In this issue of *IEEE Control Systems Magazine*, we have interviews with John S. Baras, the 2017 recipient of the American Automatic Control Council (A2C2) Richard E. Bellman Control Heritage Award; Jacquelien M.A. Scherpen, who presented one of the semiplenaries at the 2017 American Control Conference (ACC); and Ketan Savla, the 2017 recipient of the A2C2 Donald P. Eckman Award.

John S. Baras holds the endowed Lockheed Martin Chair in Systems Engineering at the University of Maryland, College Park. He received the B.S. degree in electrical and mechanical engineering from the National Technical University of Athens Greece in 1970 and the M.S. and Ph.D. degrees in applied mathematics (control and dynamical systems) from Harvard University in 1971 and 1973, respectively. Since 1973, he has been a professor with the Department of Electrical and Computer Engineering and the Interdisciplinary Program in Applied Mathematics, Statistics, and Scientific Computation. He was the founding director of the Institute for Systems Research (ISR) (1985–1991), one of the first six NSF Engineering Research Centers. He was the founding codirector (1992–1994) and, since 1994, has been the director of the Maryland Center for Hybrid Networks, founded initially as a NASA Center for the Commercial Development of Space. He is the founding director of three laboratories at the ISR: the Systems Engineering and Integration Lab, the Hybrid Networks Lab, and the Autonomy Robotics and Cognition Lab. He has coauthored more than 850 papers in refereed journals and conference proceedings, written one book, and coedited three books. He has graduated 85 Ph.D. and 112 M.S. students and mentored 50 postdoctoral fellows. His research interests include systems, control, optimization, communication networks, signal processing, robotics, manufacturing, computing systems, network security and trust, and model-based systems engineering. He has also been awarded 18 patents and cofounded four start-up companies. He has given plenary addresses in many conferences, including IEEE Conference on Decision and Control, American Control Conference, MTNS, WiOpt, ECC, CCC, MobiCom, IFAC, MED, IJCAI, EBCCSP, Society for Industrial and Applied Mathematics CT, and IEEE ETFA.

Jacquelien M.A. Scherpen is a professor in the Faculty of Science and Engineering of the University of Groningen, The Netherlands. She received the M.Sc. and Ph.D. degrees in applied mathematics from the University of Twente, The Netherlands, in 1990 and 1994, respectively, in the field of systems and control. From 1994 to 2006, she was with Delft University of Technology, The Netherlands, first as a postdoctoral researcher, followed by an assistant (1995) and associate (1999) professorship in the Control Engineering Group of Electrical Engineering and, starting in 2003, in the Delft Center for Systems and Control. Since September 2006, she has been a professor at the University of Groningen in the Engineering and Technology Institute Groningen (ENTEG) at the Faculty of Science and Engineering. Since January 2013, she has served as the scientific director of ENTEG. Since 2016, she has also served as chair of the Groningen Engineering Center, which unites all engineering-related research and teaching at the University of Groningen. She has served as an associate editor of *IEEE Transactions on Automatic Control* and several other control journals. Currently, she is on the editorial board of *International Journal of Robust and Nonlinear Control*. She has (co-)organized a number of conferences, among which the 1998 IFAC NOLCOS and the 2014 MTNS (as general cochair), and chaired the IPC of the 2015 IFAC LHMNLC workshop. Since 2017, she has served as vice-president of the European Control Association and vice-chair of the Publication Committee of the IFAC. Furthermore, in 2017, she began serving on the Board of Governors of the IEEE Control Systems Society (CSS). She has held visiting research positions at the Université de Compiegne, France, SUPELEC, Gif-sur-Yvette, France, the University of Tokyo, the University of Kyoto, Japan, and Old Dominion University. She has collaborated with a large number of companies and research institutions and is the coeditor of four books and has more than 250 book chapters, journal, and proceedings papers. Her research interests include nonlinear model reduction methods, realization theory, nonlinear control methods (particularly modeling and control of physical systems with applications to electrical circuits), electromechanical systems, and mechanical systems. For over eight years, her research interests focused on distributed (optimal) control methods for smart grid applications.

Ketan Savla is an assistant professor and John and Dorothy Shea Early Career Chair of Civil Engineering at the University of Southern California. He received the B.Tech. degree in mechanical engineering from the Indian Institute of Technology, Bombay, in 2003, the M.S. degree in mechanical engineering from the University of Illinois, Urbana-Champaign, in 2004, and the M.A. degree in applied mathematics and the Ph.D. degree in electrical engineering, both in 2007, from the University of California at

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Santa Barbara (UCSB). He was then a postdoctoral associate, followed by a research scientist in the Laboratory for Information and Decision Systems at the Massachusetts Institute of Technology until 2012, when he joined the faculty at the University of Southern California. He is currently an associate editor on the Conference Editorial Board of the IEEE CSS as well as *IEEE Transactions on Intelligent Transportation Systems* and *IEEE Control Systems Society Letters.* His honors include a Best Ph.D. Thesis Award from UCSB, the NSF CAREER, an IEEE CSS George S. Axelby Outstanding Paper Award, and the Donald P. Eckman Award of the American Automatic Control. His current research interests are in distributed robust and optimal control, dynamical networks, state-dependent queuing systems, and incentive design, with applications in civil infrastructure systems such as transportation, power, and autonomous systems.

**Jonathan P. How**

## JOHN S. BARAS

**Q. How did your education and early career lead to your interest in the control field?**

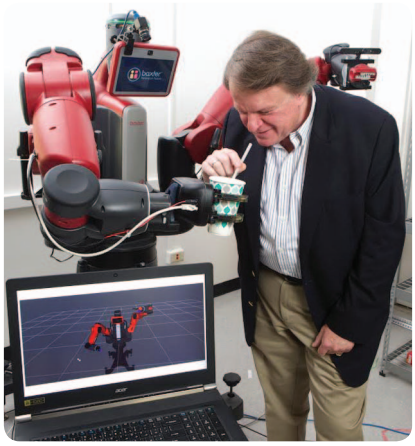
***John:*** Since my undergraduate years, I have been fascinated with the synthesis of engineering systems following a systematic workflow from an idea and specifications to physical realization. In those days (1965–1970), we were working on analog filter and feedback control synthesis following mostly frequency domain methods. The deep interconnections between mathematical models and analysis, abstractions, and the physics of implementation attracted me to analytical studies. When I came to the United States in 1970, I was debating whether to pursue a career in mathematics, physics, or engineering. The Harvard-Massachusetts Institute of Technology exceptional environment allowed me freedom of choice. Thanks to Roger Brockett, I was convinced that dynamical systems and control would be the best choice, and it has proven to be a most exciting and satisfying choice. Throughout my career, the significance of feedback and its ubiquitous presence in all aspects of engineering, biology, enterprises, life, and work have been reinforced. Handling uncertainties in models, data, and performance is tightly connected with feedback, and my focus shifted gradually to stochastic systems and control. I am continuously amazed by the new applications of these principles.

**Q. What are some of your research interests?**

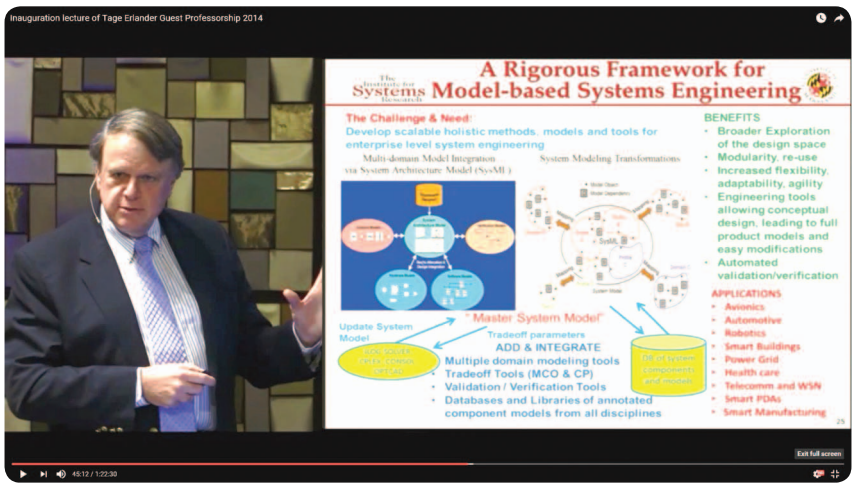
***John:*** My current research interests are as follows.

» Networked control systems, with and without humans, and the needed foundations of multiagent decision making, communications, and computing. I have developed a layered model with three interacting dynamic multigraphs (representing collaboration, information, and communication agent relations). Most fascinating is the need for noncommutative probability models due to the logical constraints in the event algebras. This has been an old interest of mine, recently reinforced by experimental evidence from human psychology and Internet interactive inference.

» Hybrid hardware (analog–digital) for signal processing and control modules. Systematic methods to design such hardware are lacking and needed, due to the emerging cyber-physical systems (CPS) and advances in artificial intelligence and machine learning. The resulting systems will involve various types of neural networks, and the associated mathematics



John Baras drinking coffee from a cup collaboratively served by a Baxter robot in the ARC Lab of the University of Maryland.




John delivering his Tage Erlanger Guest Professorship inaugural lecture, "Rigorous Framework for MBSE," at KTH. (See the lecture at https://www.youtube.com/watch?v=1Ubiue-nrCU.)

## Profile of John S. Baras

- *Current position:* professor, endowed Lockheed Martin Chair in Systems Engineering with a permanent joint appointment with the Institute for Systems Research and the Electrical and Computer Engineering Department, University of Maryland, College Park (UMCP); professor, Interdisciplinary Program in AMSSC; affiliate professor, Departments of Mechanical Engineering, Bioengineering (Fischell), and DOIT of the Robert H. Smith School of Business.
- *Visiting and research positions:* School of Electrical Engineering at the Royal Institute of Technology (KTH), Stockholm, Sweden, since January 2013; Stanford University; Harvard University; Massachusetts Institute of Technology; University of California, Berkeley; INRIA; KTH; TUM; Russian Academy of Sciences Steklov Institute of Mathematics and Institute of Control Sciences.
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- *IEEE Control Systems Society experience highlights:* associate editor, *IEEE Transactions on Automatic Control* (1980–1983); chair, Technical Committee on Stability, Nonlinear and Distributed Systems (1981–1983 and 1985–1987); member, Board of Governors (1981–1982 and 1990–1993), IEEE CSS Fellow Evaluation Committee (1988–1989), IEEE Fellow Evaluation Committee (1991–1995), IEEE Engineering R&D Committee (1986–1990), Technical Program Committee, and several IEEE Conferences on Decision and Control; chair, Ad-Hoc Committee on Control Systems Visibility (1989–1991).
- *Notable awards:* Life Fellow, IEEE; Fellow, Society for Industrial and Applied Mathematics, American Association for the Advancement of Science, International Federation of Automatic Control, and National Academy of Inventors (NAI); foreign member, Royal Swedish Academy of Engineering Sciences; 1980 IEEE George Axelby Award; 2006 IEEE Leonard Abraham Prize; 2014 Tage Erlander Guest Professorship from the Swedish Research Council; 2014–2017 Senior Hans Fischer Fellowship, Institute for Advanced Study, Technical University of Munich; UMCP A. J. Clark School of Engineering Innovation Hall of Fame, 2016; 2017 AACC Richard E. Bellman Control Heritage Award; 2017 IEEE Simon Ramo Medal.

will shed light toward the verifiable design of deep learning systems and "cortex on-a-chip" implementations.

» Future communication and sensor networks that are virtualized to provide on-demand networks with real-time adaptation to changing traffic demands. These are necessitated by the explosive increase in wireless connections and bandwidth demands. We are investigating extensions of software-defined networks to wireless (SDWN) as well as network function virtualization (NFV). These lead to networks as a service and novel architectures for networked CPS and human-CPS. SDWN/NFV are indispensable enablers for 5G, the Internet of Things, CPS, industrial Internet, Industry 4.0, smart cities, smart manufacturing, smart grids, and health care.

» Network security and trust. In the current and future networked immersed world, security and trust are of paramount importance. In this continuously evolving landscape, new attacks, threats, and defenses emerge. The newest type of threats and attacks we are investigating are outside the domain of traditional cryptography and security, as the control and inference algorithms are attacked (such as the Stuxnet worm). Consequently, these investigations are of critical importance for CPS and human-CPS. Key ideas we are pursuing are composable security, hardware-software security, models of trust and mistrust and their dynamics, and formal methods for verification.

» Rigorous model-based systems engineering (MBSE) methodologies and frameworks and associated tool suites. I have long advocated that systems and control scientists are best qualified to develop further MBSE (such as the design, manufacturing, implementation, and operation of complex systems). Past successes include the design of VLSI and aircraft (such as the Boeing 777 and 787). Biology provides the "existence proof." Today, MBSE is needed for all kinds of complex systems ranging from microelectromechanical systems and nanosystems, to automotive, networks, security, biology, healthcare, energy, enterprises, and social networks.

**Q. What courses do you teach relating to control? Do you have a favorite course? How would you describe your teaching style?**

***John:*** I teach courses on systems theory, optimal control, convex optimization, stochastic and adaptive control, nonlinear control, and hands-on MBSE. My favorite courses are hands-on MBSE and special topics such as quantum information and control, human-robot collaboration, and networked systems. My teaching style is informal and highly interactive.

**Q. What are some of the most promising opportunities you see in the control field?**

***John:*** As I already mentioned, these are multi-agent networked systems and associated decision making and inference, CPS and human-CPS, collaborative

John with his patents and honors for the conception, prototyping, and commercialization of Internet over satellite systems, services, and award-winning products.

autonomy, cognition and learning, MBSE, hybrid (analog/digital) hardware for control and signal processing, network security and trust, structural and parametric robustness, systems biology, and health-care management.

**Q. You are the coauthor or coeditor of four books. What topics do these books cover?**

***John:*** The book *Path Problems in Networks* (2010, with G. Theodorakopoulos) introduces partially ordered semi-ring models (like the Max-Plus algebra) for network trust, with practical applications. The edited volume (1990, with V. Mirelli) covers recent (at the time) advances in stochastic calculus and control. The other two edited volumes are the *Proceedings of the First* (2010) and *Second International Conference on Decision and Game Theory for Security* (2011).

**Q. What are some of your interests and activities outside of your professional career?**

***John:*** Volleyball, swimming, traveling, classical music, opera, ballet, Greek folk music and dancing, health-care and education national policies, physics of computation and natural computing Internet groups, lectures to high schools, and mentoring high-school students on STEM careers.

**Q. Thank you for your comments.**

***John:*** It was a pleasure to have this discussion. Thank you very much for the opportunity.

## JACQUELIEN M.A. SCHERPEN

**Q. How did your education and early career lead to your initial and continuing interest in the control field?**

***Jacquelien:*** During my undergraduate studies in applied mathematics at the University of Twente, my first encounter with the field was through the course Introduction to Mathematical Systems Theory. This course was very clear and appealing to me, partly because of the elegance of the mathematics behind it but also because of the clear interpretation related to the real world. Basic concepts like controllability and observability made a lot of sense to me. Afterward, the more advanced courses consolidated this. Furthermore, I was inspired by the vibrant atmosphere in the Systems and Control Group, which consisted of people like Huib Kwakernaak, Henk Nijmeijer, Arjan van der Schaft, Hans Zwart, and Jan Willem Polderman. My master's thesis advisor, Henk Nijmeijer, encouraged me to explore new subjects, and I worked on a thesis that was on the boundary of graph theory and control theory. Since I felt there was still so much more to learn and develop in the field, I decided to pursue a Ph.D. degree and postpone my decision for academia or industry.

Luckily, there was an opportunity to work on Ph.D. research under the supervision of Arjan van der Schaft. I started to work on model reduction based on balanced realizations for nonlinear systems, which did not yet exist. My Ph.D. work was embedded in the Dutch Institute of Systems and Control (DISC), and I pursued a number of high-level courses, increasing my enthusiasm about the field. Toward the end of my Ph.D. a similar process took place, and a feeling that there was still so much more to explore in the field resulted in a preference for an academic position. In combination with a "double career" issue, I was lucky that I found a postdoctoral research position at Delft in the Control Engineering and Circuits and Systems Groups of the Electrical Engineering Department, to work with Michel Verhaegen on the H-infinity control problem for linear time-varying systems. This topic was interesting and required quite a number of nontrivial steps. However, the outcome was less exciting, as it resulted in an expected characterization by two Riccati equations.

That year, I tried to become a member of the electrical engineering community in Delft, and I was at the right place when an assistant professor vacancy in the Control Engineering Group opened. Also, I received some visiting researcher opportunities with some influential people abroad, such as Romeo Ortega in France and Hidenori Kimura at the University of Tokyo in Japan. I learned to value applications and circuits more, and started to work on the passivity-based control of power converters, also

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