PSCR

Public Safety Broadband Stakeholder Meeting

AGENDA - DAY 1

Tuesday, July 9, 2019
The Westin Michigan Avenue Chicago

NIST

PLENARY WILL TAKE PLACE IN THE GREAT LAKES BALLROOM

#PSCR2019

7:00 – 8:00 AM ARRIVE AND CHECK-IN

8:00 – 9:00AM WELCOME AND OPENING REMARKS | **Walt Copan** - *Under Secretary of Commerce for Standards and Technology, NIST Director*
Keynote Speaker, Jonathan Lewin - *Bureau of Technical Services Chief at Chicago Police Department*

9:00 – 9:30AM PSCR PROGRAM OVERVIEW | **Dereck Orr** - *Division Chief, NIST PSCR*

9:30 – 10:00AM BREAK

10:00 – 10:45AM PSCR PORTFOLIO OVERVIEWS

10:45 – 11:30AM HAPTIC INTERFACES FOR PUBLIC SAFETY | **Scott Ledgerwood** - *NIST PSCR,* **Megan Waldock** - *Yet2*

11:30 – 1:00PM LUNCH BREAK *Please note that lunch will not be provided*

LEGEND

- Location-Based Services
- Security
- Resilient Systems
- Analytics
- Enhanced UI/UX
- Mission Critical Voice
- Open Innovation Session

Level of Technicality

- ●○○ Beginner
- ●●○ Intermediate
- ●●● Advanced

ONTARIO	HURON	GREAT LAKES AB	GREAT LAKES DE
1:00 – 1:30PM			
NIST Identity, Credential, and Access Management (ICAM) Workshop Outcomes: Bill Fisher, *NIST NCCoE* ●●○	**Evaluating Speech Analytic Technology Tasks in Simulated Public Safety Related Communications:** Fred Byers, *NIST* ●○○	**Indoor Mapping & Navigation Pilot - Improved First Responder Preplanning through Open Standards:** Bart De Lathouwer, *Open Geospatial Consortium* ●●○	**LMR Data Modeling for LTE:** Chris Dennis, *NIST* Don Bradshaw, *NIST* ●●○
1:35 – 2:20PM			
Current State of Mobile Application Security: Michael Ogata, *NIST ITL* ●●○	**Extensible Toolkit for Analytics in Public Safety:** Jason Corso and Brian Moore, *VOXEL 51* ●●○	**Point Cloud City:** Lan Wang, Eddie Jacobs, *City of Memphis Enfield Fire Dept.*, Joel Lawhead, *Hancock County, MS* ●●○	**Coverage, Capacity, & Resilience Enhancement in Limited Public Safety Networks:** Hyeong-Ah Choi and Amrinder Arora, *George Washington University and Miami University* ●●○
2:25 – 3:10PM			
Evaluating Voice and Hand Tracking in Virtual Reality and the Impact They Have on Users: Cole Sandau, Justin Mette, and John Dwyer, *Health Scholars* ●○○	**Accelerating Data-Driven Operations in the Fire Service:** Tyler Garner, *Prominent Edge LLC* ●○○	**Hyper-Reality Helmet with Multimodal Interfaces:** Yang Cai, *Carnegie Mellon University* ●●○	**Open Ecosystems in Public Safety Communications: Mission Critical Open Platform Lessons Learned and Future Steps:** Fidel Liberal, *University of the Basque Country,* Jani Lyrintzis, *BITTIUM,* Bartolo Scanavino, *ENENSYS/EXPWAY,* Harald Ludwig, *TCCA* ●●○
3:15 – 4:00PM			
Cognition-driven Display for Navigation Activities (Cog-DNA): Personalized Spatial Information System Based on Information Personality of Firefighters: Eric Jing Du, *University of Florida, Texas A&M,* Ryan Qi Wang, *Northeastern University,* Yingzi Lin, *Northeastern University,* Patrick Suermann, *Texas A&M University* ●●○	**Information-Driven Video Communication for Public Safety Networks:** Rui (April) Dai, *University of Cincinnati* ●●●	**Accelerating Adoption and Use of Emerging Location Based Services by Public Safety:** Paul Doherty, PhD and Jared Doke, *National Alliance for Public Safety GIS (NAPSG) Foundation* ●○○	**End-to-End Mission Critical Push-to-Talk – Pushing for the Future:** Robert Escalle, *Sonim* Jose Oscar Fajardo, *Nemergent Solutions* ●●○
4:05 – 5:30PM			
DEMOS **LOCATION:** ERIE AND MICHIGAN BALLROOM			**Bridging Non-ISSI LMR and LTE Mission Critical Push-To-Talk:** Chris Walton, *NIST,* Don Bradshaw, *NIST* *** This sessions ends at 4:35PM*** ●●○

PSCR

Public Safety Broadband Stakeholder Meeting

AGENDA - DAY 2

Wednesday, July 10, 2019
The Westin Michigan Avenue Chicago

NIST

PLENARY WILL TAKE PLACE IN THE GREAT LAKES BALLROOM

#PSCR2019

LEGEND

- Location-Based Services
- Security
- Resilient Systems
- Analytics
- Enhanced UI/UX
- Mission Critical Voice
- Open Innovation Session

Level of Technicality

- ●○○ Beginner
- ●●○ Intermediate
- ●●● Advanced

8:00 – 9:00AM — **WELCOME & KEYNOTE ADDRESS**
Ed Horowitz - *FirstNet Board Chairman*

9:00-10:00AM — **TECH TO PROTECT: DESIGNING APPS THAT FURTHER THE MISSION OF EMERGENCY RESPONDERS | Craig Connelly** - *NIST PSCR*

10:00-10:45AM — **BREAK** *DEMOS OPEN & LOCATED IN ERIE & MICHIGAN BALLROOM

	ONTARIO	HURON	GREAT LAKES AB	GREAT LAKES DE
10:45-11:30AM	**Improving the Security and Authentication Features on First Responders' Mobile Devices:** John Beltz, *NIST PSCR,* Mike Bartock, *NIST ITL,* Sarah Hughes, *NIST PSCR,* Bill Fisher, *NIST NCCoE,* Santosh Rajvaidya, *Nok Nok Labs* ●●○	**Body-Worn Camera Analytics:** Jason J. Corso, *University of Michigan* ●●●	**Ultimate Navigation Chip – Chip-Scale Personal Navigation System Integrating Deterministic Localization and Probabilistic Signals of Opportunities:** Andrei M. Shkel and Zak Kassas, *University of California Irvine* ●●○	**Propagation Channel Models & System Performance:** Andreas Molisch and Hussein Hammoud, *University of Southern California* ●●○
11:30-1:00PM	**LUNCH BREAK** *Please note that lunch will not be provided*			
1:00-1:45PM	**Securing First Responder Mobile and Wearable Devices – Going Beyond the Public Safety Use Case:** Gema Howell, *NIST ITL*, Michael Ogata, *NIST ITL* ●●○	**Imagine a World Where Data Is Shared Safely:** Terese Manley, *NIST,* Christine Task, *Knexus Research Corporation,* Challenge Winners, Community First Responder ●○○	**An Infrastructure-Free Localization System for Firefighters:** Anthony Rowe, *Carnegie Mellon University* ●●○	**Enabling Service Continuity Using UE-to-Network Relays:** Richard Rouil, David Griffith, *NIST* ●●●
1:50-2:35PM	**Security Standards Influence Public Safety Communication:** Mike Dolan, *First Responder Network Authority,* Jeff Cichonski, *NIST ITL,* Adam Lewis, *Motorola,* Bill Fisher, *NIST NCCoE* ●●○	**Video and Imagery Dataset to Drive Public Safety Capabilities:** Andrew Weinert, *MIT Lincoln Laboratory in partner with New Jersey Office of Homeland Security and Preparedness* ●○○	**Robust First Responder Tracking and Mapping with Thermal, Inertial, and Radar Sensing:** Jamie Cousins, *HFRS,* Dr. Pedro Porto Buarque de Gusmao, Dr. Johan Wahlstrom, Niki Trigoni and Andrew Markham, *University of Oxford* ●●○	**Improving ProSe Off-Network Coverage:** Dan Ericson, *Harris* ●●○
2:40-3:25PM	**Towards the Development of a VR-Based Emergency Response Scenario and Intelligent User Interface:** Randall Spain, *North Carolina State University,* Donia Slack, *RTI International* ●●○	**Cognitive Mobile Edge Computing: Video Analytics Use Case:** Zongru (Doris) Shao, *Spectronn* ●○○	**First Responder 3D Mapping and Location:** Jeff Kunst, *TRX, Inc.* Matt Herbert, *Battalion Chief, Arlington County* ●●○	**Public Safety Communications Above Six GHz – Challenges and Opportunities:** Marco Mezzavilla, *New York University* ●●○
3:30-4:15PM	**FirstSimVR: Evaluating Future Tools Using Today's VR:** Jason Jerald, Jason Haskins, Charles Laird, and Blake Boyd, *NextGen Interactions* ●●○	**Next Generation First Responder Deployables and Internet of Things (IoT) Technology:** Sam Ray, Alison Kahn, Max Maurice, Hien Nguyen, *NIST* ●○○	**Decimeter Accurate, Long Range Non-Line-of-Sight RF Wireless Localization Solution for Public Safety Applications:** Hun-Seok Kim, *University of Michigan* ●●○	**Mission Critical Voice Quality of Experience Measurement Methods:** Tim Thompson, *NIST PSCR* ●●○
4:20-5:30PM	**DEMOS** **LOCATION:** ERIE AND MICHIGAN BALLROOM			

PSCR

Public Safety Broadband Stakeholder Meeting

AGENDA - DAY 3

Thursday, July 11, 2019
The Westin Michigan Avenue Chicago

NIST

PLENARY WILL TAKE PLACE IN THE GREAT LAKES BALLROOM

#PSCR2019

LEGEND

- Location-Based Services
- Security
- Resilient Systems
- Analytics
- Enhanced UI/UX
- Mission Critical Voice

Level of Technicality:
- ●○○ Beginner
- ●●○ Intermediate
- ●●● Advanced

Open Innovation Session

8:00-9:00AM — **WELCOME AND FIRESIDE CHAT**
Paul Steinberg - *Senior Vice President and Chief Technology Officer for Motorola Solutions*

9:00 – 9:45AM — **BREAK** *DEMOS OPEN & LOCATED IN ERIE & MICHIGAN BALLROOM

	ONTARIO	HURON	GREAT LAKES AB	GREAT LAKES DE
9:45-10:30AM	**Demonstration of the Wildland-Fire Data Logistics Network (WDNL):** Nancy French, *Michigan Tech Research Institute*, Ezra Kissel and Martin Swany, *Indiana University*, Micah Beck, *University of Tennessee* ●●○	**Developing Real-Time Analytics to Improve Outcomes:** David Blankinship, *Interra* David Van Ballegooijen, *Western Fire Chiefs* ●○○	**First Responder Indoor Location using LTE Direct Mode Communications Signal:** H. Howard Fan, *University of Cincinnati* ●●○	**Modeling and Improving Device-to-Device Direct Discovery:** Collin Brady, *University of Washington* ●●○
10:35-11:35AM	**7000+ First Responders Have Something to Say: Are We Answering the Call?:** Kristen Greene, Mary Theofanos, Yee-Yin Choong, Sandra Spickard Prettyman, Pamela Konkol, *NIST* ●○○	**Demonstrating the Power of Collaboration to Solve Video Analytics Challenges in Baltimore Citiwatch:** John Garofolo, *NIST*, Major Samuel Hood, *Baltimore Citiwatch/ Baltimore PD,* Julie Stroup, *City of Houston,* Jason Corso, *VOXEL51,* James Horan, *NIST* ●●○	**Situational Awareness for Emergencies through Network Enabled Technologies (Safe-T-Net):** Professor Moe Z. Win, *Massachusetts Institute of Technology* ●●○	**Open-Source Simulation Platform for Public Safety:** Richard Rouil, *NIST,* Tom Henderson, *University of Washington,* Marco Mezzavilla, *New York University,* Michele Polese, *University of Padova* ●●○

11:35-1:00PM — **LUNCH BREAK** *Please note that lunch will not be provided*

1:00-1:45PM	**Emergency Edge Supercloud:** Robert Van Renesse, *Cornell University* ●●○	**Real-Time Video Analytics for Situation Awareness:** Junwei Liang and Salvador Medina, *Carnegie Mellon University* ●●○	**UWB Localization and Mapping Using Computational Imaging:** Fabio da Silva, *NIST* ●●●	**Recent Mission Critical Voice QoE Awarded Projects:** Brad Fain and Alessio Medda, *Georgia Tech Research Institute,* Henning Sculzrinne, *Columbia University* ●○○
1:50-2:35PM	**Requirement Analysis and Participatory Design of Next Generation Public Safety User Interfaces:** Regis Kopper & Jeronimo Grandi, *Duke Univ.* ●○○	**Towards Cognitive Assistant Systems for Emergency Response:** Sarah Masud Preum, *University of Virginia* ●●○	**Mobile Edge Services in 4G LTE:** Max Hollingsworth, *University of Colorado Boulder* ●●○	**Mission Critical Voice Quality of Experience Speech-Based Access Time Measurement:** Jaden Pieper, *NIST PSCR* ●●○
2:40-3:25PM	**Mixed Reality Training and Testing Facility for First Responders (VALOR):** John Blackwell, *Diamond Age Technology,* Patrick Hagan, *Houston Fire Department,* David Kortenkamp, *TRACLabs* ●○○	**Public Safety Video, Analytics, and Workflow to Enable the End User - Lessons Learned:** Shishir Shah, *University of Houston,* Julie Stroup, *City of Houston* ●●○	**ReDiCom: Resilient Communications for Dynamic First Responder Teams in Disaster Management:** Dr. K.K. Ramakrishnan, *University of California Riverside,* Dr. Murat Yuksel, *University of Central Florida,* Dr. Hulya Seferoglu, *University of Illinois at Chicago,* Dr. Jiachen Chen, *WINLAB, Rutgers University* ●●○	**OpenFirst – The Open-Source LTE Platform for First Responders:** Paul Sutton, *Software Radio Systems* ●●○
3:30-4:15PM	**Augmented Reality Testing of Equipment in Multiple Immersive Simulations (ARTEMIS):** Brad Fain, Sarah Farmer, and Nicole Kosoris, *Georgia Tech Research Institute* ●●○	**SAFE-NET: A Computing Platform for Public Safety Applications:** Khaled Abdelghany and Barbara Minsker, *Southern Methodist University*, May Yuan, *University of Texas at Dallas* ●●○	**DistressNet-NG: A Resilient Broadband Communication & Edge Computing Infrastructure for FirstNet:** Radu Stoleru, *Texas A&M Engineering Experiment Station,* Harsha Chenji, *Ohio University* ●●○	**Device-to-Device System for Public Safety (DDPS):** Richard Lau, Stephanie Demers, Eric Beck, Heechang Kim, *Perspecta Labs* ●●○
4:20-5:30PM	**DEMOS** **LOCATION:** ERIE AND MICHIGAN BALLROOM			**Evaluating Multicast Capability in LTE Public Safety Networks:** Chunmei Liu, *NIST* ***This sessions ends at 5:05PM*** ●●●

SESSION DESCRIPTIONS

Haptic Interfaces for Public Safety

NIST

Come learn about NIST PSCR's ongoing Haptic Interfaces for Public Safety Challenge. This challenge is assessing the relevancy of haptic interfaces for first responder tasks. Contestants are developing and testing prototypes in PSCR virtual scenarios for evaluation by conference attendees. Contestants will then update their solutions based on feedback and enter a final prototype in a live firefighter navigation course.

NIST Identity, Credential, and Access Management (ICAM) Workshop Outcomes

NIST

In April 2019 the NIST Public Safety Communications Research (PSCR) Division and the National Cyber Security Center of Excellence (NCCoE) held a workshop with senior executive public safety officials and industry subject matter experts to discuss public safety cybersecurity challenges, specifically identity, credential and access management (ICAM) for public safety personnel and systems. Detailed outcomes from this meeting can be found in the corresponding NIST interagency report. This talk will give an overview of the topics discussed during the meeting to include feedback from public safety senior executives, challenges to implementing ICAM strategies for public safety, and ways in which NIST intends to move forward helping public safety communities with this challenge.

Evaluating Speech Analytic Technology Tasks in Simulated Public Safety Related Communications

NIST

This speech analytic technology study focuses on the impact of loud background noises and state of urgency in speech relating to public safety communications. With advances in assistive technologies in first responder communications, speech analytic technologies are challenged not only with loud background noises but also changes in speech during loud background noises. The Lombard effect is an involuntary response when communicating in loud background noises that raises the level of vocal effort and can change pitch and annunciation in speech. The feeling of urgency can also impact speech. These speech conditions can be present for first responders at the most critical time during an emergency event and combined with the loud background can be extremely challenging for communications to be processed completely or accurately by speech processing technologies.

The DHS has sponsored an effort through the PSCR to create an audio dataset and to test and evaluate state of the art speech analytic systems with the challenging conditions mentioned above. Come hear about the process to create this dataset and future applications of the study.

Indoor Mapping & Navigation Pilot - Improved First Responder Preplanning through Open Standards: Open Geospatial Consortium

In this session, we describe a two-stage process for first responders conducting routine preplanning activities. In the first stage, preplanners survey building interiors using LiDAR and 360-degree camera imagery, coupled with advanced

software processing, to generate 3D point clouds and additional information. In the second stage, the first responders view generated datasets conforming to the Open Geospatial Consortium (OGC) CityGML and IndoorGML Standards and enhanced with symbology from the National Alliance for Public Safety GIS (NASG). Navigation routes are then overlaid onto these views, assisting in the preplanning of building navigation routes.

From a technology point of view, this session will highlight the use of open standards for encoding, models and processing services to achieve interoperability - helping avoid vendor lock-in and reducing information sharing costs.

LMR Data Modeling for LTE

NIST

This session includes a brief description of the PSCR Geolocation Sensor System, including LMR data to be obtained. Following, attendees will hear a detailed description of PSCR's plan to create data models for use with LTE infrastructure, as well as device-to-device, mission critical voice application development.

Current State of Mobile Application Security

NIST

Mobile App security directly impact the day to day operations of public safety. This round table discussion will explore the current state of the art in mobile app vulnerabilities and the tools being used to find and repair them. It is based on the report from Michael Ogata on SATE, which explored the capabilities, reliability, and interoperability between different application security vetting tools. This panel invites several of the vendors that participated in the testing to provide their perspective, including public safety specific focus, and what could be done to improve the current state.

Extensible Toolkit for Analytics in Public Safety: Voxel51

This project implements the foundational platform for an open ecosystem of innovation around large-scale video analytics for public safety. Learn about its current public deployment and pilot in a number of public safety applications.

Point Cloud City: City of Memphis, Enfield Fire Dept., Hancock County

Indoor mapping is the next big frontier for the geospatial field. Lack of adequate indoor maps is a well-documented public safety issue reasserted with each building fire, earthquake, mass shooting, and other tragedies. While technology exists capable of mapping buildings, very few standards and best practices are available to create reliable, affordable, and consistent indoor maps. Come listen to the three award recipients tasked with addressing point cloud indoor mapping.

The Point Cloud City Hancock County, Mississippi grant project allows public safety and geospatial subject matter experts to work hand in hand with federal oversight to further develop approaches which improve indoor mapping techniques and datasets in the US to make them more common. Because Hancock County is a rural area, any approach used here should be applicable nationwide.

In the collaboration between the City of Memphis and the University of Memphis, we survey nine facilities with 1.86 million square feet of indoor space to produce annotated 3D point cloud models. With accurate building models and detailed annotations, first responders and building occupants can navigate safely during emergency operations.

Moreover, we will share our data with various public stakeholders through the City's open data platform (data.memphistn.gov) and open two buildings for additional evaluation activities beyond the project period. The data and buildings will help other researchers perform research in autonomous indoor navigation.

Coverage, Capacity, & Resilience Enhancement in Limited Public Safety Networks: George Washington University and Miami University

The next few years form a critical stage in the evolution of broadband PSNs; we anticipate that key PSN related issues including coverage and capacity extension methods, support for end-to-end QPP, failure resilience, and multicast will be fully standardized (reach final and stable version) only after this time, given the current lack of fully-compliant chips and interoperability tests in some aspects. We have already obtained a number of important results that can inform and impact handling of MCV, MCPTT, general QPP support, as well as general coverage enhancement, and reconfiguration methods in future PSN networks. In particular, our pioneering study on the analysis of potential spectrum savings and improving FR communications by using MBSFN and our results on optimal selection of channel parameters for PSN applications in

LTE Direct are useful for MCV, MCPTT and general QPP support. Our work on FR trajectory-based mobile BS placement is important for general coverage enhancement and reconfiguration, and useful to the first responder communications and operations. Several articles are already published from the results of this research, and additional articles are expected to be submitted.

Evaluating Voice and Hand Tracking in Virtual Reality and the Impact They Have on Users: Health Scholars, Inc.

The presentation will review multiple different user interfaces in virtual reality ("VR") for public safety. Key user interfaces reviewed will include: wand controllers, gloves and voice. The presenters will cover the benefits and challenges associated with each interface and the use cases that are most appropriate for the user interface. The presentation will also explore how the selection of user interfaces impacts user experience, matching to reality and cognitive load. Examples will be shown to drive meaningful discussions with the audience.

Our research enables more appropriate decision-making on the selection of the user interface to the VR experience design goals. This allows for better overall design of training applications and better cost/performance trade-off decisions for first responders.

Accelerating Data-Driven Operations in the Fire Service: Prominent Edge

Transitioning fire departments into data-driven organizations is critical to improving public safety. This session will address barriers that departments face when making this transition and how our team has accelerated this process for departments across the country. Our research has seen the following impacts:

Improves Public Safety Response Times -- We have heard from multiple fire departments that our tools have significantly improved response times by as much as 30 seconds.

Improves Firefighter Safety -- Our research can alert department leaders to the units that are at a higher risk of experiencing negative health impacts from the job. For example, we alert departments when units are committed to emergency incidents for longer than 3 hours during the night time hours. This allows decision makers to mitigate the impact of sleep deprivation by moving those personnel to slower units during subsequent shifts.

Hyper-Reality Helmet with Multimodal Interfaces: Carnegie Mellon

The hyper-reality helmet is designed to provide on-demand information on a heads-up display for first responders to work in indoor and hazardous environments where GPS signal is not available and visibility is poor. In this session, we present our second generation helmet with multimodal interfaces, including sensors, pre-incident planning maps, stereo vision, and voices. Our experiments showed the importance of pre-incident planning and sensory fusion in the real-world problem-solving. This research has impacts on advancing the technology for pre-incident planning, firefighting, emergency medicine, and other first responding and risk management missions. It also affects future research initiatives in emergency medicine, robotic rescue and recovery, and smart city technologies.

Open Ecosystems in Public Safety Communications: Mission Critical Open Platform Lessons Learned and Future Steps: University of the Basque County

The Mission Critical Open Platform was launched to reduce the entry barriers that different stakeholders (device manufacturers, application developers and integrators) face in order to develop and test innovative MCPTT apps. The MCOP approach comprises the use of fully 3GPP standardized interfaces and the definition of northbound and southbound APIs in the devices. Additionally, in order to test the proposed architecture fully functional MCPTT Open Source SDK and app have been released. In this session the outcomes of the MCOP initial 2 year project will be described, together with an analysis of the identified challenges, lessons learned and future plans for the Mission Critical Open Platform growing community.

Cognition-Driven Display for Navigation Activities (Cog-DNA): Personalized Spatial Information System Based on Information Personality of Firefighters: Texas A&M

This session will introduce a cognition-driven, personalized information system for emergency indoor wayfinding. It addresses the emerging yet critical challenge in emergency response: information overload. On one hand, as modern buildings become more spatially complex and are equipped with new sensing and information systems, firefighters can be exposed to huge volumes of information in the line of duty. On the other hand, these first responders have only

limited capacity for information processing. Aimed to solve this conflict, this research employs the latest neuroimaging technologies (brain sensing) to monitor a firefighter's cognitive status in real time, providing the basis to adjust the contents and format of wayfinding information and consequently control the level of the cognitive load. The system also captures and track "information personality", i.e. the firefighters' preferences to different types of information. To achieve these goals, the research integrates the latest developments in visualization (e.g., virtual reality), building science, neuroscience and information technologies. Ultimately, the research paves a path to develop individualized intelligent and adaptive systems for firefighters.

Information-Driven Video Communication for Public Safety Networks: University of Cincinnati

Networked video surveillance systems are indispensable components in today's public safety infrastructure. The situational awareness of public safety professionals could be greatly improved if they receive high quality video observations along with their analytics results in real time. Overall, the proposed research targets at evaluating the quality of information (QoI) for public safety videos and designing QoI-based sensing, compression, and communication solutions. More specifically, the outcomes from the first two years of this project could impact the design of video sensing and compression solutions, offering new ways for improving the quality of videos for analytics tasks and fostering future research initiatives in this area.

Accelerating Adoption and Use of Emerging Location Based Services by Public Safety: National Alliance for Public Safety GIS Foundation

Mapping, tracking, and navigating indoors is one of the greatest challenges facing first responder safety today. Now more than ever, responders need Location-Based Services (LBS) solutions to provide better situational awareness indoors, equipping them with necessary capabilities to operate effectively while maximizing responder and citizen safety. Even though this technology is becoming more readily available, it has yet to be widely adopted by the first responder community. Through the Accelerating Adoption and Use of Emerging LBS by Public Safety project, the National Alliance for Public Safety GIS (NAPSG) Foundation would like to identify innovators and early adopters who are exploring LBS solutions to solve operational problems and work with them to collect and document best practices; share success stories with the broader public safety community; provide outreach and education about best practices to first responders; and actively engage in ongoing dialogue with stakeholders to understand and document their evolving needs. At this session, we will launch the Map of LBS Innovators as a hands-on exercise, which will guide the direction of the project.

End-to-End Mission Critical Push-to-Talk -- Pushing for the Future: Sonim

The session will start by covering mission critical push-to-talk (MCPTT) and mission critical services (MCS) basis in order to explain the complexity of achieving an end-to-end (e2e) integration according to 3GPP standard definition. In this regard, the presentation will describe the importance of having both mission critical QCI support and eMBMS support in the e2e chain with XP8 Sonim devices and Nemergent Solutions' MCPTT/MCS products.

The session will also highlight the adaptation of the MCS client application to the defined northbound interface (MUOAPI-GUI agnostic-) and southbound interface (IAPI-device agnostic-) by the NIST project Mission Critical Open Platform (MCOP). In this regard, the MCS client supports the above mentioned interfaces, expanding them in order to handle Rel14 MCS MCVideo and MCData communication types. Besides, the project will show its clear advocacy toward the fulfillment of standard key performance indicators (KPI), having thoroughly work on audio quality and mouth-to-ear delay (KPI3) as the most constrained one due to the implication of every component in the communication (e.g. device firmware, audio loopback delay, operating system, MCPTT/MCS app, LTE delay and MCPTT/MCS application server).

Finally, the session will also serve to illustrate the different activities carried out with first-responders and researchers with the clear focus of improving the user experience and as enablers of fully 3GPP-compliant MCPTT/MCS technology for new adopters and researchers. Thus, covering the project experience with Fairfax and Atlantic City first-responders, the deployment of an end-to-end MCPTT/MCS testing facility in Boulder lab and the involvement of new components so as to play the gateway role between the 3GPP compliant solution and legacy networks.

Bridging Non-ISSI LMR and LTE Mission Critical Push-to-Talk

NIST

Panelists will discuss the importance of improving technology to allow the bridging of non-ISSI LMR push to talk systems

(analog and legacy P25 and other digital) into 3GPP LTE mission critical push to talk solutions. Discussion topics will include affordable, open source, standards-based solutions to allow interworking between non-ISSI systems and LTE and PSCR's current research project and long term projects in this area.

Tech to Protect: Designing Apps that Further the Mission of Emergency Responders

NIST

A mobile first, always-connected first responder is possible today using smartphone technology. See the possibilities & hear about a unique PSCR led effort to develop apps to support the unique missions of first responders. Learn how you can participate and provide input.

Improving the Security and Authentication Features on First Responders' Mobile Devices

NIST

The SIM card, already used in every mobile device, has characteristics that make it a robust storage device for critical mobile subscriber data. The SIM card is a tamper-resistant hardware storage container and, if utilized as a credential storage container, it would enable applications to use authentication credentials provisioned to it seamlessly. It offers several usability benefits for public safety, as it would be more user friendly; allow networks to provision credentials over-the-air via a secure channel; and potentially enable device sharing by keeping sensitive information on the removable SIM card. Additionally, as the SIM card is currently used in every mobile device, it would offer cost savings for public safety units as extra hardware would not be necessary. Come learn more about this concept and the PSCR Prize Challenge, Expanding the SIM Card Use for Public Safety, posed to solve it.

Body-Worn Camera Analytics: University of Michigan

This research advances knowledge on how to model body-worn camera video for use with state of the art deep learning based computer vision video analytics. It will allow body-worn camera to be better leveraged operationally in public safety.

Ultimate Navigation Chip -- Chip-Scale Personal Navigation System Integrating Deterministic Localization and Probabilistic Signals of Opportunities: University of California, Irvine

This brief is on development of the Ultimate Navigation Chip (uNavChip) concept. Our project develops a Chip-Scale Personal Navigation System to localize emergency responders, assets and people indoors and in covered outdoor environments, where GPS signals are unusable. We will talk about the Micro-Electro-Mechanical Systems (MEMS) technology that we are developing within this project, groups' latest analytical and modeling results, and in-field test and evaluation. Our technical approach is based on simultaneous integration of Deterministic, Probabilistic, and Cooperative Localization. The Deterministic Navigation is based on foot-mounted sensors and motion models providing zero-velocity updates, constituting a unique, self-contained and high accuracy dead reckoning capability. Signals of Opportunity are turned into our own "dedicated pseudolites" for position fixing and augmentation. We are investigating cellular signals (CDMA & LTE), Digital TV, and WiFi, and exploring the availability of signals within building infrastructure. Cooperative Localization is utilized by a team of mobile agents equipped with the uNavChip, with communication and computational capabilities, jointly processing a relative measurement between any two agents leading to increase in localization accuracy.

Propagation Channel Models & System Performance: University of Southern California

The next generation of emergency responder systems will be based on LTE, as the use of commercial off-the-shelf components will lead to a dramatic decrease in cost. However, since PSOs (Public Safety Organizations) often need to operate in areas where there is no cellular infrastructure (either by design, or because the infrastructure is nonoperative after a natural disaster), it is essential that DMO (Direct Mode Operation), also known as Device-to-Device (D2D) communication is fully operational and reliable. At the current time, the D2D mode of LTE is still under development, and no proper testing has been done yet.

A key requirement is testing in realistic channels; it is not sufficient to analyze performance with the 3GPP (or similar) channel models, as those are intended to compare different systems, not to evaluate absolute performance and reliability.

The key goal of this project is thus to perform extensive measurement campaigns for D2D channels, in particular concentrating on channels that are most important for PSOs, namely (i) channels for vehicle-to-vehicle (V2V)

communications, including convoys, and (ii) indoor-to-outdoor (I2O) channels, where one mobile device is outdoors at street level, and the other indoors, possibly at a higher floor. For those scenarios, existing measurements are missing critical components such as (i) sufficient number of measurements to provide statistical viability, (ii) directional channel characteristics (which are needed to evaluate multi-antenna terminals), and (iii) evolution of channel characteristics when the device moves on a trajectory.

Securing First Responder Mobile and Wearable Devices: Going Beyond the Public Safety Use Case

NIST

NIST Interagency Report (IR) 8196 Security Analysis of First Responder Mobile and Wearable Devices, analyzes the needs of public safety mobile devices and wearables from a cybersecurity perspective. The analysis primarily focuses on the security needs of first responders (i.e., fire service, emergency medical service (EMS), and law enforcement). NISTIR 8196 identifies the security objectives that should be taken into consideration when selecting and developing secure mobile and wearable devices for public safety. Utilizing the security objectives, PSCR engineers performed a security analysis of the current state of mobile and wearable devices. This presentation describes the best practices and guidance provided in NISTIR 8235 Security Guidance for First Responder Mobile and Wearable devices. This guidance provides recommendations of the security capabilities that should be included in first responder mobile and wearable devices. This presentation will also identify the current capabilities of mobile and wearable devices and identify any gaps in the security capabilities necessary to meet the needs of first responders.

Imagine a World Where Data Privacy is Shared Safely

NIST

As first responders utilize more advanced communications technology, there are opportunities to share data amongst public safety agencies and help to inform decision-making while increasing safety.Imagine a world where datasets were shared amongst organizations freely because the data is safe and sanitized from personal or private information. If public safety agencies operated in this environment of de-identified datasets, would that translate into faster response time, better incident predictions and saving more lives? PSCR is evaluating the use of a mathematical technique called Differential Privacy to better understand the problem of de-identifying datasets by removing personally identifiable information (PII) without risk of re-identifying the personal data. It is a rapidly growing field in computer science and being explored by NIST PSCR for use in public safety operations and the research community at-large.

An Infrastructure-Free Localization System for Firefighters: Carnegie Mellon

This talk will discuss our work on developing a rapidly deployable infrastructure-free localization system to track first-responders inside potentially harsh environments. Our goal is to provide team members outside of the facility (like fire safety chiefs) a live feed on a tablet or computer a read-out with the position of each crew member. Given the hostile nature of burning structures and the time criticality of missions, this requires that a system can track firefighters without any pre-installed internal and limited external infrastructure, and without assuming knowledge of the structure's layout. For a system to be practically adopted at scale, it also needs to be low-cost and extremely simple to configure and deploy. We show how the combination of sensor fusion and advances in RF ranging technology can be used to provide accurate tracking from a body-worn telemetry package no more sophisticated or expensive than a modern mobile phone.

Enabling Service Continuity Using UE-to-Network Relays

NIST

First responders may experience loss of connectivity when going inside buildings or moving away from the cell towers. While LTE Proximity Services (ProSe) allows for off-network communication between out of coverage devices, the UE-to-Network relay capability allows a device to stay connected to the network by attaching to another device. In this presentation, we discuss several performance metrics related to the discovery, attachment, and overhead associated with the UE-to-Network capability.

Security Standards Influence Public Safety Communication

NIST

With all the technology advances taking place in public safety communications, from the incredible capabilities of

public safety broadband networks to the transition to 5G, ensuring the security of all of these new services is extremely challenging. One important way we advocate for security is through standards. This panel will discuss the latest security challenges and how standards are rapidly evolving to meet those challenges. Topics will include updates on the 3GPP SA3 standards for 5G and MCV and authentication and access control protocols playing a huge role in application security. This panel has a forward-looking focus and will include topics of great interest to our stakeholders:

- Enhanced authentication with FIDO 2.0, Oauth, Open ID Connect
- Fast pace of IoT and the rush to implement standards
- 5G privacy, encryption, and security transparency
- Role of traditional IT standards bodies like IETF, IEEE, etc.

Video and Imagery Dataset to Drive Public Safety Capabilities: MIT Lincoln Lab in partner with New Jersey Office of Homeland Security and Preparedness

Video applications and analytics are routinely projected as a stressing and significant service of the Nationwide Public Safety Broadband Network. As part of a NIST PSCR funded effort, the New Jersey Office of Homeland Security and Preparedness and MIT Lincoln Laboratory have been developing a computer vision dataset of operational and representative public safety scenarios. This dataset will enable the technology development tailored to public safety scenarios. Informed by public safety outreach, the dataset includes images from all fifty state of the United States. It includes operational images and videos from the Civil Air Patrol (CAP), the Defense Visual Information Distribution Service (DVIDS), Massachusetts Task Force One(MA-TF1), Unmanned Robotics Systems Analysis (URSA),and the United States Geological Survey (USGS). Representative content was largely complied from Creative Commons video hosted on YouTube. A small quantity of non-Creative Commons content was obtained with the permission of the content's owners. We also, along with our collaborators, generated over thirty hours of video representative of some public safety scenarios. Lastly, the scale and scope of this dataset necessitates a hierarchical organization approach for efficient compute and storage. In total, there are millions of labeled public safety operational and representative images and key video frames.

Robust First Responder, Tracking and Mapping with Thermal, Inertial, and Radar Sensing: Oxford

Accurate and robust tracking and mapping of first responders is key to improved situational awareness, efficiency and enhanced safety. Conventional positioning techniques e.g. based on GPS, do not work in complex indoor environments. Through the NIST-funded IPSER project, the University of Oxford and its first responder partners have been working towards tackling this problem, using a combination of novel sensor modalities and algorithmic innovations e.g. deep learning. We have identified three modalities which are particularly robust to the challenges faced in dark, smoke-filled indoor environments, namely, thermal imaging, inertial tracking and millimeter-wave radar. Thermal imaging is widely used already by first responders to see through dense smoke and identify key details. In this work, we seek to use the thermal imaging stream to provide accurate tracking, similar to visual odometry. Inertial tracking measures accelerations of moving objects e.g. a person's foot, and then uses this to determine a relative trajectory. We have made a number of innovations in this area to make it more robust,

especially to the unique motions and behaviours of first responders (e.g. foot sweeping, right-hand search). Lastly, we have started using single-chip mmWave radar sensors which are able to penetrate smoke and operate in complete darkness to provide a sparse depth image of a scene. Combining these data together, we show progress towards providing accurate and robust tracking and mapping. We present results from simulated and real fire trials.

Improving ProSe Off-Network Coverage: Harris

ProSe off network capabilities were developed to replace and enhance the capabilities of LMR Talkaround. Current ProSe standards fail to match the range capabilities of LMR direct communications. V2X standards that have further developed direct communication capabilities generally have use cases were message priority lessens with distance. Braking due to road hazards would be an obvious example. By contrast isolated worker scenarios have priorities that depend on the nature of the communications rather than distance. New work in direct communications may be taken up in 5G. This work should include the capability to extend coverage when relays and networks are not available. The presentation explores various approaches for extending range in uncongested environments.

Towards the Development of a VR-Based Emergency Response Scenario and Intelligent User Interface: North

Carolina State University

Heads-up displays can deliver critical information to first responders. For example, they can provide firefighters with information about oxygen tank levels, temperature, and way points, all at a glance. However, as data becomes increasingly available through these displays, they pose a significant challenge: how can interface designers ensure that first responders receive the right information, in the right format, and at the right time? Further, designers must also ensure that first responders can use these interfaces efficiently and effectively in a broad range of environments. The objective of this project is to address this question by examining the effect of intelligent user interfaces on first responder performance in a fully immersive VR-based emergency response scenario. Intelligent user interfaces leverage state-of-the art artificial intelligence techniques from machine learning, natural language processing, data mining, knowledge representation, and reasoning to improve human-computer interaction. The purpose of this project is to (1) develop a VR emergency response scenario that will serve as a testbed for evaluating the impact of intelligent user interfaces on performance, and (2) conduct empirical evaluations to determine the effects of an intelligent user interface on task performance, mental workload, presence, and usability. In this session, we will review our development accomplishments towards these goals and discuss our research milestones for the upcoming year. The first year of the project has been dedicated to developing a rich VR-based incident scenario that features a coordinated multi-unit response to a subway fire and a data-driven heads-up display. The project team is working closely with our Public Safety Organization (PSO) operational partners at the Metro Transit Police Department (MTPD) of the Washington Metropolitan Area Transit Authority (WMATA), the Fire Chiefs Committee of the Metropolitan Washington Council of Governments (MWCOG), and tri-jurisdictional first responder personnel to guide our human-centered design approach.

Cognitive Mobile Edge Computing: Video Analytics Use Case: Spectronn

Mobile edge computing brings networking and computing closer to the device or network edge. This improves key performance metrics such as latency, throughput, and cost. In this talk, we present Spectronn's cognitive mobile edge computing technology developed with PSCR funding. Specifically, we present the key lessons learned in developing and deploying artificial intelligence (AI) driven video analytics applications on mobile edge. Dynamic optimization of wireless networking for remote cloud access and local computing at the edge for low latency are discussed. Technology demonstrations are presented to support the technical approach.

The technology developed from our research was deployed at the 2019 Boston Marathon to support the Brookline PD. This technology transition will provide resilient access to mission-critical applications (e.g., voice and video calls) and services (e.g., video streaming and storage) even when the wireless links are intermittent or totally unavailable.

First Responder 3D Mapping and Location: TRX, Inc.

Public safety personnel often work indoors, underground, and in other areas where GPS is denied or inaccurate. To obtain clear situational awareness, on-scene and remote commanders need to understand the area in which personnel are operating and to have access to accurate real-time location of personnel, even in buildings they are visiting for the first time. This session will review the research and development conducted by TRX Systems to accelerate availability of:

- Improved 3D location accuracy
- Easy to use 3D map data tools
- Actionable, 3D visualization for first responder use cases.

Field testing results will be presented from work with first responders including the Arlington County Fire Department in Virginia.

Public Safety Communications Above Six GHz -- Challenges and Opportunities: New York University

Advanced public safety communication (PSC) services call for fast, reliable and low-latency communication technologies, capable of supporting diverse communication modes (aerial, unmanned, vehicular, and peer-to-peer), fast channel dynamics, and ad hoc or mesh structures. For this reason, PSC has been identified as one of the key potential uses cases for the next generation of communication systems, the so-called 5G. In this scenario, the millimeter wave (mmWave) bands and other frequencies above 6 GHz are particularly interesting, since they are largely untapped and offer vastly more spectrum than current cellular allocations in the highly congested bands below 6 GHz, thus enabling orders of magnitude greater data rates and reduced latency. For example, new PSC networks in the mmWave bands could support high- definition video, virtual reality, and other broadband data to large numbers of first responders. Surveillance drones

or ambulances could also be provided high-speed connectivity along with machine-type communication for remotely controlled robotic devices entering dangerous areas. However, the way towards this ambitious goal is hindered by a number of open research challenges. In this project, we are working on a test platform for mmWave systems that is functional to the study of such complex scenarios and that we plan to develop as an invaluable tool for realizing mmWave PSC networks.

FirstSimVR: Evaluating Future Tools Using Today's VR: NextGen Interactions

Next-generation first-responder tools and their interfaces have the potential to significantly enhance public safety. However, many such tools are still at an early experimental stage and are not yet ready to be used or fully tested. Even when the tools come to fruition, it can be difficult to evaluate and optimize their use in the context for which they will be deployed. To propel tool development, evaluation, and usage, we are leveraging virtual reality (VR) technologies to efficiently test early prototypes of those new tools in virtual environments that simulate the context in which they will be used.

Whereas consumer VR systems can support scenarios that are quite visually and aurally realistic, most of today's VR hardware is lacking when it comes to physical touch. This shortfall is especially critical when simulating real-world user interfaces and the real physical world first responders work in. For FirstSimVR, we focus on adding (and evaluating) realistic physical cues to VR interfaces and the environment the system is simulating. For this talk, we will discuss two simulations we are building: 1)the integration of a physical pump panel with VR, and 2) A hazmat scenario with a tracked prop serving as a MultiRAE gas monitor.

Next Generation First Responder Deployables and Internet of Things Technology

NIST

PSCR will be presenting its latest in its Internet of Things (IoT) and broadband deployable systems research for public safety. Specifically, the panel will discuss how technology specifically interacts with the first responders. Over the past year the projects have dived into the integration of various situational awareness applications, sensor types, broadband infrastructure, and what it means to be connected. Topics include research into IoT sensors, Situational Awareness Applications and integration, User Devices, and the role of broadband in a first responders tool kit. Panelists will also cover spectrum access technologies, small Unmanned Aircraft System research, Named Data Networking, and broadband planning applications.

Decimeter Accurate, Long Range Non-Line-of-Sight RF Wireless Localization Solution for Public Safety Applications: University of Michigan

This session presents a new innovative radio frequency (RF) localization solution with unprecedented accuracy and power efficiency. The proposed RF localization solution for wireless tags is small, low energy, and rapidly deployable without heavy infrastructure investment. The proposed approach enables decimeter-level (tens of centimeter) accuracy in large indoor environments where non-line-of-sight (NLOS) scenarios dominate and GPS

does not reliably operate. To date, no existing solution addresses this set of challenging specifications which is critical to a collection of public safety applications including workforce, robots and equipment tracking for emergency search and rescue operations, and epidemiology analysis.

Mission Critical Voice Quality of Experience Speech-Based Access Time Measurement

NIST

This talk will explore the technical details of the latest end-to-end access time measurement developed by NIST/PSCR. It will focus on how to quantify access time as a quality of experience (QoE) metric and the relationship between access time and intelligibility. It will then describe the path for verifying and revising the measurement method through human intelligibility testing.

Demonstration of the Wildland-Fire Data Logistics Network (WDNL): Michigan Tech Research Institute The project provides a demonstration of a new hardware and software system that can improve access to complex data for wildland fire incident command firefighting in remote front line locations. This includes maps and other geospatial dada useful for informed decision making.

Developing Real-Time Analytics to Improve Outcomes: Western Fire Chiefs

This session will provide attendees an opportunity to explore the latest real-time performance analytics that have been developed by the Fire Data Lab. Attendees will be able to see an example of a framework that integrates multiple data feeds, and discuss current and future applications that would improve their capabilities.

First Responder Indoor Location using LTE Direct Mode Communications Signal: University of Cincinnati

Without GPS, indoor location is a difficult problem, especially for emergency first responders since a pre-installed WiFi or beacon transmitter infrastructure may no longer be available in an emergency situation. On the other hand, emergency first responders must carry radios for critical communication needs in emergency response missions. The FirstNet has adopted AT&T's LTE as an emergency first responder's critical broadband communications waveform. With the advent of Release 12 of the 3GPP specifications, LTE devices now have the capability to support Device-to-Device (D2D) communications enabling direct mode operations and Proximity Services (ProSe) that allows the devices to detect each other and communicate directly with one another without the aid of a cellular network infrastructure. In this work, we use the LTE ProSe mode and the system information blocks of the LTE sidelink communication signals to measure time of arrivals (TOAs) among a few such communication devices that form an ad hoc wireless network, thereby providing indoor location service that uses no additional hardware device and uses almost no communications payload bandwidth. This concept is tested by simulation and by implementation on a software defined radio (SDR) network which is demonstrated in a real-world indoor setting.

Modeling and Improving Device-to-Device Direct Discovery: University of Washington

In this presentation we will discuss modeling of the discovery process, including the effects of different modeling assumptions. We will also propose methods to improve the discovery process which make use of the discovery modeling done in NS-3.

7000+ First Responders Have Something to Say: Are We Answering the Call?

NIST

Come hear what 6000+ first responders have to say about current and future technology! Building on the NIST usability team's interviews with first responders, we now present brand new data from a large nationwide survey, covering all four major public safety disciplines—Fire, Law Enforcement, EMS, and 911/Dispatch. This broad survey sample has representation from every state (including the District of Columbia), as well as urban, suburban, and rural areas.

With survey topics ranging from current to future technology, and from day-to-day usage to major events, we offer an extensive view of the public safety technology landscape. This holistic understanding includes new analyses of special technology issues in rural areas, as well as the crucial nature of the 911 center in incident response. The new NIST dataset offers a nationwide picture of the state of technology across the U.S. that is both timely and in dispensable for industry developers, researchers, and first responder organizations alike.

Learn how to access our extensive, operationally focused, publicly available interview data!

Demonstrating the Power of Collaboration to Solve Video Analytics Challenges in Baltimore Citiwatch

NIST

Knowledge sharing and close collaboration between researchers and public safety experts are essential to the development and acceleration of analytics in public safety communications applications. This panel discusses an organic collaboration created between NIST, Baltimore Citiwatch, The City of Houston under a PSCR grant, and a PSCR grant-funded startup, Voxel 51, in agilely developing and testing novel video analytics in Baltimore. The panel will discuss the process employed to plan the effort, perform site analysis, plan application and infrastructure development, curate the data used in developing and testing the analytics, implement both laboratory and field testing of the analytics, the outcomes achieved, and lessons learned from the collaboration.

Situational Awareness for Emergencies through Network Enabled Technologies (Safe-T-Net): Massachusetts Institute of Tech

SafeT-Net will develop new localization algorithms for low-cost devices that can obtain localization information using

different radio technologies such as ultra-wideband (UWB) or orthogonal frequency-division multiplexing (OFDM). An important aspect in SafeT-Net is to exploit multipath propagation to increase localization accuracy and to enable localization capabilities on mobile end-user communication devices. In particular, multi-path phenomena are exploited by inferring the indoor propagation environment together with transmitter/receiver positions. This approach is particularly promising in future 5G communication systems, where millimeter wave signals allow the integration of antenna arrays on handheld devices.

Open-Source Simulation Platform for Public Safety

NIST

This presentation will provide an overview of the modeling and simulation platform developed by NIST and some of the awardees to support public safety communication research. Specifically, panel members will talk about specialized models for Mission Critical Push-to-Talk and Direct Mode, as well as enhancements to 3GPP LTE, 3GPP NR, and other 5G simulation models.

Emergency Edge Supercloud: Cornell University

Real-Time Video Analytics for Situation Awareness: Carnegie Mellon University

The ubiquity of mobile phone cameras allows public safety events to be captured on video right on the spot and be rapidly shared via social media. Our project seeks to develop video analytics and visualization tools based on computer vision and machine learning techniques for public safety events. For example, we will demonstrate such a system would have been able to localize the shooter from the Las Vegas Shooting event that occurred in 2017, solely based on social media videos.

Our project seeks to develop video analytics and visualizations tools based on computer vision and machine learning for public safety events. The goal is to make public safety analytics less labor-intensive and more manageable at a large scale. Component tools have already been applied to public safety situations.

UWB Localization and Mapping Using Computation Imaging

NIST

This talk will cover a potential method to simultaneously obtain interior structural details and indoor localization of personnel from outside a building by using standard communications pulses in the microwave region of the electromagnetic spectrum (0.5 – 5 GHz). The idea is to recover the digital version (N pixels) of the two-dimensional birds-eye view projection of an indoor scene and the assets within using a train of ultra-wide bandwidth (UWB) pulses emitted by a linear array of transmitting antennas located outside the scene. The reflected signal is detected by a single receiving antenna located in the middle of the transmitter array and digitized into M time-ordered measurements by a fast analog-to-digital converter. The signal y and the scene x are related to each other by the pattern A created by the microwave pulses (Ax=y). The digital version of the scene can then be recovered with as little as a few microseconds of data acquisition followed by a few milliseconds of calculations in a state-of-the-art graphics processing unit (GPU). In the talk I will describe the details of the physical model that allows for such imaging to happen, the technical challenges this method solves and the challenges it still has and others it creates. The talk will be complemented by a live demo setup comprising all the details of this approach.

Recent MCV QoE Awarded Projects: Georgia Tech Research Institute and Columbia University

GTRI is developing a framework for the evaluation of mission critical voice (MCV) quality of experience (QoE) for first responders operating in real field scenarios. The GTRI research team will develop a comprehensive suite of software and hardware tools for the simulation, recording, and evaluation of land mobile radio systems, Long Term Evolution (LTE) Systems and Future Technologies with the ability to, at a minimum, concurrently vary four proposed key performance (KPI). By dynamically varying these KPIs, the GTRI team will evaluate QoE for active duty operators and first responders in real operating scenarios by measuring objective and subjective outcomes, recording data in input and output of the system and leveraging new and existing partnerships with local organizations. Furthermore, GTRI will leverage outcomes to design, develop and validate a model for QoE for public safety users. The GTRI ARTEMIS-QUARC project will integrate with the ARTEMIS (usability testbed for first responders), seamlessly enabling a Virtual Test Facility for the collection of real-time, objective data.

Columbia is building a testbed and measurement platform and are designing a set of human factors experiments reflecting public safety tasks to evaluate the impact of LMR voice quality impairments, such as PTT delay and voice codecs, on speech intelligibility and task Performance. This research will provide a quantitative assessment of the impact of key LMR voice quality-of-experience (QoE) and quality-of-service (QoS) parameters on first responder task performance for both current and future public safety voice systems.

Requirement Analysis and Participatory Design of Next Generation Public Safety User Interfaces: Duke University

We will detail the initial phase of our project "Design, Prototyping and Evaluation of Next Generation Public Safety User Interfaces," where we closely gathered the requirements from partner public safety organizations. We will present the methodology adopted to make the deployment and adoption of next-generation user interfaces reflect the first responders' needs, requirements, and contexts of use. We will describe the results of interviews and training observations and present the early prototypes designed with the participation of first responders. We will conclude by laying out the next phases of the project.

Towards Cognitive Assistant Systems for Emergency Response: University of Virginia

This presentation will cover the status of CognitiveEMS, a system that provides real-time cognitive assistance to EMS providers by collecting and analyzing the audio data from an emergency scene and suggesting safe interventions according to EMS protocols. Specifically, we will present the status of different components of CognitiveEMS, including speech recognition, information extraction, protocol modeling, automatic form filling and their ongoing real-world testing.

Mobile Edge Services in 4G LTE: University of Colorado at Boulder

Edge services provide fast computation for time sensitive mobile applications. We demonstrate the design and deployment of Mobile Edge Computing (MEC) services in 4G LTE networks; the LTE modifications and additions necessary for users to receive fast and reliable edge services while maintaining mobility. We will dive into the details of the MEC system design and demonstrate potential public safety applications.

Mission Critical Voice Quality of Experience Measurement Methods

NIST

Mission Critical Voice (MCV) QoE measurement methods are being developed by NIST/PSCR to determine levels of key performance indicators (KPI) and to provide fair comparison mechanisms for Push To Talk (PTT) technologies. A mouth-to-ear (M2E) latency measurement method and test results were discussed at last year's stakeholder's meeting. Building upon that foundation, NIST/PSCR has developed a measurement method to quantify end-to-end access time of PTT technologies. The end-to-end access time measurement method and test results will be reviewed. Further work will include determining the probability of access and probability of retaining communications by performing extensive field testing of PTT technologies. This session will review the goals of further testing.

Mixed Reality Training and Testing Facility for First Responders (VALOR): TRACLabs

We will discuss the practical utility of the current simulation, the technical progress made during the last year, and the intended next steps as they relate to the overall goals and impact of our research and development. We will break down our platform VALOR, the Virtual and Augmented Laboratory for Objective Realities, into four primary components: the virtual environment, software infrastructure, physical reality, and the user experience. VALOR is the foundation for the mixed reality facility we are constructing as part of our PSIAP-UI grant. This facility will provide training and testing for first responders as well as a validated virtual testbed for assessing the impact of new technologies on first responders. Mixed reality training offers many of reality's benefits with few of its drawbacks. Its digital nature allows us to prepare for more types of emergency events in less time and provides better opportunities to improve performance through data. As a product deployment testbed, it offers economic efficiencies and rapid iteration opportunities. The ultimate goal of VALOR is to save the lives and resources of first responders and the public they serve.

Public Safety Video Analytics and Workflow to Enable the End User -- Lessons Learned: University of Houston

Use of video camera systems has become common across various public safety agencies. While manual review of captured video can be beneficial, there are a growing number of applications that would benefit from automated analyses of

captured video. In the recent past, considerable attempts have been made towards video analytics for monitoring, e.g. analytics for automatic left object (baggage) detection, or line (perimeter) crossing are common today. While more advanced and sophisticated analytics can be designed and developed, the ingestion of resulting information to facilitate communication and timely response from first responders requires integration of video analytic methods with existing information management and communication systems. Typical video systems leverage a video management system (VMS) to record video from cameras and pushes event information into a public safety information management system (PSIM). The PSIM is often used as the information management and communication system to define standard operating processes for each event, which in turn facilitates planning and response. We have studied existing infrastructure of public safety video systems, both to understand its impact on design of video analytic solutions and to realize requirements on integration of developed solutions to enable its use by end users. In this session, we will discuss our learnings and share insights for both video analytic solution developers and end users of public safety video systems.

ReDiCom: Resilient Communications for Dynamic First Responder Teams in Disaster Management: University of California, Riverside

Effective communication among first responders during and in the aftermath of a disaster can affect outcomes dramatically. We seek to build a resilient architecture that allows first responders to communicate even with: (i) damage to infrastructure – civilian and/or specialized communication facilities may be damaged by the disaster, (ii) congested channels – because affected people report something about the disaster, and these messages may be broadcast, (iii) dynamically formed groups – first responder teams may be formed dynamically in response to a disaster and team member addresses (e.g., phone numbers) may not be known to one another, (iv) impediments to communication – because the new command chain to manage the disaster may be different from the original organizational hierarchy, (v) poor interoperability – each sub-team might use different communication facilities, and (vi) security attacks – disaster situations are often vulnerable to attacks, requiring authentication and authorization as well as establishing data integrity and provenance.

We propose a resilient network architecture that allows efficient communication among first responders during and after a disaster. Our network architecture will be informed by models for traffic demand that we develop based on a careful study of reported experiences and communication requirements of first responders from a variety of recent disaster situations. We seek to support dynamically formed groups for incident response, allowing first responders to securely and conveniently communicate based on roles (names), rather than network addresses. The architecture will directly address the needs identified above for communication in disasters by (i) building resilience into the framework across all the layers, (ii) creating a framework that allows communication by role and identity, rather than addresses, (iii) supporting multiple modalities (data, voice, video) for communication among dynamically formed first responder teams, and (iv) providing robust and resilient communication and computing even when facilities are error- and disruption-prone.

In this session, we will focus on the progress we have made in the last year, which includes 1) a detailed study on the communication status in 2 natural disasters – hurricanes Harvey and Irma; 2) the design and implementation of graph pub/sub protocol using Click modular router and DPDK; 3) the namespace propagation among fragmented networks; 4) device-to-device communication software protocols that can utilize heterogeneous wireless links (i.e., Bluetooth and WiFi Direct), 5) an extensive study of measuring device-to-device link qualities in the user space, 6) coded cooperative mechanisms in heterogenous, time-varying, and adverse environments. We will also introduce a demo which is a collaborative effort across all four teams in the project. It integrates resilient D2D communication with WiFi Direct and Bluetooth, dynamic naming and name propagation, and coded computing aspects of the project.

OpenFirst - The Open-Source LTE Platform for First Responders: Software Radio Systems

OpenFirst is the open-source LTE software-radio platform for first responders, providing a complete mobile broadband network reference implementation for research, prototyping, test and validation of LTE technologies for public safety communication. Building upon the proven success of the srsLTE suite of open-source software-radio libraries and applications, OpenFirst has the potential to significantly accelerate the development and deployment of public safety communication technologies.

Augmented Reality Testing of Equipment in Multiple Immersive Simulations (ARTEMIS): Georgia Tech Research Institute

ARTEMIS allows first responders to test the effectiveness of new equipment, technology, capabilities, and techniques in

virtual and mixed reality. Researchers at the Georgia Tech Research Institute are working closely with the Cobb County and Georgia Tech Police Departments to develop a traffic stop scenario (and evetually, other useful scenarios) in virtual reality and to understand how the experience could be enhanced through the use of near-future technology. Still under development, an early version of ARTEMIS is available for demonstration.

SAFE-NET: A Computing Platform for Public Safety Applications: Southern Methodist University

We present the modeling frameworks and solution methodologies for three problems related to enhancing the dispatching operation of emergency vehicles in urban areas. First, we discuss the problem of workload balancing among stations. Next, we present results related to spatial risk analysis for emergency vehicle routing. Finally, a framework for data fusion for flash flood detection is discussed. The results of applying these methodologies for the Dallas area are presented.

DistressNet-NG: A Resilient Broadband Communication & Edge Computing Infrastructure for FirstNet: Texas A&M

In this talk, we will present DistressNet-NG, which provides: a) a scalable and resilient wireless interconnection fabric for first responder communication equipment; and b) a novel mobile edge computing service, pushing cloud computing beyond the network edge and onto the user equipment itself. Smartphones carried by first responders are capable of performing analytics on shared data using the computing and storage power of nearby devices, eliminating the need for constant high capacity connections to the Internet. We will also present our work on Network Function Virtualization for Public Safety (PS-NFV), TCP optimization for LTE, and integration with edge computing paradigms. The presentation will conclude with a discussion of directions for future research and collaboration with other grantees.

Device-to-Device System for Public Safety (DDPS): Perspecta Labs

In disaster situations, centralized cellular infrastructure can fail, crippling emergency communications. LTE Direct mode communications provide a way for first responders to communicate without a network infrastructure. However, key technical challenges, such as discovery, synchronization, resource management, and interference mitigation for the User Equipment (UE) must be addressed. Perspecta Labs, in collaboration with EURECOM, a founding member of OpenAirInterfaceTM (OAI), develop a Device-to-Device system for Public Safety (DDPS), demonstrates 3GPP Proximity Service (ProSe) for public safety (PS) applications and aims to solve the aforementioned challenges. DDPS will deliver core technologies essential for transitioning into a full-fledged PS network. In this session, we discuss the OAI software, DDPS testbed based on software defined radio, and demonstration of service continuity, and how the first responder community can benefit from it.

Evaluating Multicast Capability in LTE Public Safety Networks

NIST

Public safety incidents typically involve significant amount of group traffic among first responders. Using traditional point-to-point unicast communication to serve this traffic requires to transmit the same content multiple times over the air interface. In this study we explore the potential savings on the precious spectrum from using multicast to serve this traffic, and the resulting network and user performance.

SPEAKER BIOGRAPHIES

Khaled **Abdelghany**

Dr. Khaled Abdelghany is an Associate Professor at the Department of Civil and Environmental Engineering and a fellow in the Hunt Institute for Engineering and Humanity of Southern Methodist University. He received his Ph.D. from the University of Texas at Austin in 2001. From 2001 to 2004, he worked as an operations research analyst at United Airline's R&D in Chicago. Dr. Abdelghany joined the Department of Civil and Environmental Department at SMU in 2004 as an Assistant Professor. He served as the chairman of the department from 2011 to 2016. Dr. Abdelghany has extensive research experience in transportation system modeling and analysis, smart city applications, crowd dynamics and management, public safety, and airlines operations management. Dr. Abdelghany authored two books focusing on modeling application in the airlines industry, and numerous peer-reviewed journal and conference articles. His research has been supported by the National Science Foundation, U.S. Department of Transportation, Department of Energy, Department of Commerce, and several consulting firms including Schneider Electric and Booz Allen Hamilton.

Amrinder **Arora**

Amrinder Arora (Co-PI) is an adjunct faculty member in the Department of Computer Science at the George Washington University. His research interests lie in the field of online algorithms, artificial intelligence and wireless networks. Dr. Arora is also the author of the book "Design and Analysis of Algorithms".

Michael **Bartock**

Mike Bartock is an IT specialist in the Computer Security Division in the Information Technology Laboratory at the National Institute of Standards and Technology. He performs applied cybersecurity research specializing in hardware roots of trust to enforce policy-based cloud workload migration, LTE backhaul protection, and derived PIV credentials. His work focuses on collaborating with industry partners to build and implement proof of concept reference architectures. He has experience in managing virtualized environment, cloud computing, software development, cryptography, derived PIV credentials, and LTE security for public safety networks.

Eric **Beck**

Eric Beck is a Senior Research Scientist at Perspecta Labs in Red Bank, NJ where he works in the Wireless Networks & Systems Department. His research interests include digital signal processing, radio and digital hardware. He is working on the Device-to-Device System for Public Safety (DDPS) project where he works on hardware design and implementation of the testbed, algorithms for side-link synchronization and testbed performance (link budgets, etc). Other recent projects include but are not limited to DARPA 100G and DARPA LADS programs. Prior to joining Perspecta Labs he was a Distinguished Member of Technical Staff at Bell Laboratories and LGS Innovations where he worked in a variety of technical areas including integrated circuit design, long haul transmission, submarine cable systems, cellular telephony and ISR sensors.

Micah **Beck**

Micah Beck began his research career in distributed operating systems at Bell Laboratories and received his Ph.D. in Computer Science from Cornell University (1992) in the area of parallelizing compilers. He then joined the faculty of the Computer Science Department at the University of Tennessee, where he is currently an Associate Professor working in distributed high performance computing, networking and storage.

John **Beltz**

John Beltz is the IT Security Manager for Communication Technology Laboratory (CTL), Public Safety Communications Research (PSCR) Division. He leads security specific public safety research projects and incorporates security into all aspects of PSCR research. Additionally, he ensures that adequate security controls are in place to protect the diverse PSCR demonstration network from cybersecurity threats. John's background is in network security where his prior role was managing security teams at NIST in completing activities including activities such as project management, security architecture consultation, network and web application vulnerability scanning and analysis, hands-on technical testing, and reporting results to executive authorizing officials. Prior to that, he performed similar services as a senior consultant with Booz Allen Hamilton. John is a proud veteran of the US Army where he served his country for 6 years. During his military career, he completed his Bachelor's Degree at Hawaii Pacific University, majoring in Computer Information Systems. He also completed a Graduate Degree at Johns Hopkins University majoring in Information and Telecommunication Systems. John is a native of the Washington, DC area, but now lives in Colorado with his wife and young son. He enjoys playing in the Rocky Mountains and his favorite pastimes including mountain biking, backcountry skiing, and hiking.

Jeb **Benson**

Jeb Benson has 15 years of experience as a Technology Lead, Engineering Manager, and RF Engineer with NIST and the Department of Defense researching, developing, and fielding innovative technologies, products, and systems for public safety and ISR applications. Prior to that, he worked for five years as a Research Biologist in Alaska. Jeb has a BS in Electrical and Computer Engineering from the University of Alaska-Fairbanks, and a BS in Environmental Science from Oregon State University. He is also a licensed Professional Engineer and a DAWIA certified Level 2 Science and Technology Manager.

John **Blackwell**

John Blackwell and his company Diamond Age Technology are passionate about solving unsolved problems and optimizing systems through close collaboration with subject matter experts and the creative application of advanced technology. In the past, he has worked extensively with NASA developing multimedia products including augmented and virtual reality for education and scientific missions. He lives and works at the intersection of two of his favorite quotes, Paul Graham's advice to "Live in the future, then build what's missing" and William Gibson's observation that "The future is already here — it's just not very evenly distributed."

David **Blankinship**

David Blankinship has 22 years of experience in the geospatial analytics field focused on bringing operational relevance through integration of large, disparate systems. He is the Co-Founder and Chief Experience Officer for Intterra, a leading geospatial response and analytics platform for first responders.

Blake **Boyd**

Blake Boyd works part time for NextGen Interactions as a subject-matter expert. He is a 20-year veteran of the fire service who has served in multiple roles within the Cary Fire Department where he currently serves full-time as the department's Data Analyst. Blake has served on multiple advisory committees and is actively working on implementing future technologies such as Virtual Reality into the fire department's training and assessment processes. Blake graduated from Coastal Carolina Community College with an Associates degree in Fire Protection Technology and from Fayetteville State University with a Bachelors in Fire and Emergency Services Administration.

Donald **Bradshaw**

Don Bradshaw is the group lead for PSCR's Research, Testing, and Evaluation Group and the Mission Critical Voice Portfolio manager. Prior to joining PSCR, Don spent 12 years with the Department of Defense performing research and analysis of current and emerging communications technologies. Don received a BS in Electric Engineering from the University of Alaska Fairbanks and an MS in Electrical and Computer Engineering from John Hopkins University.

Collin **Brady**

Collin Brady earned his Bachelor of Science degree in Electrical Engineering from the University of Illinois at Chicago. He received a Master's degree from the University of Washington in Electrical engineering and is currently pursuing his PhD in Electrical engineering from the University of Washington. His Research interests include Wireless Communications in Public Safety Networks.

Kevin **Brady**

Kevin Brady Jr is an IT Specialist at the National Institute of Standards and Technology. Kevin works researching methods and developing applications to evaluate the security of wearable devices for public safety at the National Cybersecurity Center of Excellence (NCCoE). Kevin specializes in packet analysis automation and application development for network analysis and evaluation. Prior to working in public safety, Kevin worked developing applications for precision timing and cyber-physical systems research in ITL.

Fred **Byers**

Fred Byers is the project lead for the Open Speech Analytics Technologies Evaluation Series to be held by NIST annually. Fred has been with NIST for 21 years contributing to systems analytics, measurement standards and guidelines development. Notable areas are optical media testing and magnetic tape and optical disc storage handling standards, information sharing in interstate response for disasters, testing and evaluation of contactless fingerprint scanners, and currently, evaluation of speech analytic systems.

Yang **Cai**

Dr. Yang Cai is the Director of Visual Intelligence Studio (VIS) in the College of Engineering at Carnegie Mellon University. His research area includes Artificial Intelligence, Machine Vision, and Augmented Reality. He is the author of: "Instinctive Computing" (Springer-London, 2016) and "Ambient Diagnostics" (CRC Press, 2014).

Dr. Jiachen **Chen**

Jiachen Chen is a Postdoctoral Associate in WINLAB, Rutgers University. He received the B.E. and M.E. degrees in Software Engineering from Fudan University, China, and Ph.D. degree in computer science from University of Göttingen. His research interests are in the area of Information-Centric Networks (ICN), Internet of Things (IoT), cloud computing and network management.

Harsha **Chenji**

Dr. Chenji is an Assistant Professor in the School of EECS at Ohio University, where he leads the Wireless Systems Research Group (WSRG). His research interests include free space optical networks (funded by NSF), wireless networking for public safety (funded by NIST), and machine learning/signal processing for cognitive radio networks (funded by OFRN Ohio). He received his PhD and MS degrees in Computer Engineering from Texas A&M University, advised by Prof. Radu Stoleru.

Hyeong-Ah **Choi**

Hyeong-Ah Choi (PI) is a Professor of Computer Science at the George Washington University. Her research interests lie in network scheduling and optimization algorithms. She has been also engaged in public safety networks research in collaboration with the NIST CTL, Gaithersburg MD on various topics including QPP-aware scheduling algorithms and study on the analysis of potential spectrum savings by using MBSFN.

Yee-Yin **Choong**

Yee-Yin Choong is a Human Factors Scientist in the Information Technology Laboratory at the National Institute of Standards and Technology (NIST). Yee-Yin conducts research in the areas of user-centered design and evaluation methodology, public safety communications, usable cybersecurity, biometrics usability, human factors, and cognitive engineering. She has contributed to numerous papers, book chapters and conferences on the topics of user-centered design and evaluation, cross-cultural usability, symbols and icons design, biometrics symbology, and usable cybersecurity.

Prior to joining NIST in 2006, she practiced usability engineering in the private sector for 10 years, covering areas such as telecommunications, Business-to-Business eCommerce, Web-based applications, and software internationalization. Yee-Yin received her MS degree in Industrial Engineering from the Pennsylvania State University and her PhD in Industrial Engineering, specialized in Human Factors from Purdue University.

Walter **Copan**

Dr. Walter Copan was confirmed by Congress as Under Secretary of Commerce for Standards and Technology and NIST Director on October 5, 2017. As NIST Director, Dr. Copan provides high-level oversight and direction for NIST. He has had a distinguished and diverse career as a science and technology executive in large and small corporations, U.S. government, nonprofit and other public-sector settings.

Jason J. **Corso**

Prof. Jason J. Corso is CoFounder and CEO of Voxel51. He is also an associate professor of Electrical Engineering and Computer Science at the University of Michigan. He holds a Ph.D. in Computer Science and Engineering from The Johns Hopkins University. He is an internationally recognized expert in video understanding and has authored more than 135 peer reviewed papers and hundreds of thousands of lines of code on topics in the areas of computer vision and machine learning. Dr. Corso is the recipient of a University of Michigan EECS Outstanding Achievement Award 2018, Google Faculty Research Award 2015, the Army Research Office Young Investigator Award 2010, NSF CAREER award 2009, SUNY Buffalo Young Investigator Award 2011, a member of the 2009 DARPA Computer Science Study Group, and a recipient of the Link Foundation Fellowship in Advanced Simulation and Training 2003. At Voxel51, he coleads the strategic roadmap and vision, and he is actively involved in technology development and business development.

Jamie **Cousins**

Jamie has worked for Hampshire Fire and Rescue Service for the past 20 years and is a Station Manager with the Community Response Team. Jamie has led the introduction of multiple new firefighting technologies, concept vehicle evaluations and supporting policy development. He is currently involved in the review of fire in a highly automated environment and is integral to the collection and analysis of a wide range of evidence from multiple sources.

Rui (April) **Dai**

Rui (April) Dai is an Assistant Professor in the Department of Electrical Engineering and Computer Science at the University of Cincinnati, Ohio, USA. She received her PhD degree in Electrical and Computer Engineering from the Georgia Institute of Technology, Atlanta, GA, USA in 2011, under the supervision of Professor Ian F. Akyildiz in the Broadband Wireless Networking Laboratory. She was a postdoctoral fellow at the Center for Assistive Technology and Environmental Access of Georgia Tech in 2012. She was an Assistant Professor at the Department of Computer Science at North Dakota State University from 2012 to 2014. Her recent research interests include multimedia communications and networking, wireless sensor networks, and cyber-physical systems.

Bart **De Lathouwer**

Mr. De Lathouwer is OGC's President. In this role, he manages the consortium, provides oversight and direction to the Consortium's strategy, budget, outreach & marketing, and membership recruitment goals, in close collaboration with the CEO. Mr. De Lathouwer also continues to be the General Manager for OGC Europe.

In Mr. De Lathouwer's previous role at OGC, he was responsible for planning and managing Innovation Initiatives such as testbeds, pilots, and interoperability experiments with an emphasis on activities in Europe.

Previous to his time at OGC, Mr. De Lathouwer worked first as European liaison to the geospatial division of Autodesk

and later as Autodesk's Product Manager for Server Technologies. In this role, he also served as member company representative to the OGC. As a company representative, he started the OGC CAD-GIS Interoperability Working Group (which evolved into the OGC 3DIM Domain Working Group) and managed the development of a core data access technology FDO (Feature Data Object) that later went open source in OSGeo. After returning to Europe, he worked as a geospatial expert for both private and government organizations focused on interoperability.

Previously, Mr. De Lathouwer was technical project manager at electric and water utilities as well as telecommunication companies. He holds a BS in Computer Science from the Karel de Grote-Hogeschool.

Stephanie **Demers**

Stephanie Demers has more than 15 years of experience in wireless communication spanning the areas of system performance evaluation, modeling and simulation, protocol specification, and implementation. She is currently working on the DDPS project, where she is co-developing the LTE ProSe application and leads the service continuity effort. She is also currently providing wireless priority service support for the Cybersecurity and Infrastructure Security Agency Emergency Communications Division and participates/monitors the 3GPP SA6 working group on mission critical services and ATIS working groups of wireless emergency services. Other recent projects include leading numerous wireless consulting engagements with large service providers on topics of voice, video, and data performance evaluation and benchmarking over GSM, UMTS, HSPA, and LTE systems. Ms. Demers has also worked on developing LTE threats from malicious UEs and eNBs, and detection and mitigation algorithms to recover from these threats which she successfully implemented and demonstrated in simulation and in indoor and outdoor testbeds using Amarisoft eNodeBs, and a mix of OAI UEs and android phones. Ms. Demers has published 13 papers on wireless communication system design and modeling and has 14 patents issued.

Chris **Dennis**

Christopher Dennis is an Electrical Engineer for the Public Safety Communications Research (PSCR) Division and joined NIST in the start of March 2015. Christopher spent 5 years in the United States Marine Corps as an Arabic Cryptologic Linguist in the field of Signals Intelligence. Following his time with the Corps, he spent 2.5 years on a U.S. Department of State Diplomatic Security Services contract where he was the Tactical Commander of a Protective Security Detail for the U.S. Embassy in Iraq. Additionally, he spent 4 years on a U.S. Air Force contract as an Electronic Warfare Operator in support of military training exercises. Furthermore, Chris was a Federal employee with the U.S. Air Force for 2.5 years under the U.S. Strategic Command where he was a Lead Telecommunications Planner for Electronic Warfare/Signals Intelligence training exercises. Chris received his Bachelor of Science in Electronics Engineering Technology and a Master of Science in Information Management Project Management from Grantham University.

Paul **Doherty**

Paul Doherty: Paul Doherty started his career as a biologist (B.S. SUNY ESF, MS Hofstra Univ.) in his home state of New York. He later completed his PhD at the University of California, Merced where he focused his research on the application of Geographic Information Systems (GIS) to Search and Rescue (SAR) while simultaneously serving as a Law Enforcement/SAR Ranger in Yosemite National Park. Paul recently spent two years in New Zealand bringing together emergency management practitioners and GIS staff through his role in the private sector. He is now a Program Manager for the National Alliance for Public Safety GIS (NAPSG) Foundation and adjunct instructor for the Johns Hopkins University Advanced Academic program, teaching GIS for Emergency Management.

Jared **Doke**

Jared Doke: Jared Doke completed an M.A. in Geography at the University of Kansas, focusing his research on lost person behavior in Yosemite National Park. While completing his graduate degree, he was a full-time firefighter at a combination department and gained valuable experience as an active member of the department's water rescue team and a regional Urban Search and Rescue team. Most recently, he spent four years as a contractor for the National Park Service conducting wildfire risk assessments on park facilities nationwide in support of the Wildfire Risk Assessment project, and in 2018, became a Tech Info Specialist for Missouri Task Force One (MO-TF1). Jared is currently a Program Specialist for the National Alliance for Public Safety GIS (NAPSG) Foundation.

Dr. Eric **Jing Du**

Dr. Eric Jing Du is an associate professor in the Engineering School of Sustainable Infrastructure and Environment

(ESSIE) at the University of Florida. Before joining the University of Florida in January 2019, he was a faculty member at Texas A&M University (2015-2018) and University of Texas at San Antonio (2013-2015). Dr. Du has 15 years of research and teaching experience in civil engineering, human factors, and information visualization. Dr. Du received his PhD degree in construction from Michigan State University (2012), Master's degree in Enterprise Management (2007) and Bachelor's degree in Civil Engineering (2004), both from Tianjin University in China. His current research interests focus on the development and test of the next generation Intelligent Information Systems (IIS) and Intelligent Physical Systems (IPS) for the design, engineering, and operations of built environments.

John **Dwyer**

John Dwyer, PhD is VR product manager for Optera Group and an instructional designer by training. He has been engaged in working to ascertain the value of augmented/virtual reality in adult learning. He has helped to design eight augmented or virtual reality applications that have been used commercially. He designed a study to test the acceptance of augmented and virtual reality when used by surgeons for anatomical and procedural training. The project was undertaken jointly with the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). He is currently participating in two studies to determine the efficacy of VR training in medical applications.

Dan **Ericson**

Mr. Ericson is an expert in the development and specification of wireless communications systems that serve mission-critical markets including Public Safety, Critical Infrastructure, and Business Services. He is an active contributor to FCC policy proceedings and has served as a SME (subject matter expert) on two national subcommittees developing the technical and governance requirements for the US Legislative edict established by the Middle-Class Tax Relief and Job Creation Act of 2012 for nationwide Public Safety interoperability. He has also authored company positions on FCC Notices of Proposed Rule Making. As a delegate to 3GPP, Mr. Ericson has led Harris contributions to cellular standards focused on radio access networks particularly for mission critical markets. He holds over 10 patents covering communication systems, coding, land mobile radio, and broadband systems.

Robert **Escalle**

Robert Escalle serves as Sonim's Vice President responsible for the Public Safety and Defense market segments. Robert has overseen Sonim's expansion and continued leadership in these focused verticals. Before joining Sonim, Mr. Escalle served as the Director of Product Management at Motorola Solutions, where he focused on managing the broadband device product portfolio. Before joining Motorola Solutions, Mr. Escalle held various senior level positions in both product and business management focusing on wired, wireless, and semiconductor market segments within the telecommunications industry for AT&T, Cassidian Communications, QuantM Voice, Lucent Technologies, Texas Instruments, and Globespan Semiconductor.

Brad **Fain**

Dr. Brad Fain (Principle Research Scientist at GTRI) is the project's Principal Investigator. He leads GTRI's collaboration with the GTPD as the Public Safety Organization critical to the correct development of a PSCR-supported VR tool and system assessment framework. Dr. Fain is widely known as an expert on usability and human systems interaction analysis and testing. He has been invited to present at multiple conferences including two keynote addresses, has had three refereed published journal papers, thirty-seven major technical reports, and eleven refereed conference presentations with proceedings.

Jose Oscar **Fajardo**

Dr. Jose Oscar Fajardo is co-founder and CEO at Nemergent Solutions SL (Bilbao, Basque Country, Spain), focused on the development, experimentation and provisioning of 3GPP-based Mission Critical Services over 4G LTE networks. Within his responsibilities, he manages the company's private and public projects including the R&D projects related to new Mission Critical applications and new service deployment schemes such as 5G and NFV. Since 2003, he has been working as a research fellow in the University of the Basque Country (UPV/EHU) at the Faculty of Engineering in Bilbao, where he received his PhD degree in 2016 in the area of adaptive management of mobile multimedia services in 4G and 5G networks. He has co-authored more than 50 journal and conference papers, mainly in areas of QoS/QoE and service performance assessment.

H. Howard **Fan**

H. Howard Fan obtained his PhD in Electrical Engineering from the University of Illinois, Champaign-Urbana in 1985, and has been a faculty member with the University of Cincinnati since then. His research interests include signal processing, channel estimation and equalization, multi-user communications, wavelets and applications, system identification, array signal processing, GPS and GPS-denied location and navigation, and machine learning.

Sarah **Farmer**

Ms. Sarah Farmer (Research Scientist at GTRI) is the technical lead for the evaluation of potential technologies. With a background in psychology and statistics, she has been executing research related to human performance and successful aging since 2012. She led data collection efforts for several human performance research projects including a project designed to model fatigue during manual labor and a project designed to model human hand performance. Ms. Farmer has led or contributed to a wide variety of journal articles, conference proceedings, and technical reports.

Bill **Fisher**

Bill Fisher is a security engineer at the National Cybersecurity Center of Excellence (NCCoE). In this role, he is responsible for leading a team of engineers that work collaboratively with industry partners to address cybersecurity business challenges facing the nation. He leads the center's Attribute Based Access Control (ABAC) project, Mobile Application Single Sign On (SSO) for the Public Safety and First Responder Sector, and is part of the ITL Cybersecurity for IoT program.

The NCCoE is a collaborative hub where businesses, government agencies, and academia work together to address broad cybersecurity problems of national importance. As part of the National Institute of Standards and Technology, the NCCoE uses standards, best practices, and commercially available secure technologies to demonstrate how cybersecurity can be applied in the real world. Ultimately, the NCCoE helps promote widespread adoption of cybersecurity technologies by developing example solutions to cybersecurity problems that affect whole sectors of industry, or even multiple sectors.

Prior to his work at the NCCoE, Mr. Fisher was a program security advisor for the System High Corporation in support of the Network Security Deployment division at the Department of Homeland Security. He holds a bachelor's degree in business administration from American University and a master's degree in cybersecurity from Johns Hopkins University.

Nancy **French**

Dr. Nancy French has been working on applications of remote sensing to ecology and wildland fire for more than 25 years. Dr. French's research has focused on wildfires and their effect on the structure and function of ecosystems as well as the use of remote sensing for research and decision support. Her work has included studies in boreal, arctic, and temperate ecosystems with a variety of remote sensing systems and geospatial technologies. Dr. French serves on the Editorial Board and as an Assistant Editor for the International Journal of Wildland Fire.

Tyler **Garner**

Mr. Garner is a Principal Software Engineer, Chief Operating Officer, and co-founder at Prominent Edge LLC. He is the architect and technical project manager for several large public safety projects including the Fire-Community Assessment Response Evaluation System (firecares.org), the National Fire Operations Reporting System (nfors.org) and StatEngine (statengine.io), a NIST Public Safety Innovation Accelerator project. He is a principal member of NFPA Technical Committees 950, Standard for Data Development and Exchange for the Fire Service, and 951 Guide to Building and Utilizing Digital Information.

Mr. Garner began his service in the public safety sector as a volunteer firefighter over thirteen years ago. As a technologist, he then began working with fire department Computer Aided Dispatch systems, Records Management applications, and Geographic Information Systems (GIS) supporting the Richmond Fire Department. He transitioned to the National Geospatial-Intelligence Agency (NGA) where he worked in the Readiness, Response and Recovery team, providing support during national emergency responses for the White House, FEMA Urban Search and Rescue Teams, the Secret Service, USAID and other customers. He left the NGA to become a senior software engineer on the Army Geospatial Center's ROGUE project.

Mr. Garner is still a volunteer firefighter in Northern Virginia and works closely with the fire service to leverage open source tools to automate workflows, analyze and visualize data. He has successfully provided technical leadership and managerial

oversight on multiple open source development efforts for commercial and government customers.

John **Garofolo**

John Garofolo has been with the National Institute of Standards and Technology (NIST) Information Technology Laboratory since 1987 leading the development of HLT-, vision-, and multimedia technology RDT&E. As Senior Adviser for Information Access Programs, he provides strategic leadership for development of new research and measurement science programs focused on unstructured data analytic technologies, especially in the area of video analytics. He brings knowledge of analytic technologies, data- and evaluation-driven research, and an interdisciplinary perspective to bear in working with diverse communities of interest to create innovative approaches to critically important national needs. John created the IARPA ALADDIN Video Analytics R&D Program, the OSTP NITRD Video and Image Analytics IWG, and recently led groundbreaking workshops in public safety analytic technologies. He's leading the PSCR analytics portfolio and working to foster robust public safety analytics technology R&D and standards. John has a BGS from UMD, a BS in Computer Science from UMBC, and a MS in Computer Science from JHU

Jeronimo **Grandi**

Dr. Jeronimo G. Grandi is a postdoctoral associate in the department of Mechanical Engineering and Materials Science at Duke University. His research interests lie in the area of Virtual, Augmented and Mixed Reality systems and Human-Computer Interaction. Dr. Grandi has experience in the design and evaluation of 3D User Interfaces for Virtual and Augmented realities and collaborative interactions for mixed reality environments. Dr. Grandi received his Ph.D. in Computer Science from the Federal University of Rio Grande do Sul, Brazil.

Kristen **Greene**

Kristen Greene is a Cognitive Scientist at NIST, the National Institute of Standards and Technology. She conducts usability and human factors research for NIST's PSCR (Public Safety Communications Research) and usable cybersecurity programs. She has an M.A. and Ph.D. in Cognitive Psychology from Rice University. She is an experienced researcher, having conducted research in the Attention and Perception Laboratory at the University of South Carolina, the Usability Testing and Analysis Facility at NASA Johnson Space Center, the Computer Human Interaction Laboratory at Rice University, and now the Information Technology Laboratory at NIST.

Patrick **Hagan**

Patrick Hagan is an Emergency Operations Technical Specialist with the Houston Fire Department.

Hussein **Hammoud**

Hussein Hammoud received his B.Sc in Electrical Engineering from the American University of Beirut in July 2016. He is currently working towards his PhD in Electrical Engineering at the University of Southern California (USC). His research interests includes Millimeter-wave (measurement-based) MIMO channel Modeling and analysis, Parameter Estimation, and Localization systems.

Don **Hariss**

Don Harriss is an IT Security Engineer specializing in Network Security and Lab Operations for the Communications Technology Laboratory (CTL) at the National Institute of Standards and Technology (NIST). Don works in CTL to design and maintain networked laboratories within PSCR. He is researching interoperability standards with the Internet of Things in Public Safety Networks as well as integration into Highly Deployable Public Safety Networks.

Jason **Haskins**

Jason Haskins is Lead Technical Designer at NextGen Interactions, where he tackles day-to-day challenges of conceptualizing, designing, and implementing VR solutions using tools such as the Unity Game engine and Autodesk Maya. His design focus is in training and educational research in New Media and his technical proficiencies help him ideate on a broad range of projects, enabling him to better empathize with his team mates while generating solutions that fit with big picture thinking. Jason has worked for multiple research companies including BTEC and the Center for Educational Informatics (CEI) as a Game designer using the Unity engine. He is recently published in an international journal for his work

on creating and implementing a VR training platform for a BTEC Fermentation Bioreactor. Jason has a degree in Art and Design from North Carolina State University and a background in Computer Science, Information Technologies, and hands on training in health care as a Corpsman in the US Navy.

Tom **Henderson**

Thomas R. Henderson is a co-founder and the lead maintainer of the ns-3 network simulator project, and the Executive Director of the ns-3 Consortium. He is an Affiliate Professor at the University of Washington Electrical Engineering Department, with which he has been affiliated for the past sixteen years. He was previously a Technical Fellow with Boeing Research & Technology, a Member of Technical Staff at COMSAT Laboratories, and was a founding engineer of GlobeArc, a Bay Area technology startup in the late 1990s. He received his B.S. and M.S. degrees from Stanford University, and a Ph.D. from the University of California, Berkeley, all in Electrical Engineering.

Matthew **Herbert**

Battalion Chief Matthew Herbert is a 27 year veteran of the Arlington Fire Department. During his time with Arlington he has served as a firefighter, paramedic, hazardous materials specialist, company officer, and Emergency Medical Service Supervisor. Matthew also spent two years as a fire department captain assigned to the Office of Emergency Management. He was a first responder to the terrorist attack on the Pentagon on September 11, 2001 and has been deployed to Florida and Mississippi following major hurricanes both in the incident management and emergency response roles. He has worked in fire and EMS in Auburn Alabama, Valley Alabama, and The City of Fairfax Virginia. Matthew holds a Bachelor's Degree in Public Administration from Auburn University and he is a graduate of the Leadership in Crisis program at Harvard University.

Max **Hollingsworth**

Max is a PhD student at the University of Colorado Boulder, supervised by Dr. Dirk Grunwald. His research interests are in wireless system security and networking. He obtained a Master's degree in Computer Systems from the University of Colorado in 2018.

Samuel **Hood**

Major Samuel Hood III is a 23 year veteran of the Baltimore Police Department Homeland Security Division, currently the Director of Law Enforcement Operations for "CitiWatch", the City of Baltimore's Closed Circuit Surveillance Network which consist of 800 Cameras connected to an additional 3000 cameras across the state of Maryland and Virginia. A Department of Homeland Security Best Practice for Public – Private Partnerships (P3) in Proactive Public Safety & Services. He is responsible for the virtual law enforcement, and public safety, of Baltimore City, which attracts approximately ten million Tourists, Convention Attendees, Vacationers, Preakness Enthusiasts, Sport Fans, and the downtown workforce each year. He previously commanded the Baltimore Police Department Planning & Research Section, where one of his duties included the Emergency Mobilization Planning and Citywide Security Assessment. Samuel Hood III was a 1999 finalist for the Herman Goldstein Problem Oriented Policing Award for his Chronic Truancy Abatement program.

Jim **Horan**

Mr. Horan is a senior electrical engineer working for the NIST Information Technology Laboratory in the Information Access Division.

Since 2016, Mr. Horan has been working at NIST in the areas of high-performance computing, computer vision, applied analytics and video quality research. As part of the NIST Public Safety Communications Research program Mr. Horan has been developing reference and test systems to support measurement and evaluation of analytics in a public safety environment.

Previously, Mr. Horan has worked with the FBI and DoD on a large variety of R&D and operational technology projects over a 20-year period. This included design and deployment of the FBI next generation IP video surveillance network. He has also worked on design of fixed, mobile and airborne surveillance systems as well as performing engineering research, design and deployment of specialized communication, exploitation and biometric systems for use by DoD combatant commands and SOCOM elements.

Gema **Howell**

Gema Howell is an IT Security Engineer at the National Institute of Standards and Technology (NIST). Gema works to create reference architectures for enterprise mobile deployments at the National Cybersecurity Center of Excellence (NCCoE). Also, Gema researches methods to secure Band 14 devices and wearables tailored to public safety. Prior to this effort, Gema researched mobile isolation systems and mobile application vetting solutions for public safety. Outside of mobile security, Gema actively participates in the development of standardization for voting systems.

Sarah **Hughes**

Sarah Hughes joined the Public Safety Communications Research (PSCR) Division's Open Innovation team in April 2018 and serves as a Prize Competition and Challenge Specialist. In this role, she manages internal and external R&D, communications, legal, administrative, and procurement resources to design and implement prize competitions and challenges to advance PSCR's mission. She is responsible for managing all aspects of the prize competitions and challenges assigned to her within the Open Innovation portfolio. Prior to PSCR, Sarah supported entrepreneurs, small businesses, and innovation at the U.S. Small Business Administration (SBA) for five years in many different roles within Colorado and Washington, DC. Sarah first started her federal public services as Presidential Management Fellow. Sarah holds a Master of Public Affairs degree from the School of Public and Environmental Affairs (SPEA) at Indiana University and a Bachelor of Arts degree from DePauw University.

Alison **Kahn**

Alison Kahn is an Electronics Engineer with NIST's Public Safety Communications Research Group (PSCR). Alison is currently working on research related to Personal Area Networks for the next generation of first responders. Alison acts as the lab'slab's device liaison, working with vendors to ensure that public safety features are addressed in impending device releases to allow PSCR to release and test cutting edge technology for the future of public safety. Alison has 14 years of experience in the telecommunications industry. Before joining PSCR in 2016, she worked on end to end device interoperability programs for companies such as Motorola and Nokia. She also worked with commercial carriers to develop and implement carrier-specific and industry standard interoperability with the company's network equipment. Alison's education includes a Bachelor's of Science in Mathematics and Computer Science from the Colorado School of Mines.

Zak **Kassas**

Dr. Zak Kassas is an Assistant Professor in the Department of Mechanical & Aerospace Engineering and the Department of Electrical Engineering & Computer Science at the University of California, Irvine (UCI). He received a B.S. in Electrical Engineering from the Lebanese American University, an M.S. in Electrical & Computer Engineering from The Ohio State University, and an M.S.E. in Aerospace Engineering and a Ph.D. in Electrical & Computer Engineering from The University of Texas at Austin. Prof. Kassas' research in autonomous navigation in GNSS-challenged environments has been featured in dozens of national and international media outlets and received several awards, including the National Science Foundation (NSF) CAREER Award, the Office of Naval Research (ONR) Young Investigator Program Award, the IEEE Walter Fried Award, and the ION Burka Award. Since starting his academic career in Fall 2014, his research has attracted more than $3M in federal grants from

ONR, NSF, and NIST. His current research interests include cyber-physical systems, autonomous vehicle navigation, and intelligent transportation systems.

Heechang **Kim**

Dr. Heechang Kim has more than 17 years of experience in wireless communications spanning the areas of performance modeling and analysis, simulation, algorithm development, and prototype development of various commercial and military networking and wireless communication systems resulting in 3 granted patents and numerous technical papers. He is currently working on Device-to-Device System for Public Safety (DDPS) project, where he develops LTE ProSe prototype system and leads LTE Sidelink resource allocation research. Other recent work experience includes DARPA Concerto, Dynamo, 100G and Mobile Hotspots, in which he developed aircraft simulation platforms for modeling flight paths and communication links performance, and designed dynamic spectrum optimization algorithms for an airborne network. In SET S&T program, he helped design capacity assignment algorithms for iNET telemetry networks and led performance analysis study by conducting OPNET and Linux testbed experiments of the capacity assignment algorithms. He also participated in the development of a wireless optimization tool called AutoRF where he helped develop algorithms

to optimize frequency /power assignments for GSM/CDMA/UMTS wireless networks for balancing the load of each cell. Heechang Kim holds a Ph.D. in Electrical and Computer engineering from Polytechnic University in Brooklyn, NY. He served as an Adjunct Professor at New Jersey Institute of Technology from 2007 to 2013.

Hun-Seok **Kim**

Hun-Seok Kim is an assistant professor at the University of Michigan, Ann Arbor. Kim received his B.S. degree from the Seoul National University (South Korea), and M.S. & Ph.D. degrees from the University of California, Los Angeles (UCLA), all in Electrical Engineering. His research focuses on system analysis, novel algorithms, and efficient VLSI architectures for low-power/high-performance wireless communication, signal processing, computer vision, and machine learning systems. Before joining the University of Michigan, Kim worked as a technical staff member at Texas Instruments (2010 – 2014). He is serving as an associate editor of IEEE Transactions on Green Communications & Networking, and IEEE Solid State Circuits Letters. Kim is a recipient of the 2018 Defense Advanced Research Projects Agency (DARPA) Young Faculty Award (YFA).

Ezra **Kissel**

Ezra Kissel holds the position of Assistant Scientist within the Department of Intelligent Systems Engineering at Indiana University. His interests include high-performance networking, distributed systems, and software defined networks.

Regis **Kopper**

Dr. Regis Kopper is an assistant research professor of Mechanical Engineering and Materials Science, and Computer Science at Duke University and the director of the Duke immersive Virtual Environment (DiVE) Lab. Dr. Kopper has experience in the design and evaluation of virtual reality systems in the areas of interaction design and modeling, virtual human interaction and in the evaluation of the benefits of immersive systems. His research interests include 3D user interfaces, novel interaction techniques and immersive display systems. Dr. Kopper is a recipient of the best paper award in the IEEE Symposium in 3D User Interfaces and was a member of the first team to be awarded the IEEE 3D User Interfaces Grand Prize. His research has been funded by NIST, DoD, NSF and NIH. Dr. Kopper received his B.A. and M.S. in Computer Science from the Pontifical Catholic University in Porto Alegre, Brazil and his Ph.D. in Computer Science from Virginia Tech.

David **Kortenkamp**

David Kortenkamp is a senior scientist with TRACLabs. He has numerous technical publications in the areas of robotics, artificial intelligence, and augmented reality. He is working on NASA human spaceflight projects involving augmented reality and automation.

Jeff **Kunst**

Jeff Kunst is Vice President of Product Development at TRX Systems and is responsible for full life-cycle product management of TRX's patented NEON Location Solutions including NEON Personnel Tracker and NEON Signal Mapper. He has more than 20 years of leading-edge technology development in optics, wireless, and mobile app development. Prior to TRX, Jeff held leadership roles in product management, strategy, marketing, and business development at large technology companies as well as venture backed start-ups including MobileAccess, Corning, Lucent and Chromatis. He earned a B.S. degree in Electrical Engineering from the U.S. Coast Guard Academy and a M.S. degree in Electrical Engineering from The George Washington University.

Charles **Laird**

Charles Laird serves as a part-time first-responder subject-matter expert and community manager for NextGen Interactions. He works full-time for the First Responder Emerging Technologies Program in the Broadband Infrastructure Office of the North Carolina Department of IT, where he is the Program Specialist. Charles is also a volunteer firefighter with the Youngsville Fire Department in Franklin County, North Carolina, and has been in the fire service for 12 years. He previously worked for Emergency Management for 4 years as a Search and Rescue Coordinator and Emergency Management Officer. He has always been a "technology buff" and is excited to be supporting our first responder community in the technology space.

Richard **Lau**

Dr. Richard C. Lau has over 25 years of experience in wireless and mobile technologies, signal processing and program management. He received his Ph.D. from the University of Pennsylvania in 1987. His research and contribution span multiple disciplines in mobile networks, power grid security, and deep learning. His recent research includes LTE D2D networks, predictive distributed-MIMO networking, cyber security, and neural networks for anomaly identification. Dr. Lau is co-Principal Investigator for the NIST Device-to-device System for Public Safety project. He was the Principal Investigator for multiple government programs including Adaptive Cognition Enhanced Ratio Team (DARPA), GPS-denied navigation system (ONR), and demand response for smart grid (NIST). He was inducted into the New Jersey Hall of Fame and received the New Jersey Inventor of the year award in 1997 for his contribution to broadband network, elected as Perspecta Labs (formerly Telcordia) Fellow in 2004, and co-authored a book on "Service assurance for VoWiFi and 3G networks" in 2005 (Artech House).

Joel **Lawhead, PMP, GISP**

Mr. Lawhead has worked as a geospatial developer and analyst for 18 years. He is a certified Project Management Professional and certified Geographic Information Systems Professional. He has managed geospatial projects for NASA, NOAA, the Navy, USGS, Army, NGA, FEMA, and the states of Louisiana, Mississippi, and Florida. His work includes Lidar analysis for multiple agencies. He has used Lidar mapping in public safety applications for FEMA and the Hancock Emergency Operations Center. Mr. Lawhead has written four books and two training video series through Packt Publishing on automated GIS processing including Lidar data.

Scott **Ledgerwood**

Scott Ledgerwood's work in the Public Safety Communication Research (PSCR) Division at NIST is focused on improved usability and user interface testing for first responders. His team is developing new test methodologies leveraging virtual and augmented reality to enable improved research, testing and development of first responder technologies. Prior to joining NIST in 2015, Scott worked at the DHS-CBP where he managed cybersecurity teams responsible for Risk Assessments and FISMA Compliance. Scott holds a BS in Applied Information Technology from George Mason University, an MBA from Bellevue University and an MS in Telecommunications from University of Colorado Boulder. Scott moved from the Washington, D.C. area to join NIST in 2015. He is thoroughly enjoying the beautiful scenery with his wife, son and goldendoodle. Scott is an avid triathlete, mountain biker, and an occasional participant in the Scottish Highland Games.

Junwei **Liang**

Junwei Liang is a Ph.D. candidate in the Language Technologies Institute at Carnegie Mellon University. He received a degree from Renmin University, Beijing, China, in 2015, where he worked as a research assistant in the multimedia lab. He received the Master of Language Technologies degree from the Language Technologies Institute at Carnegie Mellon University in 2017. He was at Google Inc., Pittsburgh, PA, as a student researcher in 2018. His research interests include computer vision, natural language processing and machine learning.

Fidel **Liberal**

Dr. Fidel Liberal (MCOP coordinator) is a well-recognized expert in the Mission Critical communications environment. He currently works in the University of the Basque Country (UPV/EHU) where he leads different mission critical communications and 5G related R&D projects. In recent years, he has been very active in the field of Public Safety communications related to both NG911/NG112 systems and next generation Public Safety systems. He has served as technical expert in NG112 and MCPTT interoperability events organized by ETSI and has co-founded two security & mission critical communications related Spin-Offs.

Dr. Yingzi **Lin**

Dr. Yingzi Lin is the director of the Intelligent Human-Machine Systems (IHMS) Laboratory, and Associate Professor in the Department of Mechanical and Industrial Engineering, College of Engineering, Northeastern University, Boston, MA, USA. She received a Ph.D. in mechanical engineering from the University of Saskatchewan (Saskatoon, Canada). She is a recipient of NSF CAREER award and NSERC University Faculty Award. Her area of expertise includes: intelligent human-machine systems, virtual environment simulation, smart structures and systems, sensors and sensing systems, human machine interface design, and human friendly mechatronics.

Chunmei **Liu**

Chunmei Liu has more than 15 years of academica and industry research and product experience in wireless communications and networking area. She received athe PhD degree in Computer Systems from MIT.

Harald **Ludwig**

Mr. Harald Ludwig is the chairman of the TCCA Technical Forum, working on interoperability and testing of standard-based critical communications solutions. Harald has more than 20 years of experience in mission critical communications, e.g. in development and testing of safety-critical communication systems, integration of command and control systems and end-to-end design of nationwide public safety systems.

Jani **Lyrintzis**

Mr. Jani Lyrintzis is North-American VP and GM of the Bittium USA, Inc, a developer of cutting-edge secure embedded technology solutions for wireless markets including public safety and defense by leveraging its mass market cellular expertise. Jani has over 25 years of wireless product development experience with a diverse set of leadership positions at Bittium, and brings a wealth of industry knowledge to Bittium – from and across various wireless technologies, including LTE, WCDMA/HSPA+, GSM/GPRS/EDGE, Mobile Satellite Services, P25, TETRA, to name a few.

Andrew **Markham**

Andrew is Co-I of the NIST IPSER project and works in the Cyber Physical Systems group at the University of Oxford.

Maxwell **Maurice**

Maxwell is a Physicist and an Electronics Engineer at the Communications Technology Laboratory (CTL) with the Public Safety Communications Research (PSCR) Division. He primarily performs system integration and testing of Mobile Broadband Communications systems and is currently focused on the Highly Mobile Deployed Networks project (HMDN). Maxwell has previously worked with RF systems before joining PSCR in March 2017. He holds a Bachelor of Science in Engineering Physics from the University of Colorado at Boulder and is a graduate student in the Master of Engineering program within the Electrical, Computer & Energy Engineering department.

Alessio **Medda**

Dr. Alessio Medda (Senior Research Engineer at GTRI) is the project Co-PI and main technical lead. He will supervise laboratory testing, field testing events and exercises designed to generate publicly releasable dataset, and to develop models for mission critical voice QoE. Dr. Medda has more than 10 years of experience in Electrical Engineering and Signal Processing and he is a Senior Member of IEEE and Chair of the Atlanta Signal Processing Chapter. He also serves as a part-time instructor at the Georgia Institute of Technology, Department of Electrical and Computer Engineering and he has published 10 refereed journal papers and more than 20 refereed conference papers with proceedings.

Salvador **Medina**

Salvador Medina is a Ph.D. student in the Language Technologies Institute at Carnegie Mellon University. He received a Master's degree in Computer Science from ITAM, CDMX, Mexico; and a Master's degree in Language Technologies from the Language Technologies Institute at Carnegie Mellon University. He recently worked for the just-walk-out store project from Amazon: Amazon Go. His research interests lie within the fields of computer vision and multimodal machine learning.

Paul **Merritt**

Paul Merritt joined the PREP Program at CU Boulder in September 2018, working at NIST in the PSCR division. He has completed three projects in Augmented Reality as part of the UI/UX portfolio. They are simulations intended for firefighters, bomb technicians, and police officers: one for the Microsoft Hololens, one for the Magic Leap One, and one for the Vuzix Blade.

Justin **Mette**

Justin Mette is Director of VR Development for Health Scholars. He has over 20 years of experience running large

development teams. He has run his own development companies, having worked on hit games, including Rock Band and Rockstar Rising. In 2015 he started a studio to work on VR and AR development. The level of immersion in VR led him to consider voice recognition as a natural extension of that immersion. He did considerable work on voice-controlled UI during that time and has brought that background to Optera Group.

Marco **Mezzavilla**

Dr. Marco Mezzavilla is a Research Scientist at NYU Tandon School of Engineering, where he leads various mmWave-related research projects, mainly focusing on 5G PHY/MAC design. He received a B.Sc. (2007) and a M.Sc. (2010) in Telecommunications Engineering from the University of Padova (Italy), and a Ph.D. (2013) in Information Engineering from the same university. He held visiting research positions at the NEC Network Laboratories in Heidelberg (Germany, 2009), at the Telematics Department at Polytechnic University of Catalonia (UPC) in Barcelona (Spain, 2010) and at Qualcomm Research in San Diego (USA, 2012). He has authored and co-authored multiple papers in conferences, journals and some patent applications. He is serving as reviewer for many IEEE and ACM conferences, journals and magazines. His research interests include design and validation of communication protocols and applications to Fourth-generation (4G) broadband wireless technologies, millimeter wave communications for 5G networks, multimedia traffic optimization, radio resource management, spectrum sharing, convex optimization, cognitive networks and experimental analysis.

Barbara **Minsker**

Dr. Barbara Minsker is the Bobby B. Lyle Professor of Leadership and Global Entrepreneurship and a senior fellow in the Hunt Institute for Engineering and Humanity. Dr. Minsker holds a B.S. (Cornell University 1986) in operations research and industrial engineering, and Ph.D. (Cornell University 1995) in environmental and water resources engineering. She was on the faculty at the University of Illinois from 1996 to 2016. Dr. Minsker's research focuses on developing innovative systems approaches to improve sustainability and resilience of coupled human and natural systems, with a particular focus on integrating machine learning and social computing with "Big Data." Dr. Minsker has received numerous awards for her research, including the National Science Foundation CAREER Award, Army Young Investigator Award, Presidential Early Career Award for Scientists and Engineers, and the American Society for Civil Engineers (ASCE) Walter L. Huber Civil Engineering Research Prize.

Andreas **Molisch**

Andreas F. Molisch is Professor and Solomon Golomb - Andrew and Erna Viterbi Chair at the University of Southern California . His research interest is wireless communications, with emphasis on wireless propagation channels, multi-antenna systems, ultrawideband signaling and localization, novel cellular architectures, and cooperative communications. He is the author of four books, 19 book chapters, more than 240 journal papers, 320 conference papers, as well as 80 patents. He is a Fellow of the National Academy of Inventors, IEEE, AAAS, and IET, as well as a Member of the Austrian Academy of Sciences and recipient of numerous awards.

Brian **Moore**

Dr. Brian E. Moore is CoFounder and CTO of Voxel51. He holds a Ph.D. in Electrical Engineering from the University of Michigan, where his research was focused on efficient algorithms for large-scale machine learning problems, with a particular emphasis on computer vision applications. He has authored dozens of articles in peer reviewed journals and conference proceedings on various topics in machine learning, statistics, and optimization. At Voxel51, Dr. Moore coleads the technical strategy and vision and is actively involved in the design and execution of the core software infrastructure.

Hien **Nguyen**

Hien Nguyen is an Electronics Engineer in the Communications Technology Laboratory at the National Institute of Standards and Technology (NIST). Before joining NIST in 2015, Mr. Nguyen worked as an avionics system engineer for eight years and has been working in the telecommunications industry for the last 20 years, particularly in the GSM, WCDMA and LTE environments. He is currently working on a deployable systems project, assessing the state of the industry and investigating different and unique aspects of the systems in relation to public safety.

Michael **Ogata**

Michael Ogata has worked for the National Institute of Standards and Technology (NIST) since 2005. Michael is currently serving as Co-Lead for the PSCR Cybersecurity group. He is also lead on the mobile application security research efforts being undertaken by PSCR. For the past 4 years, Michael has worked closely with members of the public safety community to explore mobile application concerns unique to that audience. In addition to his public safety work, his other roles at NIST revolve around digital forensics, specializing in mobile application forensics. Michael has a Bachelor of Science in Computer Science from the University of Maryland, Baltimore County.

Dereck **Orr**

Dereck Orr is the Division Chief for the Public Safety Communications Research Division at NIST's Communication Technology Laboratory, and has held that position since December 2002. In that role, he leads the Public Safety Communications Research (PSCR) program that serves as an objective technical advisor and laboratory to FirstNet, the Department of Homeland Security, and public safety to accelerate the adoption and implementation of the most critical public safety communication standards and technologies. From October 2003 until October 2004, Mr. Orr was detailed to the Department of Homeland Security to serve as the Chief of Staff of the SAFECOM Office within the Science and Technology Directorate, to help establish the new program. Prior to working at NIST, Mr. Orr served as a professional staff member of the Senate Appropriations Subcommittee for the Departments of Commerce, Justice, and State, and Related Agencies under Senator Fritz Hollings. In that position, Mr. Orr was responsible for the appropriations accounts relating to state and local law enforcement issues. Prior to that, Mr. Orr served four years at the Office of Community Oriented Policing Services (COPS) at the Department of Justice. Mr. Orr received a Masters in Public Policy from the College of William and Mary and a Bachelor of Arts in American History from the University of Texas at Austin.

Jaden **Pieper**

Jaden Pieper has worked for NIST/PSCR since December 2015. He graduated with his M.S. in Applied Mathematics in May 2017 from the University of Colorado Boulder.

Michelle **Polese**

Michele Polese received a B.Sc. degree in information engineering and a M.Sc. degree in telecommunication engineering from the University of Padova, Italy, in 2014 and 2016, respectively, where he is currently pursuing a Ph.D. degree with the Department of Information Engineering, under the supervision of Prof. M. Zorzi. He visited New York University in 2017, AT&T Labs, Bedminster, NJ, in 2018, and Northeastern University, Boston, MA, in 2019. He is collaborating with several academic and industrial research partners, including Intel, InterDigital, NYU, AT&T Labs, University of Aalborg, King's College, Northeastern University and NIST. His research interests are in the analysis and development of protocols and architectures for the next generation of cellular networks (5G), in particular for millimeter-wave communication, and in the performance evaluation of complex networks.

Dr. Pedro **Porto Buarque de Gusmao**

Pedro is a postdoctoral researcher on the NIST IPSER project at the University of Oxford. He is working on developing thermal-inertial odometry.

Sarah **Masud Preum**

Sarah Masud Preum is a PhD candidate in the Department of Computer Science at the University of Virginia working under the supervision of Prof. John Stankovic. She focuses on developing data-driven, knowledge-integrated information extraction and fusion systems to provide personalized decision support for safety critical health applications, including health intervention recommendation for chronic disease patients, anomaly detection for remote health monitoring, and real-time decision support for emergency response. Specifically, the goal is to infer the contexts and semantics of textual and time-series data generated from heterogeneous sources (e.g., health and wellness apps, in-situ sensors) using novel natural language processing, knowledge extraction and temporal modeling techniques. She published several papers in flagship conferences for data mining and pervasive computing including PerCom, CIKM, and ICDE.

Dr. K.K**. Ramakrishnan**

K. K. Ramakrishnan is a Professor of Computer Science and Engineering at the University of California, Riverside.

Previously, he was a Distinguished Member of Technical Staff at AT&T Labs-Research. He joined AT&T Bell Labs in 1994 and was with AT&T Labs-Research since its inception in 1996. Prior to 1994, he was a Technical Director and Consulting Engineer in Networking at Digital Equipment Corporation. Between 2000 and 2002, he was at TeraOptic Networks, Inc., as Founder and Vice President. Dr. Ramakrishnan is an ACM Fellow, IEEE Fellow and an AT&T Fellow, recognized for his fundamental contributions on communication networks, congestion control, traffic management, VPN services, and a lasting impact on AT&T and the industry. His work on the "DECbit" congestion avoidance protocol received the ACM Sigcomm Test of Time Paper Award in 2006. He has published over 250 papers (with a few best paper awards) and has 172 patents issued in his name. K.K. has been on the editorial board of several journals and has served as the TPC Chair and General Chair for several networking conferences. K. K. received his MTech from the Indian Institute of Science (1978), MS (1981) and Ph.D. (1983) in Computer Science from the University of Maryland, College Park, USA.

Santosh **Rajvaidya**

Santosh Rajvaidya is responsible for Product Management at Nok Nok Labs. Prior to Nok Nok, he was responsible for strategy and execution of Cloud Identity and Access Management Service at Cisco. Santosh has led a variety of security and analytics initiatives at Cisco and Brocade over the years. Santosh holds an MBA from UC, Berkeley - Haas School of Business and MS in Computer Science from the University of North Carolina.

Samuel **Ray**

Sam Ray is an Electronics Engineer with the Public Safety Communications Research Division (PSCR) at NIST's Communication Technology Laboratory. In that role, he serves as the portfolio lead for PSCR on projects sponsored by the Department of Homeland Security and as a technical contributor to various projects in the portfolio. He also oversees the engagement of students in PSCR's mission through NIST student programs. Prior to his arrival at NIST in 2016, Mr. Ray spent 20 years in various system test, deployment and engineering management roles in cellular/LTE infrastructure and device teams for Motorola and Nokia. Sam earned his BA from Hardin-Simmons University and BSEE from Texas Tech University and studied Systems Engineering at the University of Texas at Arlington.

Richard **Rouil**

Richard Rouil is a researcher working in the Wireless Networks Division at the National Institute of Standards and Technology (NIST). He holds a Ph.D. in Computer Science from Telecom Bretagne, France (2009) that focused on mobility in heterogeneous networks. His main interests include protocol modeling and simulation of communication networks. He is currently leading a team of researchers that focuses on the performance evaluation of wireless technologies such as LTE to support the deployment of networks used by Public Safety.

Anthony **Rowe**

Anthony Rowe is an Associate Professor in the Electrical and Computer Engineering Department at Carnegie Mellon University. His research interests are in networked real-time embedded systems with a focus on wireless communication. His most recent projects have related to large-scale sensing for critical infrastructure monitoring, indoor localization, building energy-efficiency and technologies for microgrids. His past work has led to dozens of hardware and software systems, five best paper awards and several widely adopted open-source research platforms. He earned a Ph.D in Electrical and Computer Engineering from CMU in 2010, received the Lutron Joel and Ruth Spira Excellence in Teaching Award in 2013, the CMU CIT Early Career Fellowship and the Steven Ferves Award for Systems Research in 2015 and the Dr. William D. and Nancy W. Strecker Early Career chair in 2016.

Cole **Sandau**

Cole Sandau is Chief Executive Officer of Optera Group/Health Scholars. Cole has been involved in a variety of VR projects over the past 8 years and pioneered industry innovations in VR. He has presented dozens of talks on VR and has been featured in television and trade news stories regarding VR.

Bartolo **Scanavino**

Mr. Bartolo Scanavino is the Solution and Market Manager at ENENYS/Expway in charge of the public safety market. He has worked at Expway since 2007 and has been in charge of project management for the deployment of DVB-H, ATSC-MH and

LTE broadcast.

Henning **Sculzrinne**

Prof. Henning Schulzrinne, Levi Professor of Computer Science at Columbia University, received his Ph.D. from the University of Massachusetts in Amherst, Massachusetts. MTS at AT&T Bell Laboratories; associate department head at GMD-Fokus (Berlin), before joining the Computer Science and EE departments at Columbia University. He served as chair of Computer Science from 2004 to 2009 and as Engineering Fellow, Technical Advisor and Chief Technology Officer of the Federal Communications Commission (FCC) from 2010 until 2017. Protocol standards co-developed by him, including RTP, RTSP and SIP, are now used by almost all Internet telephony and multimedia applications. Fellow of the ACM and IEEE.

Shishir **Shah**

Shishir Shah is Professor and Associate Chair in the Department of Computer Science at the University of Houston. His current research focuses on fundamentals of computer vision, pattern recognition, and statistical methods in image analysis with applications in multi-modality sensing, video analytics, object recognition, biometrics, and microscope image analysis. Shah has served as principal-investigator or co-investigator on variety of research projects funded by ARL, ONR, NSF, IARPA, DoJ, NIST, and private companies. In recent years, his research efforts have led to innovative algorithms in video analytics. Shah currently serves as an Associate Editor for Image and Vision Computing and the IEEE Journal of Translational Engineering in Health and Medicine. He received the College of Natural Science and Mathematics John C. Butler Teaching Excellence Award in 2011. He also has extensive industrial experience and has served in varying capacities in hi-tech companies ranging from Software Developer, Project Manager, to Chief Operating Officer and President. He has been an integral contributor to commercializing imaging, image analysis and data mining software products from BioDiscovery, Inc, Spectral Genomics, Inc, and Spin Diagnostics, Inc.

Zongru (Doris) **Shao**

Dr. Zongru (Doris) Shao is a Senior R&D Engineer at Spectronn. Her expertise is in AI, machine learning, natural language processing, and video analytics. She leads the AI R&D and product strategy. Dr. Shao is a recipient of a number of awards including the New Jersey Technology Council's Innovators to Watch – Rising Stars in STEEM.

Dr. Hulya **Seferoglu**

Hulya Seferoglu is an Assistant Professor in the Electrical and Computer Engineering

Department of the University of Illinois at Chicago (UIC). She received a B.S. degree in Electrical Engineering from Istanbul University, M.S. degree in Electrical Engineering and Computer Science from Sabanci University, and Ph.D. degree in Electrical and Computer Engineering from the University of California, Irvine. She worked as a Postdoctoral Associate in the Laboratory of Information and Decision Systems at the Massachusetts Institute of Technology before joining UIC. She worked as a summer intern at AT&T Labs Research, Docomo USA Labs, and Microsoft Research. She serves as an associate editor for IEEE/ACM Transactions on Networking (2017–2019), and executive editor for Transactions on Emerging Telecommunications Technologies (2016–2019). Her research interests are in the area of networking: design, analysis, and optimization of network protocols and algorithms. She is particularly interested in resilient networks, Device-to-Device (D2D) networking, computation for Internet of Things (IoT), network coding, and multimedia.

Andrei M. **Shkel**

Dr. Shkel has been on faculty at the University of California, Irvine since 2000, where he is now a Professor of Mechanical and Aerospace Engineering, Electrical Engineering and Computer Sciences, and Biomedical Engineering. From 2009 to 2013, he was on leave from academia serving as a Program Manager in the Microsystems Technology Office of DARPA, where he initiated and managed over $200M investment portfolio in technology development. His research interests are reflected in over 250 publications, 40 patents, and 2 books. Dr. Shkel has been on a number of editorial boards, most recently as Editor of IEEE/ASME JMEMS and the founding chair of the IEEE Inertial Sensors. Dr. Shkel is the IEEE Fellow and the 2018 President-Elect of the IEEE Sensors Council. He has been awarded in 2013 the Office of the Secretary of Defense Medal for Exceptional Public Service, the 2009 IEEE Sensors Council Technical Achievement Award, and the 2005 NSF CAREER award. He received his Diploma with excellence (1991) in Mechanics and Mathematics from Moscow State University, Ph.D.

degree (1997) in Mechanical Engineering from the University of Wisconsin at Madison, and completed his postdoc (1999) at UC Berkeley.

Donia **Slack**

Donia Slack is a Research Forensic Scientist at RTI International. Ms. Slack leads advanced technology projects in support of RTI's mission. A certified Project Management Professional (PMP), she has over 14 years of experience in the forensic community, directing and overseeing federally funded forensic software projects for genomic analyses of human, plant, and microbial DNA. She has managed complex research and operational efforts serving the DOD, DOJ, and the Intelligence Community, and has provided contractual and programmatic oversight of contracts and subcontracts. She is a co-inventor on two U.S. patents that were developed under federally funded research efforts and currently leads one of RTI's largest virtual reality programs, which focuses on the development of training programs for crime scene investigation and military exploitation of forensic evidence.

Randall **Spain**

Randall Spain is a Research Psychologist in the Center for Educational Informatics at North Carolina State University where he uses principles, theories, and methods of applied psychology (human factors, educational psychology, personnel psychology, experimental psychology, and psychometrics) to design and evaluate the impact of advanced training technologies on learning and performance. He has conducted training and human factors research for the Department of Defense and the Department of Homeland Security for the past 10 years with a focus on adaptive training, performance assessment and measurement, user modeling and human-automation interaction. He is a PhD graduate from Old Dominion University's Human Factors Psychology program and serves on the editorial board for Military Psychology.

Radu **Stoleru**

Dr. Stoleru is an Associate Professor in the Department of Computer Science and Engineering at Texas A&M University. His current research interests are in edge computing, cyber physical systems (CPS), Internet-of-Things (IoT), distributed systems, and wireless networking. He is the recipient of the NSF CAREER, a Fulbright Scholar, and several other awards. He has authored or co-authored over 90 conference and journal papers with over 5,000 citations.

Julie **Stroup**

Julie Stroup is the Program Manager for the City of Houston's Public Safety Video Initiative, a role she has held since its inception in January 2007. Utilizing a vision and grant funds provided by the Director of the Mayor's Office of Public Safety and Homeland Security, Julie has overseen the development and implementation of the strategic plan, project strategies and system infrastructure to implement the City's Public Safety Video System. Today, in addition to continuing to grow the capability and coverage of the current system, Julie serves as CTO for the IP-based wired and wireless infrastructure to support 950+ cameras owned and operated by the City and securely accessing over 500 more, and sharing cameras with 10 partner agencies and several City Departments. With a focus on Public Safety/Homeland Security/Critical Infrastructure Protection priorities, the system has proven to have the flexibility and scalability to continue to grow across the greater Houston region, some 600 square miles. Additionally, it provides the capability for collaboration during incident management and response scenarios. Julie also oversaw the upgrade an expansion of the Houston Police Department's helicopter downlink system to one that now includes 7 digital downlink sites and 9 aircraft.

In addition to her role with the City of Houston, Julie is currently serving as the Project Manager and City of Houston Technical lead for the University of Houston Computer Science Department's PSIAP research project entitled Multi-tiered Video Analytics for Public Safety, funded by NIST. In conjunction with her counterparts in other U.S. cities, Julie has developed "Sister City" relationships across the country with others undertaking similar efforts.

Julie holds a Bachelor of Science degree in International Studies from the University of St. Thomas in Houston, Texas.

Dr. Patrick **Suermann**

Dr. Patrick Suermann is the head of Department of Construction Science at Texas A&M University. Before joining Texas A&M, he was lieutenant colonel and the chief of emergency services and engineering at an Air Force mission support center in San Antonio, where he coordinated more than 700 personnel while managing $16 billion in fire emergency services, emergency management and explosive ordnance disposal projects around the world. A 2003 Texas A&M Master

of Construction Management graduate, Dr. Suermann also earned a Ph.D. in Design, Construction, and Planning at the University of Florida in 2009 and a Bachelor of Civil Engineering degree at the U.S. Air Force Academy in 1997.

Paul **Sutton**

Paul Sutton is the co-founder and CEO of Software Radio Systems (SRS). Founded in 2012, SRS is a profitable, bootstrapped company employing 9 highly-skilled engineers across Ireland and Spain. SRS is the company behind the srsLTE project – an open-source suite of software radio libraries and applications for the complete end-to-end LTE ecosystem. Paul has more than 15 years of experience in software radio development for heterogeneous processor platforms.

Martin **Swany**

Martin Swany is Professor and Chair of the Department of Intelligent Systems Engineering at the School of Informatics, Computing, and Engineering at Indiana University, Bloomington. His research areas include computer networks, high performance computing, the Internet of things, and parallel and distributed computing.

Christine **Task**

Dr. Christine Task is a Senior Computer Scientist at Knexus Research Corporation. Her research interests include privacy-preserving synthetic data, differential privacy, noise-resistant analytics, and social network analysis. She is the technical lead on the National Institute of Standards and Technology (NIST) Differential Privacy Synthetic Data Challenge, the first national challenge in Differential Privacy. She is the data architect on the Knexus CenSyn project, which develops production grade privacy-preserving software for the US Census Bureau. And, she is primary investigator on PRESNA, a project under the DARPA Brandeis program which is developing noise-resistant decision metrics that operate reliably over differentially private mobile calling data to help emergency responders efficiently detect and analyze an evolving crises. Previously, Dr. Task led the Privatized Analytics at Knexus (PAK) project, which developed a tool that allows employees to compare statistics about their own performance with differentially private performance statistics aggregated over other company employees. She earned her B.S. in Mathematics at Ohio State University, and her Ph.D. in Computer Science from Purdue University, with a thesis focus on privacy-preserving social network analysis. Her tutorial “A Practical Beginners’ Guide to Differential Privacy”, presented to the Center for Education and Research on Information Assurance and Security (CERIAS) Seminar in April 2012, has been viewed online over 7,500 times.

Mary **Theofanos**

Mary Theofanos is a Computer Scientist with the National Institute of Standards and Technology’s Material Measurement Laboratory where she performs research on usability and human factors of systems. Mary is the project lead for the Public Safety Communications Research (PSCR) usability effort evaluating human factors and usability of PSCR technology. She is the Program Manager responsible for developing standards for usability. She represents NIST on the ISO JTC1 SC7 TAG and is Convener of WG 28 on usability of software systems. She is the principal architect of the Usability and Security Program evaluating the usability of cyber security and biometric systems. She established the Biometrics Usability Program for the federal government, the first open research program to incorporate usability into biometrics research, elevating usability to a recognized critical component of biometrics research and developing standards for SC37. Before joining NIST, she was the Manager of the National Cancer Institute’s (NCI) Communication Technologies Research Center (CTRC). She spent 15 years as a program manager for software technology at the Oak Ridge National Laboratory complex of the U.S. Department of Energy.

Tim **Thompson**

Tim Thompson has over 20 years’ experience in RF engineering. He has worked for NIST/PSCR since September 2016. His experience includes working for Motorola, Hewlett-Packard, Agilent Technologies, AT&T, and Idaho National Laboratory.

Niki **Trigoni**

Niki is PI of the NIST IPSER project and is head of the Cyber Physical Systems group at the University of Oxford.

David **Van Ballegooijen**

David Van Ballegooijen has 15 years of experience managing small teams in a wide variety of fields, including politics,

technology, for-profit and non-profit organizations. He is the General Manager of the Western Fire Chiefs Association.

Robert **van Renesse**

Robbert van Renesse is a Research Professor in the Department of Computer Science at Cornell University, interested in the theory and practice of fault tolerant, secure, and scalable distributed systems. He has developed widely used distributed algorithms such as Chain Replication and Scuttlebutt (State Reconciliation for Gossip Protocols). He is a Fellow of the ACM, and currently serves as Chair of the ACM Special Interest Group on Operating Systems (SIGOPS).

Chris **Walton**

Christopher Walton transitioned to PSCR from private industry in December of 2014. After completing a Bachelor of Science in Electrical Engineering (1989) from the University of Texas at Arlington, Chris was a civilian employee of the United States Army Information Systems Engineering Command (USAISEC), where he designed and deployed RF systems. Chris left USAISEC to return to UTA where he completed a Master of Science in Electrical Engineering in 1996. Working for international telecom vendors, he gained experience testing 2G cellular technologies while working with system test teams. In the later portion of his industry experience, he led the deployments of 3G and LTE wireless technologies in both domestic and international markets. After joining PSCR, Chris's research focus has been in the areas of local control and quality of service, priority and preemption on LTE broadband networks.

Lan **Wang**

Lan Wang is Professor and Chair of the Computer Science Department at the University of Memphis. Her research focuses on improving the scalability, reliability, and security of the Internet. She has received seven research grants from the NSF, DARPA, and industry. In particular, she is on a team that has received over $15 million in grants from the NSF Future Internet Architecture program to develop the "Named Data Networking (NDN)" architecture. Her research has led to more than 70 peer-reviewed publications with over 6400 citations, an H-index of 32, two US patents issued and one patent pending, as well as routing and forwarding software deployed on the global NDN testbed and emulation software used by NDN researchers. Her work on named data networking, multi-modal sensor system for target tracking, radar-based system for target material classification, secure data sharing among autonomous vehicles, and secure medical sensor networks provides a solid foundation for this project.

Dr. Ryan **Qi Wang**

Dr. Ryan Qi Wang is an Assistant Professor at the Department of Civil and Environmental Engineering, Northeastern University and the Associate Director of Research on Social Media at the Boston Area Research Initiative (BARI). He is interested in the interplay between data science and computational social science. His research focuses on two interrelated areas: human movement perturbation under the influence of natural and manmade disasters, and mobility equality in big cities. Before joining Northeastern in 2016, Ryan was a postdoc fellow at the Department of Sociology, Harvard University (2015-2016). He received my Ph.D. degree from the Department of Civil and Environmental Engineering at Virginia Tech (2015). During his time at Virginia Tech, he was also the first Ph.D. Fellow at BioBuild, an interdisciplinary program, and a Via Teaching Fellow. He obtained his M.S. in Construction Management from Michigan State University (2011) and B.S. in Chemical Engineering from Tianjin University in China (2007).

Dr. Johan **Wahlstrom**

Johan is a postdoctoral researcher on the NIST IPSER project at the University of Oxford. He is working on developing inertial odometry and mapping and magneto-inductive positioning.

Andrew **Weinert**

Andrew Weinert is a member of the Humanitarian Assistance and Disaster Relief Systems Group in the Homeland Protection and Air Traffic Control Division at MIT Lincoln Laboratory. Mr. Weinert joined the Laboratory in 2009, focusing on drone airspace integration and public safety information systems while supporting two R&D 100 Award winning programs. His master's thesis focused on optimization of aircraft avoidance using information theory and parallel processing techniques. In recent years for the public safety community, he has supported NIST R&D roadmaps, produced actionable intelligence from open-source and social media data, and optimized allocation of drones for disaster and incident

response. Mr. Weinert is currently serving as the technical lead for a NIST Public Safety Innovation Accelerator Program to generate representative public safety video datasets and leverage edge computing to improve tactical communications. He received a MS in Electrical and Computer Engineering at Boston University and a BS in Security and Risk Analysis with minors in Information Science Technology for Aerospace Engineering and Natural Science from the Pennsylvania State University. Mr. Weinert also serves on the Pennsylvania State University College of Information Sciences Alumni Society Board, holds a FAA remote pilot certificate (Part 107), and a FCC amateur radio license.

Moe **Z. Win**

Moe Win is a Professor at the Massachusetts Institute of Technology (MIT) and the founding director of the Wireless Information and Network Sciences Laboratory. Prior to joining MIT, he was with AT&T Research Laboratories and NASA Jet Propulsion Laboratory. His research encompasses fundamental theories, algorithm design, and network experimentation for a broad range of real-world problems. His current research topics include network localization and navigation, network interference exploitation, and quantum information science.

Professor Win is a Fellow of the AAAS, the IEEE, and the IET. He has served the IEEE Communications Society as an elected Member-at-Large on the Board of Governors, as elected Chair of the Radio Communications Committee, and as an IEEE Distinguished Lecturer. He was honored with two IEEE Technical Field Awards: the IEEE Kiyo Tomiyasu Award and the IEEE Eric E. Sumner Award (jointly with Professor R. A. Scholtz). Together with students and colleagues, his papers have received several awards. Other recognitions include the IEEE Communications Society Edwin H. Armstrong Achievement Award, the International Prize for Communications Cristoforo Colombo, the Copernicus Fellowship and the Laurea Honoris Causa from the Università degli Studi di Ferrara, and the U.S. Presidential Early Career Award for Scientists and Engineers. He is an ISI Highly Cited Researcher.

May **Yuan**

May Yuan received all her degrees in Geography: B.S. 1987 from National Taiwan University and M.S. 1992 and Ph.D. 1994 from State University of New York at Buffalo. She is the Ashbel Smith Professor of Geospatial Information Sciences and GIS Ph.D. director in the School of Economic, Political, and Policy Sciences at the University of Texas at Dallas (UT-Dallas). Before she joined UT-Dallas in August 2014, she was the Brandt Professor and Edith Kinney Gaylord Presidential Professor and Director of the Center for Spatial Analysis at the University of Oklahoma (1994-2014). She assumed the Editor in Chief of the International Journal of Geographical Information Science in 2017. Currently, she is the Vice President of US Cartography and Geographic Information Society (CaGIS) and serves on US NOAA Environmental Information Services Working Group (EISWG) and US National Geospatial Advisory Committee (NGAC) to Federal Geographic Data Committee. Her research interest expands upon space-time representation and analytics to understanding geographic dynamics. Over the years, she has been working to develop approaches to represent and model geographic processes and events in GIS databases to support space-time query, analytics, and knowledge discovery. She recently founded the Geospatial Analytics and Innovative Applications (GAIA) Lab at UT-Dallas. She and her students are exploring ways to capture and apply the concepts of place for space-time representation and analytics.

Dr. Murat **Yuksel**

Murat Yuksel is an Associate Professor at the ECE Department of the University of Central Florida (UCF), Orlando, FL. Prior to joining UCF in 2016, he was a faculty member at the CSE Department of the University of Nevada – Reno (UNR), Reno, NV. From 2006 to 2016, he was a member of Adjunct Faculty as a Postdoctoral Associate at the ECSE Department of Rensselaer Polytechnic Institute (RPI), Troy, NY. He received his B.S. degree in computer engineering from Ege University, Izmir, Turkey in 1996, and M.S. and Ph.D. degrees in computer science from RPI in 1999 and 2002, respectively. He worked as a software engineer at Pepperdata, Sunnyvale, CA and a visiting researcher at AT&T Labs and Los Alamos National Lab. His research interests are in the area of networked, wireless, and computer systems with a recent focus on big-data networking, UAV networks, optical wireless, public safety communications, device-to-device protocols, economics of cyber-security and cyber-sharing, routing economics, network management, and network architectures. He has been on the editorial board of Computer Networks, and published more than 150 papers at peer-reviewed journals and conferences and is a co-recipient of the IEEE LANMAN 2008 Best Paper Award. He is a senior member of IEEE, senior and life member of ACM, and was a member of Sigma Xi and ASEE.