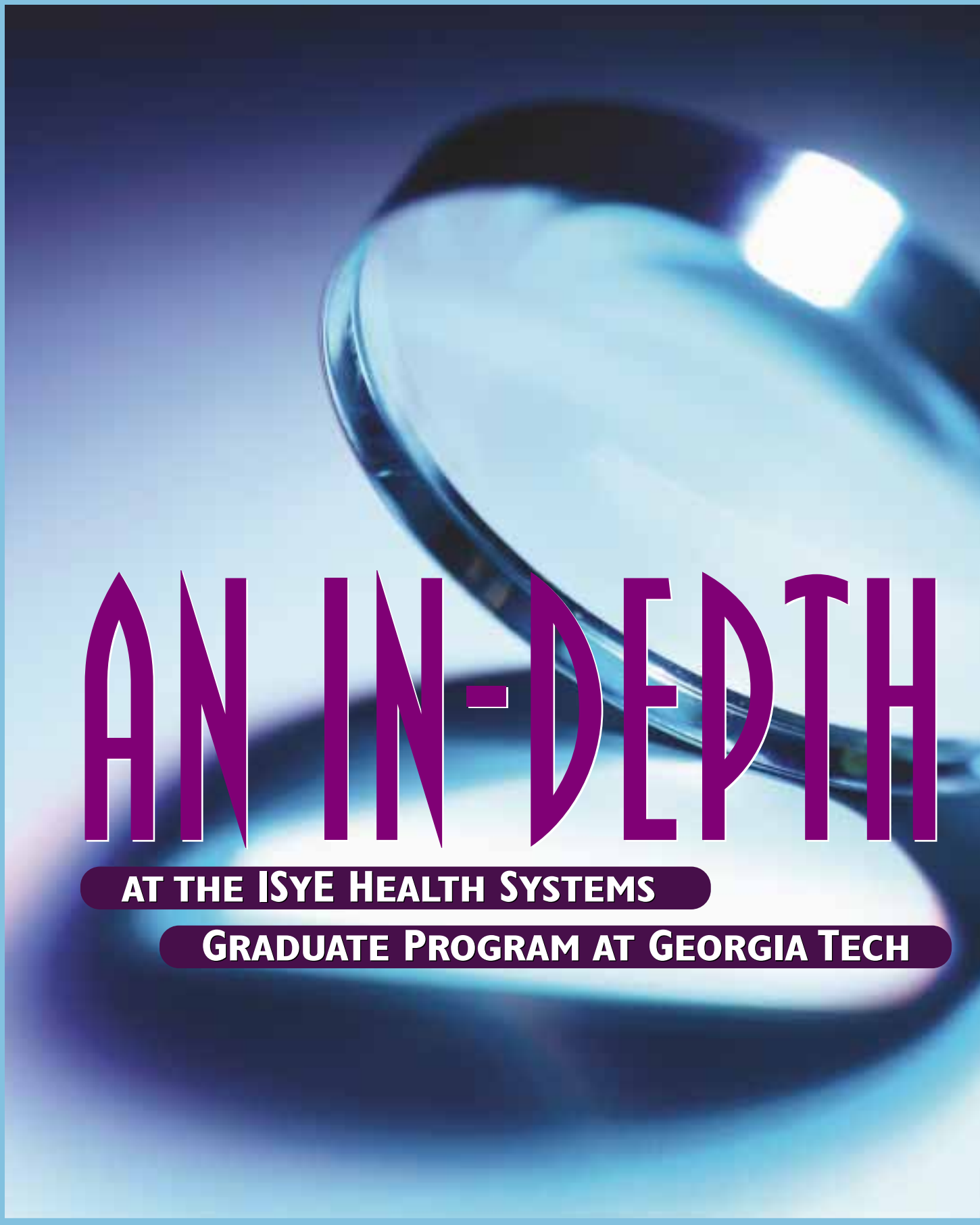
EE: Any wrap up observations?

George: I'm very excited about the role that Georgia Tech is taking. It is very significant. To what would I attribute Georgia Tech's rise? I think Tech has a remarkable ability to interact effectively between academic disciplines. It's done an excellent job of overcoming the silo effect, and getting true collaboration among different academic disciplines. Look at all the areas I've been closely involved with – the whole biomedical area. You can see it very much with the design of facilities like the Parker H. Petit Institute for Bioengineering and Bioscience and the entire philosophy of the place. Many other institutions simply have been unable to accomplish that.

EE: My experience has been that we are actually pretty good at pulling together multidisciplinary teams. That doesn't mean that we don't have a lot of rockiness along the way, but at least we're all in the room together.

George: That diversity of thought is what leads to real creativity.

EE: Thanks, Bill, for your many insights. This dialogue will undoubtedly fascinate our readers.



AN IN-DEPTH

AT THE ISyE HEALTH SYSTEMS GRADUATE PROGRAM AT GEORGIA TECH

The future strength of any industry depends upon efficiently designing, operating, and adapting to the ever-changing needs and emerging technologies that serve the diverse fields where industrial engineering principles are used. While industrial and systems engineering crosses into almost every aspect of our daily lives, its presence in the healthcare industry has been somewhat limited. The healthcare industry has not fully benefited from industrial engineering principles because industrial engineers have not been appropriately prepared to make a difference in healthcare. Industrial engineers today face the challenge of developing and applying industrial and systems engineering tools, models, and theories as well as utilizing and integrating new information and biomedical technologies that together will shape the healthcare system of the future.

Healthcare systems at all levels in the U.S. need to be evaluated, modeled, analyzed, re-designed, and significantly improved. Industrial engineering tools, models, and theories are well suited for this ambitious task. The School of Industrial & Systems Engineering (ISyE) at Georgia Tech is uniquely positioned to develop and sustain the premier industrial engineering-based Health Systems graduate program in the United States. Indeed, ISyE is the most respected Industrial Engineering program in the country and is Georgia Tech's home for an existing IE-based Master of Sciences in Health Systems (MSHS) as well as the Health Systems Research Center. Founded in 1958, the Health Systems program has approximately 600 alumni. While it has been relatively small in size and scope over the years, the program has recently been identified as one key ISyE strategic area for growth and development.

To lead that effort, professor François Sainfort joined ISyE in Fall 2000 as professor of ISyE and director of the Health Systems Research Center. Prior to his arrival at Georgia Tech, Dr. Sainfort was a professor of Industrial Engineering at the University of Wisconsin-Madison with joint appointments in the Department of Biomedical Engineering and the Department of Preventive Medicine. During that time, he was also program director for the Health Systems Engineering graduate program at Wisconsin-Madison.

Health Systems is now one of nine interest areas in the School of Industrial and Systems Engineering, and the program has five primary faculty members leading tremendous research efforts in this area.

Over the last few years, Dr. Sainfort and his colleagues, Dr. Julie Jacko, Dr. Eva Lee, and Dr. Joseph Wu have worked on developing a new vision for the Health Systems program, establishing a network of relationships among for-profit, non-profit, and government organizations in the healthcare industry, and forging links with other Schools at Tech as well as the Woodruff Health Sciences Center at Emory University in order to develop and expand the graduate program.

These individuals have also assisted Federal agencies such as the National Science Foundation in developing a new research agenda in service operations in general (currently active – the Service Enterprise Engineering program) and health care services in particular (to be activated in 2005 – the Engineering Healthcare Delivery program), and securing funds and endowments to support the growth of the Health Systems program at Georgia Tech.

In 2001, William W. George, past chairman and CEO of Medtronic Inc. and a 1964 industrial engineering graduate of Georgia Tech, established a $1 million endowment to create the William W. George Professorship in Health Systems (see www.news-info.gatech.edu/news_releases/george.html). Dr. Sainfort is the recipient of this professorship. In addition, the program is half way to its goal of endowing another Chair in Health Systems – the Smalley Chair – in honor of the late Dr. Harold Smalley, who founded the health systems program in 1958. The Health Systems program needs the continuous support and generosity of alumni and potential donors to raise funds and fully complete the Smalley Chair.

The Health Systems program has two industry experts, both early graduates of the program, who assist in developing the curriculum and goals. Nate Kaufman, MSHS 1978, serves as senior vice president of Superior Consultant Company as well as the Edenfield Executive-in-Residence at Georgia Tech. He is a leading healthcare futurist and a nationally renowned expert in hospital strategy, integrated delivery systems, managed care, joint ventures, and dispute resolution. Kaufman served as the keynote speaker at the first Annual Health Systems Symposium in 2003. David Cowan, BSIE 1977, MSHS 1979, who is supported through the George Endowment, joined the Health Systems program in 2002 to strengthen connections with industry. He is the founder and president of a healthcare organization process-improvement firm called Management Systems Consultants. Although Cowan is involved in a number of aspects of the overall program, he dedicates much of his time to the Sponsored Graduate Research Assistantships (GRAs). This program is considered an integral part of the curriculum as it allows students to work onsite at a sponsor company conducting applied research for 13 hours/week. Both these individuals bring a wealth of industry experience and guidance to the graduate students enrolled.

Health Systems is now one of nine interest areas in the School of Industrial and Systems Engineering, and the program has five primary faculty members leading tremendous research efforts in this area. The primary faculty, along with their current research are highlighted below:

Dr. Augustine Esogbue is a true pioneer in applying operations research methods to healthcare delivery problems. He has significantly contributed to developing the field of health systems engineering at Georgia Tech and in the United States. His current research interests include dynamic programming; fuzzy sets; decision making and control in a fuzzy environment; and operations research with applications to socio-technical systems such as healthcare, water resource management, and disaster control planning. All of these have great applicability to complex health systems issues.

Dr. Julie A. Jacko's research investigates the design, implementation, and evaluation of interactive, next-generation computing solutions in complex domains including, but not limited to, healthcare and healthcare delivery, with the purpose of supporting the development of systems that are both usable and accessible. This is accomplished through research that is focused on the psychological and perceptual processes underlying the interaction of people with complex systems, particularly computer systems, with the ultimate goal of combining robust empirical results with the development of engineering models of human performance that can aid in the design of real-world systems. Current projects include:

- Characterizing patterns of visual search exhibited during performance of direct manipulation tasks by patients with Age-related Macular Degeneration and Diabetic Retinopathy.
- Deriving a multifractal approach to extract and distinguish patterns from task-based pupillary behavior of older adults, including those with Age-related Macular Degeneration.
- Investigating the engagement of the visual cortex in patients who have impaired vision, using electroencephalogram (EEG), while performing computer-based tasks requiring visual search by examining two stages of visual search: preparation and focused visual involvement.
- Using on-screen pre-compensation of images presented on a computer screen through use of a patient's Wavefront Aberration Function, so they are perceived undistorted by patients experiencing Pellucid Marginal Degeneration, Terrien's Marginal Degeneration, and related refraction disorders.
- Using Principle Components Analysis to isolate principle components that define a user's search and decision processes during use of a decision support system designed to aid in selection among health plans.

Dr. Eva K. Lee works in the area of mathematical modeling and computational algorithms with a primary emphasis on medical and biomedical investigations. She has developed clinically relevant mathematical models, algorithmic strategies, and clinical decision-support systems to help analyze large-scale biological DNA/genomic and clinical data. Dr. Lee has received five patents on innovative medical systems and devices, one of which is currently under FDA review for approval for clinical use in the treatment of prostate cancer. Broadly, her medical/biomedical research can be classified into three areas:

- Novel pattern recognition and classification algorithms for early disease diagnosis and prediction, target therapeutic intervention, and disease monitoring (with a current focus on cancer and heart disease).
- Analysis of clinical treatment modalities, and design of optimal and combination treatment regimens, and drug delivery for cancer.
- Outcome analysis and development of prediction rules for treatment effectiveness, and design of improved treatment regimens.

Dr. François Sainfort's research and expertise focus on medical decision making under risk and uncertainty, health outcomes measurement, health risk perception and assessment, health status assessment and monitoring, and health-related performance measurement and analysis. Dr. Sainfort has received research funding from the federal government – the Agency for Healthcare Research and Quality, the Health Care Financing Administration, the National Institute of Aging, the National Library of Medicine, the Centers for Disease Control, the National Science Foundation, and the Department of Defense – as well as funding from industry. He served as principal investigator on more than $7 million in contracts and grants. Dr. Sainfort is an expert consultant for the healthcare industry. His clients include healthcare delivery organizations, medical devices companies, clinical laboratories, pharmaceutical companies, and information technology companies.

Advances in information, medical and biomedical knowledge coupled with rising healthcare costs, inequities in access, aging populations, legacy information systems, and increased consumer expectations require new effective methods for design, analysis, management, and decision making for healthcare planning and delivery.

Dr. Joseph Wu's current research focus is in modeling of complex biological systems and application of optimization techniques to medical problems. Recent work includes modeling and optimization of annual influenza vaccinations and replication-competent oncolytic virotherapy. Dr. Wu is also a Georgia Cancer Coalition (GCC) Distinguished Cancer Scholar. This prestigious award is conferred by GCC in order to recruit leading and nationally renowned cancer clinicians and scientists who are engaged in the most promising areas of cancer research. The selection of the scholars is closely aligned with the National Cancer Institute's "Extraordinary Opportunities in Cancer Research," which has identified areas of discovery that hold promise for making significant progress against all cancers. As a researcher in the GCC Distinguished Cancer Clinicians and Scientists Program, Dr. Wu focuses on developing and using mathematical models to assist in the design and delivery of novel cancer therapies. He is initially concentrating his research in (1) the development of mathematical models of replication-competent oncolytic virotherapy dynamics; and (2) the development of a systematic framework for optimizing combination cancer treatments.

In addition, the Health Systems program has many secondary faculty members, including Drs. Faiz Al-Khayyal, David Goldsman, Paul Griffin, Julie Swann, Brani Vidakovic, and Chip White. Together, this talented group of individuals brings key expertise in all areas of industrial engineering necessary to establish health systems engineering at Georgia Tech as the premier such program in the nation.

The Health Systems faculty has defined the following opportunity and vision for the graduate program at Georgia Tech:

Opportunity

- Advances in information
- Medical and biomedical knowledge coupled with rising healthcare costs
- Inequities in access, aging populations, legacy information systems
- Increased consumer expectations require new effective methods for design, analysis, management, and decision making for healthcare planning and delivery.

Vision

The Health and Biomedical Systems Program provides intellectual focus, international visibility, and sustained support for research in biomedical and health systems with an emphasis on disease modeling, treatment, management and control; delivery systems modeling and analysis; and information and decision support technologies for the creation, planning, and novel delivery of healthcare services.

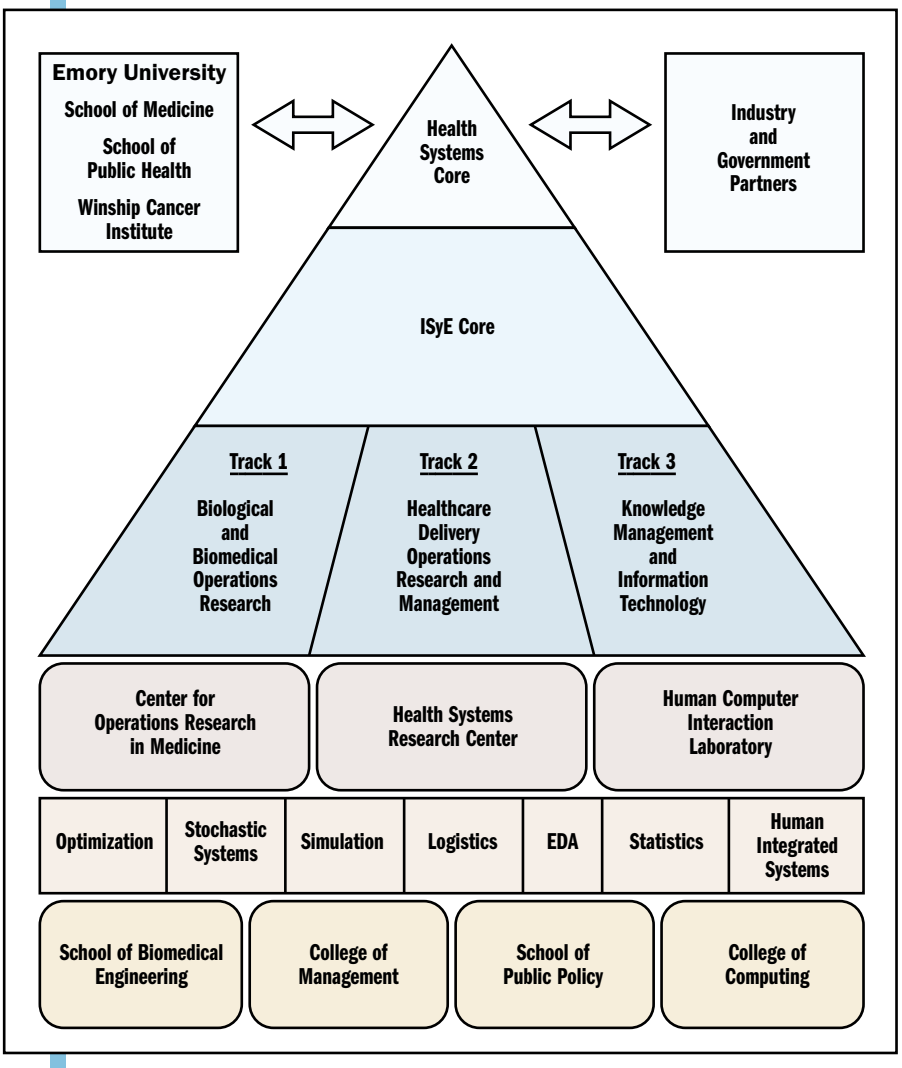


Figure 1: The Health Systems Graduate Program at Georgia Tech

As shown in the pyramid, the program relies on a core of health systems courses and ISyE courses and offers three possible tracks.

With the support of the faculty, the graduate program in Health Systems will be able to train students in the development and application of: state-of-the-art operations research and management sciences methods and theories for healthcare delivery systems modeling, analysis, and improvement: operations research methods and theories for disease modeling, treatment, management and control; and human-computer interaction methods and theories as well as information and decision support technologies to improve the delivery of healthcare services.

The current structure of the program is illustrated in Figure 1. As shown in the pyramid, the program relies on a core of health systems courses and ISyE courses and offers three possible tracks: biological and biomedical operations research, healthcare delivery operations research and management, and knowledge management and information technology. The educational program matches and builds upon three corresponding research laboratories and centers:

- The Center for Operations Research in Medicine: Directed by Dr. Lee, see www.isye.gatech.edu/~evakylee/medicalor/
- The Health Systems Research Center: Directed by Dr. Sainfort, see www.isye.gatech.edu/healthsystems
- The Laboratory for Human Computer Interaction and Health Care Informatics: Directed by Dr. Jacko, see www.isye.gatech.edu/lhci/

As shown in Figure 1, the Health Systems program draws from all other interest areas in the School of ISyE. It has forged close collaboration with four key units at Georgia Tech: the School of Biomedical Engineering, the College of Management, the School of Public Policy and the College of Computing. In addition, its has established a key partnership with the School of Medicine, the School of Public Health and the Winship Cancer Institute, all at Emory University. Finally, the program has established key alliances with industry (healthcare delivery organizations, information technology companies, biomedical companies, pharmaceutical companies, and consulting firms) as well as government agencies (the Centers for Disease Control) to support and conduct joint research, provide training opportunities, and translate research results into practice.

Future strategic goals for the program include hiring new faculty members specializing in various aspects of health systems research; restructuring and developing health systems courses, creating a Ph.D. specialization in health systems; establishing a consortium of for-profit, non-profit, and government partners; and securing additional federal, state, and industry research funding to sustain and further develop the program.

The Health Systems program has a tremendous impact on addressing current cost, quality, and access crises of the healthcare system; advancing disease prevention, detection, treatment, and management; and improving quality of life.

For more information, contact francois.sainfort@isye.gatech.edu

continued from page 5

NASA Selects ISyE Alumnus to Join its 2004 Astronaut Class

Now that NASA has set its sights on sending a manned mission to Mars, **Shane Kimbrough, MSOR 1998**, is hoping he'll be blasting off to the red planet.

An Atlanta-native, Kimbrough was named as one of 11 astronauts tapped to be part of NASA's Astronaut Class of 2004. The astronauts are NASA's first since President George Bush announced the country's new vision for space exploration in January.

"Once I finish my first year of astronaut training, I hope to be assigned to several technical jobs so I can improve myself, professionally," Kimbrough said. "But then I'd be thrilled to take on any space mission – even to the Moon or Mars."

Kimbrough, 36, will serve as a mission specialist. He is an Army major and currently works for NASA as a flight simulation engineer on the Shuttle Training Aircraft at the Johnson Space Center in Houston. A graduate of the U.S. Military Academy at West Point, Kimbrough graduated from Georgia Tech with a master's degree in Operations Research in 1998. He also graduated from The Lovett School in Atlanta.

As an Army pilot, he was trained to fly both airplanes and helicopters, but he was assigned to helicopters. He served in the first Gulf War as a platoon leader. Kimbrough also taught math at West Point, including calculus and statistics.

Though his career has been focused on serving his country, Kimbrough says the opportunity to serve as an astronaut fulfills a childhood dream. "I have been fascinated by space travel since I was a kid. I want to explore the unknown," he said.

Optimization: Finding the Best Solution

By George L. Nemhauser, *Ph.D.*
A. Russell Chandler III *Chair and Professor*

Optimization deals with problems in which many alternative decisions are possible and the goal is to find the best solution as measured by an objective such as minimum cost or maximum profit. Optimization problems abound in the real world. Logistics, supply chain, manufacturing, and revenue management are all major areas of application, and ISyE's faculty and students are actively involved in optimization projects in all of these areas.

Here is an example: Air taxi service is an emerging business opportunity that will use a new class of small, relatively inexpensive jets to give travelers the chance to fly to and from small or midsize U.S. airports on 4-8 seat planes at a much lower cost than chartering. By using small airports, the long passenger delays caused by security checks are avoided. Unlike charter service, where you rent the aircraft for a period of time, an air taxi operates like the limousines that take passengers from a major airport to downtown hotels. It may stop along the way to drop off or pick up passengers, although air taxis probably would limit the number of intermediate stops for any passenger to one or two.

Reservations for the air taxi service are usually requested only a few days in advance and can be made as late as the evening before the trip begins. A typical request is "Tomorrow I need to go from A to B and return: the earliest I can leave is 6:30 a.m. and I must be at B by 9:00 a.m. at the latest, I can return no earlier than 5:30 p.m. and I must get back by 8 p.m."

The first key question is whether it is possible to accept this request given the requests that have already been accepted for tomorrow. Those already accepted requests have been represented as a partial schedule, and the issue is whether the new request can fit into this partial schedule. Once the partial schedule begins to get tight, accepting an additional request may involve substantial changes in the tentative schedule by rerouting several planes. Technically speaking, this is a special case of optimization known as a feasibility problem, since the answer is simply "yes" or "no." A "yes" answer can be given only if a new schedule can be produced that accommodates the reservation. The challenge is that the answer must be produced very quickly, with 30 seconds being a typical time limit. This necessitates using what is known as a "heuristic," i.e. an algorithm that is very fast but doesn't guarantee producing an optimal solution.

The night before a given day's flight, all of the accepted reservations for that day are made into a final schedule by solving another optimization problem that minimizes an objective like total flying time. This overnight optimization can be solved much more precisely than the accept/reject problem, because several hours are available to perform the optimization. Nevertheless, the model for a problem with, say, 40 planes has millions of variables and is difficult to solve. We have had to customize commercial optimization software, including running the algorithm in parallel on 20 PCs, to get very high quality solutions, but the problem of guarantee optimality is still unsolved, and improving quality even 2–3 percent could significantly affect profitability.

It is widely recognized that Georgia Tech's School of Industrial and Systems Engineering has one of the best, if not the best, optimization groups in the world. Three of the optimization faculty, Professors William Cook, Bill Johnson, and myself, George Nemhauser, hold endowed chairs, and Professors Johnson and Nemhauser are members of the National Academy of Engineering. Professor Cook's amazing work on solving a traveling salesman problem with 24,978 cities was recently written up in the *Wall Street Journal* (April 20, 2004). Twenty-five years ago, we could only solve problems with fewer than 100 cities. Cook's work is an example of the ever more sophisticated work being done in optimization, which combines modeling, mathematics, and computer science. Stochastic optimization is another very active area in ISyE; this burgeoning area allows the solution of optimization problems with uncertainty and risk and has become an important tool for the new field of financial engineering.

ALUMNI NEWS

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