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5G: Fifth Generation Wireless Communications

This unclassified colloquium, sponsored by the Office of the Director of National Intelligence, will explore the architectures and technologies that will form the basis of the upcoming 5G system and how they will affect the U.S. and the world. We invite those unable to attend in person to watch the webcast of the event at <https://livestream.com/NASEM/events/8419008>.

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| 8:00 | Welcome
Christopher Boehnen, <i>Office of the Director of National Intelligence</i>
James Hinchman, <i>National Academies of Sciences, Engineering, and Medicine</i> |
| 8:15 | Overview of 5G and What It Will Enable
Andrea Goldsmith, <i>Stanford University</i> |
| 8:45 | 5G: The New Communication Fabric
Mikael Höök, <i>Ericsson</i> |
| 9:15 | Achieving Low Latency in Edge Cloud Enhanced 5G Systems
Dipankar Raychaudhuri, <i>Rutgers University</i> |
| 9:45 | Making Networks Slower: 5G and IoT
Henning Schulzrinne, <i>Columbia University</i> |
| 10:15 | Break |
| 10:30 | A New Wave of Applications Enabled by 5G
Sujit Dey, <i>University of California, San Diego</i> |
| 11:00 | New Value Creation in the 5G Era and Beyond
Marcus Weldon, <i>Bell Labs and Nokia</i> |
| 11:30 | Panel Session: Opportunities and Challenges of 5G
Moderator: Andrea Goldsmith, <i>Stanford University</i> |
| 12:20 | Closing Remarks
Andrea Goldsmith, <i>Stanford University</i> |



CHRISTOPHER BOEHNEN is the Deputy Assistant Director of National Intelligence for Transformation and Innovation at the Office of the Director of National Intelligence; he is also the Director of Science and Technology. Previously, he was a Senior Program Manager at the Intelligence Advanced Research Projects Activity focused on biometrics, computer vision, and machine learning. He was the Program Manager for the Odin, Janus, and BEST programs, 5 prize challenges, and numerous seedlings. He has served as joint faculty in the University of Tennessee's Department of Anthropology. Dr. Boehnen founded the Secure Computer Vision Team at Oak Ridge National Laboratory (ORNL). In his six years at ORNL, he served as Principal Investigator on 24 different projects which he conceived, proposed, and successfully executed. He is an inventor on 2 patents, authored over 25 different peer reviewed papers and received the ORNL Early Career Award for Engineering. Dr. Boehnen received his B.S., M.S. and Ph.D. from the University of Notre Dame's Computer Science and Engineering Department. He has been a member of the biometrics research community since 2001 when he began working on the Face Recognition Grand Challenge.



JAMES F. HINCHMAN is the Deputy Executive Officer of the National Academy of Sciences and Deputy Executive Officer and Chief Operating Officer of the National Research Council at the National Academies of Sciences, Engineering, and Medicine. He has been a member of the Academies staff since May of 1999 and was its General Counsel before assuming his current position. At the time of his appointment to the National Academies staff, Mr. Hinchman was the Principal Assistant Comptroller General in the U.S. General Accounting Office. Prior to joining GAO, Mr. Hinchman worked for 15 years in the executive branch of the federal government in positions of increasing responsibility. He was an Associate General Counsel in the Department of Agriculture, a Deputy Associate Director in the Office of Management and Budget, and Associate General Counsel of the former Department of Health, Education and Welfare, where he began his federal career in 1971. He is a member of the bar in Massachusetts and the District of Columbia.



ANDREA GOLDSMITH is the Stephen Harris Professor in the School of Engineering and a Professor of Electrical Engineering at Stanford University. Her research interests are in information theory and communication theory and their application to wireless communications and related fields. She founded and served as Chief Technical Officer of Plume WiFi (formerly Accelera, Inc.) and of Quantenna (QTNA), Inc. She has also held industry positions at Maxim Technologies, Memorylink Corporation, and AT&T Bell Laboratories. Dr. Goldsmith is a member of the National Academy of Engineering and the American Academy of Arts and Sciences, a Fellow of the IEEE and of Stanford, and has received several awards for her work.

She is the author of the book "Wireless Communications" and the co-author of the books "MIMO Wireless Communications" and "Principles of Cognitive Radio," all published by Cambridge University Press. She is also an inventor on 28 patents. She received her B.S., M.S. and Ph.D. degrees in Electrical Engineering from U.C. Berkeley.



MIKAEL HÖÖK joined Ericsson in 1994 and has held various positions targeting the research and standardization of 2G, 3G, 4G and now 5G. He is currently Research Area Director for Radio-research within Ericsson Research and is based in Kista, Stockholm. His responsibility covers research on air-interface design, advanced signal processing, multi-antenna systems, radio network performance and propagation. Results are fed into standardization, regulation and product development. His work addresses 5G technologies, LTE evolution and wireless backhaul. He received his M.Sc. degree in Electrical Engineering from the Royal Institute of Technology in Stockholm.



DIPANKAR RAYCHAUDHURI is Distinguished Professor for Electrical & Computer Engineering and Director for the Wireless Information Network Lab (WINLAB) at Rutgers University. As WINLAB's Director, he is responsible for an internationally recognized industry-university research center specializing in wireless technology. He is also Principal Investigator for several large U.S. National Science Foundation funded projects including the "ORBIT" wireless test-bed, the "MobilityFirst" future Internet architecture and the "COSMOS" Platforms for Advanced Wireless Research (PAWR) program. Dr. Raychaudhuri has previously held corporate R&D positions including: Chief Scientist, Iospan Wireless (2000-01), Assistant General Manager & Department Head, NEC Laboratories (1993-99) and Head, Broadband Communications, Sarnoff Corp (1990-92). He is a Fellow of the IEEE and the recipient of several professional awards including the Rutgers School of Engineering Faculty of the Year Award (2017), IEEE Donald J. Fink Award (2014), Indian Institute of Technology, Kharagpur, Distinguished Alumni Award (2012), and the Schwarzkopf Prize for Technological Innovation (2008).



HENNING SCHULZRINNE, Levi Professor of Computer Science at Columbia University, received his Ph.D. from the University of Massachusetts in Amherst, Massachusetts. He was an MTS at AT&T Bell Laboratories and an Associate Department Head at GMD-Fokus (Berlin) before joining the Computer Science and Electrical Engineering Departments at Columbia University. He served as the Chair of the Department of Computer Science from 2004 to 2009, as Engineering Fellow, and as Technology Advisor and Chief Technology Officer at the US Federal Communications Commission (FCC) from 2010 to 2017. He has published more than 250 journal and conference papers, and more than 70 Internet RFCs. Protocols co-developed by him, such as RTP, RTSP and SIP, are used by almost all Internet telephony and multimedia applications. He is a Fellow of the

ACM and IEEE, has received the New York City Mayor's Award for Excellence in Science and Technology, the VON Pioneer Award, the TCCC Service Award, the IEEE Internet Award, the IEEE Region 1 William Terry Award for Lifetime Distinguished Service to IEEE, the UMass Computer Science Outstanding Alumni recognition, and is a member of the Internet Hall of Fame.



SUJIT DEY is a Professor in the Department of Electrical and Computer Engineering, the Director of the Center for Wireless Communications, and the Director of the Institute for the Global Entrepreneur at University of California, San Diego. He heads the Mobile Systems Design Laboratory, developing innovative technologies in mobile cloud computing, adaptive multimedia and networking, green computing and communications, and predictive and prescriptive analytics to enable future applications in connected health, immersive multimedia, and smart transportation. In 2017, he was appointed as an Adjunct Professor, Rady School of Management, and the Jacobs Family Chair in Engineering Management Leadership. Dr. Dey served as the Faculty Director of the von Liebig Entrepreneurism Center from 2013-2015, and as the Chief Scientist, Mobile Networks, at Allot Communications from 2012-2013. Dr. Dey has co-authored more than 250 publica-

tions, and a book on low-power design. He holds 18 U.S. and 2 international patents, resulting in multiple technology licensing and commercialization.



MARCUS WELDON, President of Bell Labs and Corporate Chief Technology Officer, is responsible for coordinating the technical strategy across the company and driving technological and architectural innovations into the portfolio. He is considered to be one of the luminaries in the industry in terms of the clarity, depth and breadth of his vision. He combines his vision with the power of Bell Labs to create a unique innovation engine whose goal is to 'invent the future' of the networking and communications industry. In 1995, he joined the Physics Division at AT&T Bell Labs as a post-doctoral researcher, before becoming a Member of Technical Staff in the Optical Materials Division. He won a series of scientific and engineering society awards for his work on electronic and optical materials. He was selected as one of the Global Telecoms Business Power 100 of

the most influential people in ICT in 2014 and as one of their 'Top CTOs to watch in 2015.' He is the editor of the recent book "The Future X Network: A Bell Labs Perspective."





About the ICSB

This event is part of a colloquium series organized by the National Academies' Intelligence Community Studies Board (ICSB) and sponsored by the Office of the Director of National Intelligence (ODNI). Previous colloquium topics include Quantum Sensing and Communications, Computational Methods for Human Geography, and Artificial Intelligence. To suggest topics for future colloquia, please email us at icsb@nas.edu.

The ICSB serves as the convening authority for the discussion of science and technology issues of importance to ODNI. In coordination with ODNI and other agencies of the IC, the ICSB provides the governance structure for studies, workshops, colloquia, and expert meetings on science and technology topics of interest to the IC. The principal sponsor of the ICSB is the Director of S&T, ODNI; however, the intent is to make ICSB resources and publications available to all intelligence agencies. Learn more about the ICSB at nas.edu/icsb.

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