Passive Wireless Sensor Technology (PWST) Workshop of 2019

Speaker Summaries

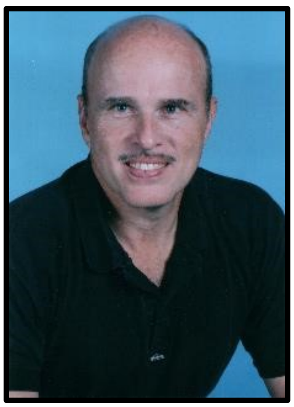
October 16 -18, 2019

PWST Workshop Chairs

Omar Torres **NASA Engineering and Safety Center (NESC)**
Omar.Torres@nasa.gov **Lead, Wireless Avionics Community of Practice**
757-864-1535 **NASA Langley Research Center**

Mr. Omar Torres serves as the lead of the NASA Wireless Avionics Community of Practice where he is responsible for bringing together engineers and managers from across the agency to share knowledge and lessons learned relating to wireless technologies. Mr. Torres has been resident at Langley Research Center in Hampton, VA for 15 years where he has contributed significantly to the research of Signals of Opportunity using GPS signals for remote sensing purposes. In addition, Omar has years of experience as an instrumentation and analysis engineer supporting the NASA Engineering and Safety Center (NESC) in high profile tests.

Dr. Don Malocha **CTO, Pegasense, LLC**
dcmalocha@cfl.rr.com **Pegasus-Professor Emeritus, E&CE Dept**
407-758-4446 **University of Central Florida, Orlando FL**



Dr. Donald C. Malocha is currently the CTO of Pegasense LLC, specializing in solid-state acoustic devices, wireless RF communications systems, and sensors. He is also Pegasus-Professor Emeritus in the Electrical and Computer Engineering Dept., University of Central Florida (UCF), Orlando. Don received a dual BS in electrical engineering (EE) and computer science (CS), an MS in EE, and Ph.D. degree in EE from the University of Illinois, Urbana. He was member of the technical staff (MTS) at Texas Instruments Corporate Research Laboratory, Mgr. of Advanced Product Development, Sawtek, and an MTS at Motorola. He has been a Visiting Scholar at the Swiss Federal Institute of Technology, Zurich (ETH), Switzerland, and the University of Linz, Austria. He is an Associate Editor of the IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS AND FREQUENCY CONTROL (UFFC), a UFFC AdCom Emeritus-member, and past-President of the IEEE UFFC Society. He is chair of IEC TC49.

George Studor **NASA Engineering and Safety Center**
George.f.studor@nasa.gov **Avionics Technical Discipline Team, consultant**
(281) 415-3986 **Wireless Avionics Community of Practice**

Mr. George Studor retired after 30 years with NASA in October 2013 in various senior program, engineering, educational and technology positions. Since then, he has concurrently been a consultant to the NASA Engineering and Safety Center for three Technical Discipline Teams (TDTs): Avionics TDT - Wireless Avionics Connections, Non-Destructive Evaluation TDT – In Space Inspection, and Robotic Spacecraft TDT – applying Natural Systems to System Engineering problems. Through the USAF, he received his BS in Astronautical Engineering from the USAF Academy in 1976, flew 2,000 hours as a C130 Pilot, and after receiving his MS in Astronautical Engineering from the Air Force Institute of Technology in 1982, he was detailed to NASA/JSC. Major Studor retired from the USAF in December 1999 after his "Fly-by-Wireless" project for the AFRL.

WiSEE Program

WiSEE 2019 Program						
Wednesday, October 16, 2019						
	7:00	8:30	Breakfast and Registration			
	8:30	9:10	Keynote: Roshdy Hafez, Carleton (Room A)			
	9:10	9:30	Break			
			Room A	Room B	Room C	Room D
S1	9:30	11:30	PWST-A	PWST-B	WiSEE	SSP
	11:30	12:30	Lunch			
	12:30	13:10	Keynote: Marco Mezavilla, NYU (Room A)			
	13:10	13:30	Break			
S2	13:30	15:30	PWST-A	PWST-B	WiSEE	SSP
	15:30	16:00	Break			
S3	16:00	17:30	PWST-A	PWST-B	WiSEE	SSP
	18:00	20:00	Reception			
Thursday, October 17, 2019						
	7:00	8:00	Breakfast and Registration			
	8:00	8:40	Keynote: Mason Peck, Cornell (Room A)			
	8:40	9:00	Break			
S4	9:00	11:30	PWST-A	PWST-B	WiSEE	SSP
	11:30	12:30	Lunch			
	12:30	13:10	Keynote: Rick Schwerdtgeger, US NSF (Room A)			
	13:10	13:30	Break			
S5	13:30	15:30	PWST-A	PWST-B	IGASC	SSP
	15:30	16:00	Break			
S6	16:00	17:30	PWST-A	PWST-B	IGASC	SSP
	18:30	20:30	Banquet Keynote: Giorgio Magistrati, ESA			
Friday, October 18, 2019						
	7:00	8:00	Breakfast and Registration			
	8:00	8:40	Keynote: Prakash Patnaik (Room A)			
	8:40	9:00	Break			
S7	9:00	10:30	PWST-A	PWST-B	STA	SSP Tutorials
	10:30	10:45	Break			
S8	10:45	12:00	PWST-A 1-on-1	PWST-B 1-on-1	STA	SSP Tutorials
	12:00	12:45	Box Lunch			
S9	13:00	14:40	PWST Panel		Canadian National Research Council (NRC) Tours	
	14:40	15:00	Break			
S10	15:00	16:30	PWST Panel			

PWST Workshop and Session Chairs

Passive Wireless Sensor Technology Workshop Sessions			
Wednesday, October 16, 2019			
	Room A		**Room B**
S0 **9:30-10:00**	**S0-PWST Worskhop Overview**		
S1 **10:00-11:30**	**S1-A Propulsion & Flight Test:** *Jacob Adams*		**S1-B Optical & EM Backscatter:** *Raymond Rumpf*
S2 **13:30-15:30**	**S2-A Industry & IoT:** *Jin Mitsugi*		**S2-B Flexible Sensors & Antennas:** *Darren Boyd*
S3 **16:00-17:30**	**S3-A Aircraft & Helicopter:** *Aaron Singer*		**S3-B EVA & Surface Systems:** *Richard Evans*
Thursday, October 17, 2019			
S4 **9:00-11:30**	**S4-A Unmanned Vehicles:** *Zach Seibers*		**S4-B SAW, BAW, MEMS:** *Tim McIntyre*
S5 **13:30-15:30**	**S5-A WAIC Systems (4.2-4.4 GHz):** *Gary Hunter*		**S5-B Thru Structure:** *Eduardo Rojas*
S6 **16:00-17:30**	**S6-A Spaceflight Sensors:** *Kristen Donnell*		**S6-B Medical & Flight Crew:** *Ami Yang*
Friday, October 18, 2019			
S7 **9:00-10:30**	**S7-A MISC PWS:** *Juan Romero*		**S7-B Industry:** *Richard Evans*
S8 **10:45-12:00**	**S8-A One-on-One Sessions**		**S8-B One-on-One Sessions**

PWST Workshop Agenda Summary

PWST Workshop Detailed Agenda

Wednesday October 16, 2019

Keynote #1 (Room A)

08:30 ***5G Powerful Engine for the Connected Society***
Roshdy Hafez (Carlton University)

09:15 ***Break***

Session 0: PWST Worskhop Overview (Room A)

Session 1A: Propulsion & Flight Test (Room A)

Chair: Dr. Jacob Adams

11:30 **Lunch**

Session 1B: Optical & EM Scatter (Room B)

Chair: Dr. Raymond Rumpf

11:30 **Lunch**

Keynote #2 (Room A)

12:30 ***Public Safety Communications above 6 GHz: Challenges and Opportunities***
Marco Mezzavilla (New York University)

13:00 ***Break***

PWST Workshop Detailed Agenda

PWST Workshop Detailed Agenda

Thursday October 17, 2019

Keynote #3 (Room A)

08:00 ***Autonomous Gram-Scale Spacecraft: Flight Experiments and Future Architectures***
Dr. Mason Peck (Cornell University)

08:40 ***Break***

Session 4A: Unmanned Vehicles (Room A)

Chair: Dr. Zach Seibers

Session 4B: SAW, BAW, MEMS (Room B)

Chair: Mr. Tim McIntyre

11:30 **Lunch**

PWST Workshop Detailed Agenda

Keynote #4 (Room A)

12:30 ***The National Science Foundation Seedfund - Non-dilutive Funding for Deep Tech Start-ups and Small Businesses***
Rick Schwerdtgeger (US National Science Foundation)

13:10 ***Break***

Session 5A: WAIC Systems (4.2-4.4 GHz) (Room A)

Chair: Dr. Gary Hunter

Session 5B: Thru-Structure (Room B)

Chair: Dr. Eduardo Rojas

PWST Workshop Detailed Agenda

Session 6A: Spaceflight Sensors (Room A)

Chair: Dr. Kristen Donnell

Session 6B: Spaceflight Sensors (Room B)

Chair: Ms. Ami Yang

18:00 **Banquet**

PWST Workshop Detailed Agenda

Friday October 18, 2019

Keynote #5 (Room A)

8:00 ***Sensors in the Aerospace Extreme Environments***
Prakash Patnaik (Canadian National Research Council)

8:40 ***Break***

Session 7A: Misc. PWS (Room A)

Chair: Mr. Juan Romero

Session 7B: Industry (Room B)

Chair: Mr. Richard Evans

10:30 ***Break***

Session 8 A&B: One-on-One (Rooms A&B)

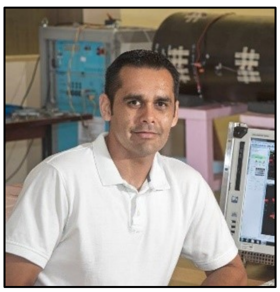
12:00 ***Box Lunch***

Passive Wireless Sensor Technology (PWST) Workshop Overview

Abstract: Passive Wireless Sensors Technologies are those that eliminate the wire from the data acquisition system to the sensor using the simplest, least costly and most robust sensor architecture – avoiding sensor power sources and complex electronics. The three co-chairs will review the purpose, objectives and main events of the PWST workshop. They will discuss the motivation for this unique workshop and provide a summary of the library of past PWST presentations. Then they will discuss the method of using the printed PWST Workshop addendum and how to sign up for the one-on-one sessions. The planned discussion panels for the third day of PWST 2019 will be discussed and PWST 2020 in Vincenza, Italy will be introduced with an invitation to comment on potential session topics. Finally, a review of potential NASA SBIR subtopic will be discussed.

Background:

Omar Torres — **NASA Engineering and Safety Center (NESC)**
omar.torres@nasa.gov — **Lead, Wireless Avionics Community of Practice**
(757) 864-1535 — **NASA Langley Research Center**

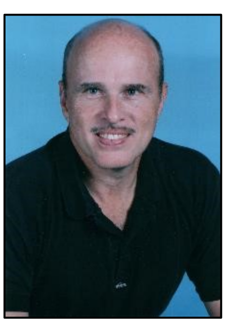


Mr. Omar Torres serves as the lead of the NASA Wireless Avionics Community of Practice where he is responsible for bringing together engineers and managers from across the agency to share knowledge and lessons learned relating to wireless technologies. Mr. Torres has been resident at Langley Research Center in Hampton, VA for 15 years where he has contributed significantly to the research of Signals of Opportunity using GPS signals for remote sensing purposes. Omar has NESC for many years of as an instrumentation and analysis engineer.

George Studor — **NASA Engineering and Safety Center**
George.f.studor@nasa.gov — **Avionics Technical Discipline Team, consultant**
(281) 415-3986 — **Wireless Avionics Community of Practice**

Mr. George Studor retired from NASA in October 2013. Since then he has concurrently been a consultant to the NASA Engineering and Safety Center for three Technical Discipline Teams(TDTs): Avionics TDT - Wireless Avionics Connections, Non-Destructive Evaluation TDT – In-Space Inspection, and Robotic Spacecraft TDT – Application of Natural Systems to Systems Engineering process. George organized 8 previous Passive Wireless Sensor Technology Workshops since 2011.

Dr. Don Malocha — **CTO, Pegasense, LLC**
dcmalocha@cfl.rr.com — **Pegasus-Professor Emeritus, E&CE Dept**
(407) 758-4446 — **University of Central Florida, Orlando FL**



Donald C. Malocha is currently the CTO of Pegasense LLC, specializing in solid-state acoustic devices, wireless RF communications systems, and sensors. He is also Pegasus-Professor Emeritus in the Electrical and Computer Engineering Dept., University of Central Florida (UCF), Orlando with research in Micro and Nano Systems. He was member of the technical staff (MTS) at Texas Instruments Corporate Research Laboratory, Mgr. of Advanced Product Development, Sawtek, and an MTS at Motorola.

Inflight Parachute Measurement Challenge

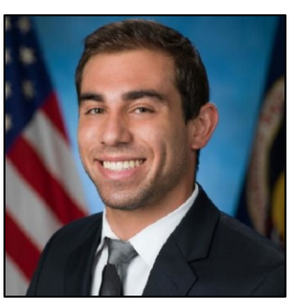
Jared Daum **NASA Johnson Space Center**
jared.daum@nasa.gov **Flight Mechanics and Trajectory Design**
(281) 244-0864 **Orion Parachute Hardware Lead**

Aaron Comis **NASA Johnson Space Center**
aaron.b.comis@nasa.gov **Flight Mechanics and Trajectory Design**
(281) 483-6702 **Commercial Crew Parachute Hardware Lead**

Abstract: Newly identified risks related to parachute component loads are currently impacting the design and analysis of human spaceflight parachute systems for NASA and its commercial partners. Unlike most traditional structural systems, loading conditions within a parachute system are very poorly understood. Current methods for structural analysis rely on decomposition of measured riser loads into component level loads using a number of assumptions. Validation of these assumptions has not been possible to date and thus the calculated margin contains significant uncertainty resulting in either conservative systems with potentially over-designed components or overestimated structural margins. **The Purpose** of the Inflight Parachute Measurement Challenge is to identify potential measurement solutions that can result in successful parachute loading assumption validation, along with validation of Fluid-Structure Interaction (FSI) simulations. A parachute system contains many components which see various loading conditions including tension and aerodynamic pressure forces. While measurements can be made in wind tunnels, significant limitations exist as compared to flight testing which include scaling, dynamic pressure time history, and cluster behavior. Traditional flight test instrumentation is difficult due the flexible nature of parachute components, packing requirements, and high forces and chaos during deployment. **The Objectives** of this challenge are to (1) describe the anatomy and behavior of parachute systems, (2) identify measurements of particular interest to the parachute design and analysis community, (3) identify additional uses of measurements such as FSI validation.

Background:

Mr. Jared Daum is an engineer at NASA Johnson Space Center in the Flight Mechanics and Trajectory Design Branch, with a B.S. in Aerospace Engineering from the University of Illinois at Urbana-Champaign. He has nine years of experience at NASA, with previous roles including Orion navigation analyst, and the development of the Orion touchdown detection algorithm. Jared has been with the Orion parachute team for about five years and is currently the hardware team lead.



Mr. Aaron Comis is an engineer at NASA Johnson Space Center on rotation to the Flight Mechanics and Trajectory Design Branch, with a B.S. in Mechanical Engineering from the California Polytechnic State University of San Luis Obispo (Cal Poly). He has five years of experience at NASA, with previous roles including mechanical, landing recovery system, and rocket propulsion design and development for space exploration vehicles. Aaron has been with the Commercial Crew parachute team for about two years and is currently the hardware team lead. Experience gained in design, testing, and analysis of parachute systems has pushed both Jared and Aaron to pursue new methods for instrumentation to better quantify and understand parachute systems capabilities and performance.

AFRC Wireless Development Plan and Needs for Flight Test Instrumentation

Mr. Richard Hang
Richard.Hang-1@nasa.gov
(661) 276-2090

Chief of the Sensors and Systems Development Branch
NASA Armstrong Flight Research Center (AFRC)
https://www.nasa.gov/centers/armstrong/capabilities

Abstract: NASA Armstrong Flight Research Center is revolutionizing its traditional wired instrumentation systems with wireless technologies. This effort faces many technical challenges, such as spectrum compliance, time synchronization, power distribution and airworthiness. This presentation highlights NASA AFRC's wireless systems development plans as well as technological needs and airworthiness challenges for flight test/research applications. The presentation discusses desired wireless sensing and wireless data communication methodologies for specific aircraft areas such as wings, tail, engines, and landing gears. The presentation also provides information for potential industry partners seeking to collaborate in the development of sensors through various means as well as to verify and validate wireless sensors and systems through flight at AFRC.

Background:

Mr. Richard Hang currently serves as the Chief of the Advanced Systems Development Branch (Code 540) at NASA Armstrong Flight Research Center (AFRC). Before leading Code 540, he served as the Chief of the Flight Instrumentation Branch for two years. He was a senior engineer on open-architecture real-time embedded data systems development for over 15 years prior to becoming supervisor. Richard aims to developing of wireless instrumentation systems for flight research and testing applications, using available COTS wireless devices/technologies and in-house developed systems to solve issues raised by the conventional flight instrumentation methodology.

Instrumentation Challenges and Wireless Sensor Opportunities at the NRC Flight Research Laboratory

Ken Hui **Principal Research Officer**
Kenneth.Hui@nrc-cnrc.gc.ca **FRL, National Research Council, Aerospace**
(613) 998-9682 **Ottawa, Canada**

Abstract: The National Research Council of Canada's Flight Research Laboratory (FRL) has conducted modelling for fixed-and rotary-wing aircraft, and UAV, using flight test data, for over 3 decades. To support these efforts, FRL has conducted research into novel flight test instrumentation (Ref.1), new flight test techniques (Ref.2), and improved modeling methods (Ref.3). The combination of high accuracy inertial measurement units and Kalman filtering, wireless airdata sensing, video recognition techniques, Wi-Fi connectivity in data acquisition systems and wireless rotor flapping measurement devices enable flight data recording and real time aerodynamic model development. Instrumentation challenges included the power requirements, aircraft vibrations, light glare effects and time alignment. The FRL uses the maximum likelihood time domain technique to identify the stability and control derivatives from flight test data, then incorporates stitching methods to create a global model of the aircraft. FRL clients, such as Bell Helicopter and CAE, have used the results of the FRL modeling efforts to greatly improve their in-house physics based models. Numerous high fidelity flight data and many of the simulation models developed by FRL have resulted in simulators certified to Level D standards, the highest fidelity designation recognized by the FAA and Transport Canada (Ref.4). These flight datasets and aerodynamic models are used to train future pilots. Thus, wireless sensors are the choice of providing aircraft flight data for simplicity and ease.

Background:

Mr. Ken Hui has been at the international forefront of aircraft modelling since 1995 due to his comprehensive set of innovations in flight testing and simulator model development. He has developed IP that brought revolutionary aircraft modelling capabilities to NRC, has one North American patent in wireless airdata sensor, 4 helicopter modelling licenses with BHTC and over 100 peer-reviewed publications, 2 of which were awarded as the best technical paper by SAE. He has successfully led a number of complex multi-disciplinary teams during award-winning projects, such as the Twin Otter S. 400 flight test program that received the NRC's Outstanding Achievement Award-Technology to Market (2015).

Extension of Interrogation Zone of Backscatter Sensors with Multiple Interrogators

Jin Mitsugi
mitsugi@keio.jp
+81-3-3516-0620

Professor, Faculty of Environment and Information Studies
Leader, Backscatter Communications Research Consortium
Keio University, Japan

Abstract: Backscatter communication systems can realize small form-factor and low power consumption – even batteryless -- sensors. However, their inherent problem is small interrogation zone because of the wireless power transfer and the weak backscatter power. Extension of interrogation zone by concatenating multiple zones is possible but shall be carefully done particularly for sensor systems requiring the synchronized collection of sensor data streaming.

Even if neighbor interrogators use dedicated carrier frequency in a multiple zone setting, backscatter sensors which receive more than two interrogator signals produce the same baseband signals in different carrier frequency band, causing interference to neighbor interrogator. This is referred to as inter-zone interference. In cases where multiple subcarriers or multiple spreading codes are used to realize synchronized streaming from multiple backscatter sensors, such inter-zone interference reduces the number of synchronized streaming.

This talk introduces the author's experience and approach toward this inter-zone interference problem in backscatter communications system. In order to separate multiple backscatters received simultaneously in the same channel by an interrogator, a new method using statistical independence of the collided signals is developed. The fundamental characteristics of the method evaluated both with simulations and experiments are reported in this talk.

This talk also updates our development and plan of synchronized backscatter communications system, which simultaneously using multiple backscatter subcarriers with batteryless sensors. We established backscatter communication research consortium in Keio University to develop prototype wireless and batteryless sensor and also to pursue experiments with prototype sensors and software defined interrogator. This talk also overviews the activity and plan of the research consortium.

Background:

Jin Mitsugi received his BS from Nagoya University in 1985, and MS and Ph.D. degrees from The University of Tokyo in 1987 and 1996, respectively, all in Aerospace Engineering. He had been with Nippon Telegraph and Telephone Corporation from 1987 to 2008 working on satellite communications systems and onboard satellite antenna. He joined Keio University in 2008 working in the field of short range wireless communications and signal processing. His research interests include short range wireless communications, RFID system, satellite communications and digital signal processing. He is an associate editor of IEEE Transactions on Automation Science and Engineering and IEEE Journal of RFID.

Advantages of IR-based Communication and Sensing in Severe Environments

Dr. Rainer Martini
Rmartini@stevens.edu
(201) 216-5634
Associate Dean for Graduate Studies
Engineering and Sciences, Department of Physics
Stevens Institute of Technology, Hoboken, NJ
https://web.stevens.edu/facultyprofile/?id=439

Abstract: With tremendous advances in the Free Space Optical Communication (FSO) technology over the last decade excellent progress has been made to showcase the potential of modern FSO and optical interrogated sensors. However, the Achilles heel of the FSO approach is still reliability – especially under low visibility conditions – especially in challenging environments. Based on our research, the solution to overcome this roadblock lies in the utilization of more resilient spectral regions.
Our measurements in lab as well as in an outdoor setup has shown that classical models overestimate losses based on visibility (Kruse-Mie model), where measured MIR losses diverged already for 6km visibility and the model overestimated the MIR drastically for visibility below 1km. Additionally the beam wander associated with scintillation effect are far lower for longer wavelengths, favoring MIR systems in areas with strong temperature variation. Most recent we have examined the combined losses due to scattering on small particles (like aerosols) in strongly turbulent media and have found much higher losses for the commonly used NIR wavelengths compared to MIR links (under same conditions the NIR link had more than 40dB losses and the MIR link less than 8dB losses). All of this three shortcomings clearly showcase that longer wavelength (MIR) has much better propagation condition – especially in low visibility conditions and hence should be favored for FSO communication links – or for remote sensing. The possibility to utilize these advantages in remote probing and interrogating of sensors will be addressed in this talk as well.

Background:

Dr. Rainer Martini received the Diploma degree in physics from the University of Bonn, Germany, in 1995, and the Ph.D. degree in physics from the RWTH Aachen, Germany, in 1999 focused on the far-infrared (terahertz-) emission from impulsively excited semiconductor heterostructures and its amplification. In 1999, he entered a joint research program with Bell Laboratories, Lucent Technologies, and Stevens Institute of Technology, where he achieved for the first time high frequency modulation from semiconductor mid-infrared lasers above 10 GHz and transmission of digital data up to 2.5 GBit/s.
Since August 2001, he has been with Stevens Institute of Technology, Hoboken, NJ, recently appointed as Associate Dean for Graduate Studies in the school of Engineering and Sciences. His research explores the possibility of communication in *up till now* 'vast' and 'unused' regions of the light spectrum (like the mid-infrared and the far-infrared) as well as the possibility of ultra-high-speed communication and sensing using all-optical techniques. Recent research results include first non-resonant optical modulation of QC-lasers and a polymer based room temperature 2 Megapixel image system working from 400nm (UV) to 70 GHz (RF). He has authored and coauthored nearly 100 articles with more than 1000 citations to date and holds 4 US patents. He is on the scientific committee for 4 international conference and serves as editor for two international journals.

Additively Manufactured RFID-Based Passive Wireless Sensors

Eduardo Rojas
rojase1@erau.edu
(386) 226-7701

Assistant Professor
Electrical and Computer Engineering
Embry-Riddle Aeronautical University, Daytona Beach

Abstract:
Additive manufacturing (AM) processes for electronics have evolved to produce high-frequency devices with superior performance when compared to traditionally manufactured counterparts. AM also enables novel 3D antenna geometries that offer advantages over the traditional planar designs. AM for space applications brings additional logistic advantages with the ability to print devices on a single machine, in the spacecraft/base, ad-hoc, with the ability of quick re-design and repair. This presentation discusses recent advancements on Laser Enhanced Direct Print Additive Manufacturing (LE-DPAM) to achieve 3D multilayer packaging and passives devices, with feature sizes down to 10 µm. LE-DPAM is also used to print conformal conductive and dielectric layers with electric permittivity up to 30 to achieve, for instance, miniaturized conformal antennas. The development of an additively manufactured RFID-based passive wireless sensor will be covered.

Background:

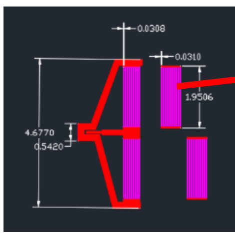
Dr. Rojas earned his M.S. and Ph.D. degrees from the University of South Florida, all in Electrical Engineering; in 2014 and 2017, respectively. He joined the Embry-Riddle Aeronautical University in 2017 where he is currently an assistant professor. His research interests are in the area of microwave/mm-wave circuit and antenna applications of additive manufacturing; and RFID for wireless sensing. He is the Director of ERAU's Wireless Devices and Electromagnetics Laboratory (WIDE Lab www.wide-lab.com). Dr. Rojas has more than 30 peer-reviewed publications, and he is a reviewer for the IEEE MTT-S Transactions on Microwave Theory and Techniques and Proceedings of the IEEE journals. He has four US patents and three active US patent applications. He is a member of the IEEE MTT-S Technical Committee 24 and the RTCA SC-236 committee for Standards for Wireless Avionics Intra-Communication System (WAIC) within 4200-4400 MHz.

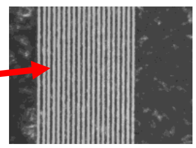
Oak Ridge National Laboratory Research and Development - What's New for PWS

Tim McIntyre **Program Manager, Energy & Environmental Sensors**
Mcintyretj@ornl.gov **DOE/Oak Ridge National Laboratory (ORNL)**
(865) 576-5402

Abstract: Ultra-low cost sensors hold the potential for broad impacts across the energy and environmental sectors. This talk presents a few examples of high impact applications for low-cost sensors and some technology development activities underway at Oak Ridge National Laboratory to address these needs. Recent work in the area of passive wireless sensors has focused on developing SAW and other sensor platform and integrating them with functional films, antennas and packaging by direct digital printing. Examples of some of the sensors and components are shown below:

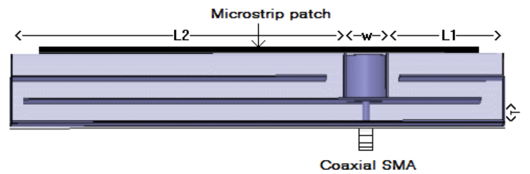
RF/SAW Sensor Platform





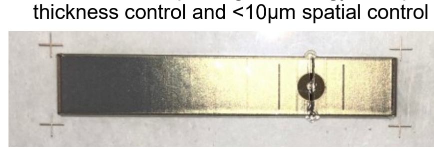
Left – Dual-channel SAW sensor design. Above – Bragg structure close-up (10µm lines with 10µm pitch).

Advanced Antenna Design



Folded micro-strip patch antenna reduces size by 1,000x (Dimensions (L) 3mm x (W) 5mm x (H) 0.5mm)

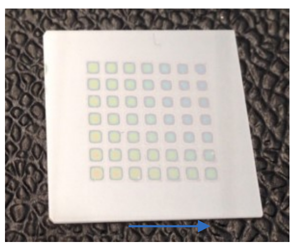
- Feature size determines operating frequency
- State-of-the-art printing technology ~100µm layer thickness control and <10µm spatial control



Developed Collaboratively with Prof. W.A. Joines at Duke Univ. on advanced antenna concepts

Sensor Functionalization

Combinatorial experiment to investigate:
1) optimum film thickness; and
2) elemental ratios (e.g. 5% increments of nickel/palladium ratio)



Film thickness (100nm to 700nm)

Background:

Tim McIntyre is a senior research staff member and Energy & Environmental Sensors Program Manager in the Electrical and Electronic Systems Research Division at Oak Ridge National Laboratory (ORNL). Tim's research activities at ORNL span >30 years and include nano-technology, optical and physical sensors, sensor networks, wireless communications, energy harvesting, and most recently, zero-power sensors and ways to functionalize them to address abroad range of physical and chemical sensor applications. Currently, Tim’s research efforts take aim at functional materials additive/hybrid manufacturing. Functional materials such as dielectrics, semi-conductors, magnetic materials and chemically selective thin and thick films for gas sensing have been a focus recently. Direct digital printing complete sensor systems is also an area of focus. Tim's work has produced many inventions disclosures, resulting in 12 patents with several pending, and >50 publications, proceedings and invited talks. Tim also served as the Department of Energy Liaison to the National Academy of Sciences' seminal report on industrial wireless sensor technology for energy efficient process control.

Wireless Concrete Sensors as IoT Solutions for Construction Industry

Mustafa Salehi
mustafa@giatec.ca
(613) 240-7451

Director of Product Development
Giatec Scientific Inc.

Abstract:
Concrete is the most widely used man-made material on earth, with over 3 tonnes used for every person on earth each year. With the usage of one material at such quantities, monitoring its performance using traditional methods becomes time- and labor-consuming regardless of project size. Giatec specializes in developing and manufacturing fully embedded concrete sensors powered by AI-algorithms that allow users to monitor concrete performance in real-time using their smartphones as well as a dedicated cloud platform. The use of these sensors allows construction personnel to achieve significant savings in material and labor costs as well as a more accurate measure of the on-site performance of concrete. To this date, the sensors have been used in over 4000 projects, of all sizes, in 80 countries. Designing wireless sensors to withstand such harsh conditions, both physically and chemically, comes with various design challenges. This talk provides an overview of the concept of using wireless sensors for the concrete industry, the sensor design and development, challenges related to wireless communication in such conditions, as well as several case studies related to the implementation of the sensors.

Background:

Mr. Mustafa Salehi is the director of product of development at Giatec Scientific. He has more than ten years of experience in the design and development of electronic systems, devices and sensors for concrete testing. He holds a Bachelor's degree in Electrical Engineering from KNTU, A Master's degree in Civil Engineering from Carleton University and an MBA from IUST. His previous industry experience includes analog and digital circuits design. He has designed and developed several electronic instruments for testing concrete properties as well as measuring corrosion in reinforced concrete structures.

From Passive to Active Sensing: Relay-Assisted Wireless Energy Transfer

Ali Abedi
ali.abedi@maine.edu
(207) 581-2231

Assistant Vice President for Research
Professor of Electrical & Comp. Engineering
University of Maine, Orono, ME, USA

Abstract: Battery replacement and charging in hard to reach and extreme environments are always a challenging part of wireless sensor networks (WSN). Passive sensor technology can be used to eliminate the need for battery, but it suffers from short communication range. Recently, wireless energy transfer for powering remote sensor nodes in a WSN has drawn considerable research attentions since it can charge sensing circuits remotely and relieve battery replacement need. In this presentation, a novel relay assisted communication scenario where a transmitter is powered by an energy source through both direct and relay links is considered. Received energy is used to power the transmitter and schedule data transmission based on stochastic models for data channel. Various static, mobile and highly scattered channel models are studied. A threshold on required transmission energy and channel quality is derived to decide whether the transmission is predicted to be successful or not. An energy efficient scheduling method is proposed for the system model to determine whether to transmit data or stay silent based on the stored energy level and channel state. An analytical expression has been derived to approximate outage probability of the system in terms of energy and data thresholds. All theoretical results are validated by numerical simulations and verify the effectiveness of energy relaying and the proposed energy efficient scheduling method in reducing the outage probability.

Background:

Dr. Ali Abedi received his BSEE (96) and MSEE (98) from Sharif University of Technology and his PhD (2004) from University of Waterloo. He joined University of Maine in 2005, where he is currently Professor of Electrical and Computer Engineering, Director of Wireless Sensor Networks Laboratory, and Assistant Vice President for Research. He held visiting appointments at NASA (2016), the University of Maryland (2012) and NIST (2012-3) and served as lecturer at the Air Force University (1998-2000), University of Waterloo (2003-4) and Queen's University (2004-5). Dr. Abedi's research in Wireless Communications area is focused on performance evaluation, resource allocation, cognitive and cooperative networks, and applications of distributed coding in sensor networks for Space exploration and Biomedical devices. Dr. Abedi is a Senior Member of IEEE and member of editorial board for IEEE RFID Journal, IEEE/KICS Journal of Communication and Networks, and IET Wireless Sensor System Journal. He was the principal investigator on wireless sensing of lunar habitat and ISS leak detection projects from 2008 to 2018. Dr. Abedi is Co-inventor of wireless sensors for brain injury detection and co-founder of Activas Diagnostics startup company.

Hybrid Direct-Write 3D Printing of 3D/Volumetric Electrical Circuits

Dr. Raymond C. Rumpf
rcrumpf@utep.edu
(202) 64-EMLAB

EM Lab
University of Texas at El Paso
Dept. of Electrical & Computer Engineering

Abstract: 3D printing is revolutionizing manufacturing and enables production of complicated multi-material parts in a single seamless process step. 3D printing devices with electro-mechanical functionality requires hybrid processes in order to deposit different materials and to utilize different tooling. Interestingly, the hardware for hybrid 3D printing is quite advanced, but the algorithms and processes remain almost non-existent. To fill this void, the EM Lab has developed a first-ever suite of tools and processes that make possible the design and manufacturing of true 3D/volumetric circuits. These include a CAD tool to design 3D/volumetric circuits and an advanced hybrid slicer to convert the circuit design into g-code that directly drives a hybrid 3D printer to build the circuit in a single process step. In a true 3D/volumetric circuit, components can be placed at any position and be oriented at any angle throughout all three dimensions. The additional degrees of freedom for placement allows for shorter trace lengths, more space-efficient placement of components, smaller and lighter devices, and the ability to form circuits into unconventional form factors. Interconnects can meander smoothly throughout all three dimensions, following spline-like paths. This minimizes parasitic impedances which maximizes bandwidth and reduces noise.

Background:

Dr. Raymond C. Rumpf is the Schellenger Professor of Electrical Research at the University of Texas at El Paso (UTEP) with a joint appointment in the Computational Science program. In Fall 2010, Raymond formed the EM Lab with a mission to develop revolutionary technologies enabled by digital manufacturing. Prior to joining UTEP, Raymond was the Chief Technology Officer for Prime Photonics where he helped transform the company's technology portfolio from exclusively fiber optic sensors to an array of technologies for extreme applications. Before Prime Photonics, Raymond was a Principal Investigator for Harris Corporation where he researched and developed technologies to radically miniaturize communications systems. Raymond earned his BS and MS in Electrical Engineering from the Florida Institute of Technology in 1995 and 1997 respectively. He earned his PhD in Optics in 2006 from the University of Central Florida. Raymond has been awarded numerous research, mentoring, and teaching awards including the 2019 Dean's Award for Excellence in Research, Most Outstanding Faculty Member in 2016/2017, and the highly prestigious University of Texas Regents' Outstanding Teaching Award. Raymond holds five world records for skydiving and has been awarded more than a dozen United States patents. He is an Associate Editor for SPIE Optical Engineering, Program Chair for Advanced Fabrication Technologies at Photonics West. He is also a member of IEEE, SPIE, OSA, and ARRL. Raymond is active in outreach with local grade schools in El Paso as well as mentoring students in third-world countries.

Damage Characterization using Nanocomposite Sensors and Tomographic Methods

Han-Joo Lee — **Ph.D. Student of Materials Science & Engineering**
hal257@ucsd.edu — **University of California, San Diego**
(858) 353-3102

Ken Loh — **Professor of Structural Engineering, Director, ARMOR Lab**
kenloh@ucsd.edu — **University of California, San Diego**
(858) 822-0431 — **www.armor.ucsd.edu**

Abstract: This talk will introduce the different sensing and actuation technologies that are being developed in the Active, Responsive, Multifunctional, and Ordered-materials Research (ARMOR) Lab at UC San Diego. The mission of the ARMOR Lab is to design, characterize, and implement game-changing, stimuli-responsive material systems for safeguarding our critical structural and human assets. In general, two main research thrusts are actively pursued. First, stimuli-responsive nanocomposites engineered with specific functionalities are designed and fabricated using scalable manufacturing techniques. Some examples include carbon nanotube strain sensors, graphene nano-sheet wearable tattoo-like sensors, ultrasonic soft robotics, and bio-inspired active skins. Second, by coupling these materials with unique tomographic measurement techniques and algorithms, spatial or densely distributed sensing using a minimal number of measurements could be achieved. This presentation will showcase how structural health monitoring and human performance sensing could be accomplished using a combination of unique engineered materials and tomographic methods. The topics that will be covered include:

- Piezoresistive carbon nanotube coatings and electrical impedance tomography for damage characterization and localization
- Multifunctional cementitious composites for load-bearing and spatial damage sensing
- Fabric-like graphene nanosheet wearable sensors for human physiological monitoring
- Noncontact structural/human health monitoring using electrical capacitance tomography
- Bio-inspired active skins for camouflage and small- and large-area gripping
- Phase-change actuation for next-generation soft robotic systems

Background:

Han-Joo Lee received his B.S. and M.S. degree in Materials Science and Engineering from Hanyang University. He is a Ph.D. student in Materials Science and Engineering Program at the University of California-San Diego. He joined the ARMOR Lab in 2016, and his thesis focuses on developing actuation methods for soft robotic systems.

(not attending): Kenneth J. Loh received his Ph.D. degree in Structural Engineering from the University of Michigan in 2008, as well as two M.S. degrees in Civil Engineering (2005) and Materials Science & Engineering (2008). His B.S. in Civil Engineering was from Johns Hopkins University in 2004. He is a Professor in the Department of Structural Engineering and leads the ARMOR Lab at the University of California-San Diego. The ARMOR Lab focuses on stimuli-responsive materials, nanocomposites, tomographic methods, wearable sensors, human performance assessment, and structural health monitoring.

Textile Antennas for Space Environment

Ami Yang
sihui.yang@nasa.gov
(281) 483-6706

NASA Johnson Space Center
Wireless and Communication Systems Branch

Abstract: This presentation will discuss design and testing of a textile patch antenna for extreme space environments to support the Exploration Extravehicular Mobility Unit (xEMU). The xEMU Project is responsible for the design and delivery of an Exploration-class space suit, which will be demonstrated on the International Space Station (ISS), with future extensibility to missions in cislunar orbit and on the lunar surface. In an effort to reduce mass and volume while increasing redundancy, two textile UHF antenna will be placed on the xEMU, replacing the current single UHF antenna on the EMU. The purpose of this presentation is to discuss the challenges with designing and certifying textile antennas for extreme space environments and the solutions we have implemented to address them.

Background:

Ms. Ami Yang graduated from the University of Michigan with a Bachelor of Science in Electrical Engineering. She started at the NASA Johnson Space Center in 2015 and supported ISS flight operations until 2017. From 2017 to present, she has been working in the Wireless and Communication Systems Branch. She develops light weight, electrically small patch antennas for various space applications such as RFID sensor tag for heat shield instrumentation and passive wearable CO_2 sensors for space station environment characterization. She is the component owner of the xEMU spacesuit UHF antenna, and responsible for designing and certifying it as a textile antenna design for astronaut communication during extravehicular activity and lunar surface operations. She is also supporting the Gateway lunar orbiter program as a member of the communication subsystem.

NASA In-Space Manufacturing Flexible Sensing Development

Curtis Hill **Senior Materials Engineer**
Curtis.W.Hill@nasa.gov **NASA Marshall Space Flight Center**
(256) 655-6876 (cell) **Huntsville, AL.**

Abstract: An overview of "Flexible Sensor Development" for Astronaut Crew Health Monitoring will be explored summarizing NASA's current development of flexible sensing technologies. The development of flexible environmental sensors and biosensors, and evaluation and development of wireless sensor communications, will be discussed. We are also developing new technologies for energy storage and power generation for the flexible sensor platforms. These development efforts are incorporating a combination of NASA internal research projects in conjunction with industry and academia collaboration projects. The motivation for this effort is to provide NASA Flight Surgeons with reliable, timely inputs on astronaut crew health environment and performance parameters. This next generation sensor device will be based on the latest technologies in hybrid flexible electronics and electronic materials.

Background:

Mr. Curtis Hill is a Subject Matter Expert Sr. Materials Engineer at NASA Marshall Space Flight Center in Huntsville, AL. He is leading the technical development of advanced materials and processes for In Space Manufacturing (ISM) applications. Curtis has developed a number of advanced functional materials and processes for NASA, with numerous awarded and pending patents. His research has included the development of high-performance dielectric materials for ultracapacitors and supercapacitors for energy storage and battery replacement, as well as for printed ultracapacitors. His current work for In Space Manufacturing includes the development and implementation of a new range of passive sensing technologies for wireless sensing for astronaut crew health.

Passive Sensors and Antennas Using Stretchable Conductors

Jacob J. Adams
jjadams2@ncsu.edu
(919) 513-1141

Associate Professor
Department of Electrical and Computer Engineering
North Carolina State University

Abstract: Rapid advancements in materials and fabrication techniques are changing the way we approach electromagnetic design. In this presentation, we describe our recent work developing both antennas and passive sensors using stretchable conductors. Combining the metallic conductivity of metals with the mechanical properties of elastomers allows us to envision new antenna and sensor configurations.

We first describe several approaches to realize reconfigurable antennas using gallium alloys that take a liquid state at room temperature. Reconfigurable antennas designed to support multiple frequency bands, radiation patterns and polarizations can dynamically accommodate a changing electromagnetic environment and allow a single-multifunctional antenna to replace several application-specific devices. Changing the conductive paths by changing the conductor's shape creates a greater range of possible states than possible using conventional lumped element loading. So-called physically reconfigurable antennas also have advantages in linearity compared to their semiconductor-based counterparts. We will study several approaches for reconfigurable liquid metal antennas using both microfluidics and stretchable materials, and compare their advantages and disadvantages to the state of the art designs based on more conventional reconfiguration techniques.

In addition, a biaxial strain sensor consisting of a silver nanowire (AgNW) conductor embedded in a polydimethylsiloxane (PDMS) substrate will be described. The two resonant modes of a multi-resonant antenna respond differently to strain applied in orthogonal directions and can be used to uniquely identify the biaxial strain state.

Background:

Dr. Jacob J. Adams received the B.S. and M.S. degrees in electrical engineering from the Ohio State University in 2005 and 2007 and the Ph.D. degree from the University of Illinois at Urbana-Champaign in 2011. From 2011 – 2012, he was an Intelligence Community Postdoctoral Research Associate at the University of Illinois. Since 2013, he has been with the Department of Electrical and Computer Engineering at North Carolina State University where he is now an Associate Professor. His research interests include electrically small and reconfigurable antennas, characteristic mode theory, and novel materials and fabrication methods for microwave devices. Dr. Adams is a Senior Member of the IEEE and the recipient of several national awards including the DARPA Young Faculty Award, the US Army Research Office Young Investigator Award, and an NSF Graduate Research Fellowship.

What We Want to Sense: Manufacturing and In-Service Aircraft Structure

Gary Georgeson — **Senior Technical Fellow in Nondestructive Evaluation**
gary.e.georgeson@boeing.com — **Boeing**
(206) 713-4313 — **Seattle, WA**

Abstract: Nondestructive Evaluation (NDE) and Structural Health Monitoring (SHM) have been used for many years to verify the quality of manufactured and in-service structure. At the same time, the gradual introduction of more and more composite structure to the field of aerospace has encouraged the development of NDE/SHM technology and practice.
NDE of end-item structures has traditionally been viewed by designers, manufacturers, and even maintainers as a "necessary evil", or a cost and time burden that is required to do business. However, the complex nature of aerospace structure fabrication and verification has led to the concept of sensor-enabled and in-process data-enabled NDE, which reduces the time and cost of end item verification of manufactured structures. In addition, in-service structural monitoring and damage detection could also benefit from intelligent and robust sensor networks and systems, in support of new Structural Health Management (SHM) approaches.
With the right kind of sensor data and analytics, NDE and Structural Health Monitoring (SHM) for aerospace structures will be much more than just a part quality check. NDE and SHM can be used in new and innovative ways to directly reduce the cost and time to design, build, test, verify, or maintain aerospace structures. This presentation will highlight some of the monitoring needs that are of direct interest to Boeing and the aerospace industry as a whole.

Background:

Dr. Gary Georgeson is the Senior Technical Fellow in Nondestructive Evaluation (NDE) at Boeing, where he has worked since 1988 in Seattle, Washington. He holds a Ph.D. in Mechanical Engineering/Materials Science from the University of California at Santa Barbara.
Gary is the technical leader to Boeing NDE scientists, engineers and technicians, advancing methods for evaluating aerospace structures, particularly composites, during manufacturing and aircraft service. As Boeing's most prolific inventor, he has developed or co-developed numerous NDE systems and methods (200+ patents). For example, Gary is the co-inventor of the Boeing X-ray Backscatter System, the Boeing Rotorblade Crawler and the Boeing ROVER Robot, which were each developed for automated inspections of various aerospace structure.
His work has supported numerous Boeing programs, and helped win contract R&D programs from the USAF, USN, NASA, TTCI, and the FAA. He is a Fellow of the American Society of Nondestructive Testing, and a regular keynote speaker, having spoken about the importance of NDE in Spain, Singapore, Germany, Brazil, China and France, as well as the U.S.
On a personal note, he has been married to his wonderful wife Lori for 35 years, and has three adult children and a two year old granddaughter. He also holds a Masters in Theology, and is the pastor of a church he founded in 1990 that serves the poor in his community.

Passive Wireless SAW Sensors, Microsystems and Applications

Marco Aimi
aimi@ge.com
(518) 387-7945

GE Research
Technology Manager
Microsystems

Abstract: GE Research has worked with key partners through the years to develop passive wireless Surface Acoustic Wave (SAW) torque and strain sensors for GE assets. These include the development and deployment of high temperature capable SAW torque systems for turbines including high speed aircraft engines and larger power generation units. Additionally, GE has deployed SAW sensors to measure linear strain to monitor the mechanical loads induced on large structures. This presentation will focus on the recent developments made to reduce the manufacturing complexity and cost associated with the integration of the SAW systems onto industrial assets utilizing printed flexible antennas. This will include a discussion of the overall system requirements needed for these applications along with several examples of deployed systems. Future needs for harsher environment strain and torque sensing will be also be discussed.

Background:

Dr. Marco Aimi joined GE in 2005 as a Materials Scientist researching new fabrication processes for MEMS devices. Over time, he expended his role to include the mechanical and electrical design of both the MEMS transducer and overall Microsystem. Marco led several programs including the multi-year effort to build and productize high power RF MEMS switches along with the transition of a MEMS production process into GE Research. In 2017 Marco started his current position as a Technology Manager for Microsystems at GE Research and works with the team to enable Microsystem based solutions with a focus on high performance and reliability in harsh environments. Marco currently holds 32 granted patents.

'Remaining Passive is Not an Option: Inspiring Youth through the Canadian Aero/Space Skills Network' Overview

Chris Kitzan
ckitzan@ingeniumcanada.org
(613) 990-5903

Director General
Canada Aviation and Space Museum
Ingenium – Canada's Museums of Science and Innovation

Abstract: A looming shortage of skilled workers is threatening Canada's leadership position in the aviation and space sector, and with it, the very survival of an industry that touches the lives of all Canadians and contributes more than 25 billion to our economy every year. In order to avoid the skills and labour shortage Canada needs to develop a national strategy to engage youth at all levels - primary, secondary and post-secondary - so they will be inspired to become part of the workforce of tomorrow.

In his presentation Chris will introduce the Canadian Aero/Space and Skills Network (CASSN) - a rapidly growing network of Canadian companies, educational institutions and government organizations that is coalescing into a collaborative body dedicated to inspiring, educating and training the next generations of industry leaders, innovators, thinkers and doers to address our national challenges in the area of aviation, space and robotics.

Background:

Those who can't do, inspire! While Chris admires the skill it takes to be an engineer, scientist, or pilot, he sadly shares none of their technical aptitudes. An historian with more than 25 years in the cultural field authoring exhibitions, programs, and publications, Chris has made a career of telling stories and engaging diverse audiences Chris came to Ingenium – Canada's Museums of Science and Innovation from Library and Archives Canada, where he recently served as Chief of Staff to the Librarian and Archivist of Canada. He has also worked for the Department of Foreign Affairs Trade and Development, the Diefenbaker Canada Centre, and the former Canadian Museum of Civilization, where he was the curator responsible for both the Canada Hall and for Western Canadian History.

Originally from Saskatchewan, Chris lives in Aylmer, Quebec, with his wife and two sons.

Opportunities for Wireless Accessories on the Lunar Exploration Spacesuit

Chris Gerty
gerty@nasa.gov
(281) 614-9097

Informatics Subsystem Lead
Exploration Spacesuit (xEMU) Project
Gateway Program
NASA, Johnson Space Center

Abstract: This talk will provide an overview of the xEMU, NASA's next spacesuit bound for the surface of the Moon. During future Lunar missions, industry partners will have a variety of opportunities to provide surface assets, including vehicle and suit components. Of particular interest to the wireless sensing community will be the ability of future suits to interface with tools and sensors while traversing the lunar surface. No decisions on specific protocols or standards have yet been made, and operational concepts supporting science and engineering objectives are still being developed, making now the perfect time to engage the wireless sensing community, and enhance the conversation about current and emerging technologies.

Background:

Mr. Chris Gerty is a technologist and entrepreneur, and a leading voice on the convergence of space exploration, human-centric design, and the "maker" culture. Chris sees emerging, exponential technologies as having enormous potential for improving life on (and off) our planet.

His passion for technology-intense projects in the aerospace industry has been fueled by projects such as planning human missions to the Moon, training astronauts on the US and Russian spacesuits, and using virtual reality to improve the systems engineering process. As a leader in NASA's Open Innovation Program, he founded collaboration events such as the International Space Apps Challenge, facilitated several makerspaces, and promoted open source technology development from within NASA's walls. Chris is also has firsthand experience as an explorer, working and surviving in extreme conditions as a NEEMO-13 crewmember living underwater aboard the Aquarius Habitat.

Chris holds a degree in Computer Engineering from Clarkson University and lives in Houston, TX. He currently works at the Johnson Space Center, leading a technical team to develop an interactive informatics system for NASA's next spacesuit.

Lunar Lighthouse

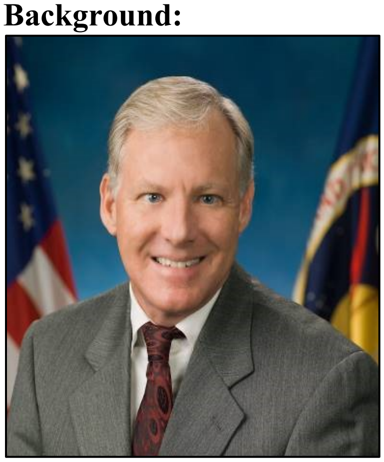
Michael Evans
michael.e.evans@nasa.gov
(281) 483-3276

Planetary Scientist
NASA Johnson Space Center
Houston, TX. 77058

Abstract: As early explorers on Earth used lighthouses to guide their ships into port, vehicles on the lunar surface will require navigation aids for surface locational awareness. The goal is to provide inexpensive, easily deployed navigational devices on the lunar surface to aid telerobotic operators driving unmanned rovers. These vehicles could directly image and measure regolith and subsurface properties, gather scientific samples, construct berms, dig holes, mine ice, or fabricate facilities for resource harvesting. Each vehicle requires location and velocity data to ensure operators maintain situational awareness when following a traverse plan. Prior experience using planetary rovers and human computer simulations reveals that vehicle-mounted cameras alone are insufficient to provide adequate situational awareness. Additionally, a network of lunar satellites providing global positioning data to these human precursor missions is unlikely. Thus, a network of surface beacons ("lighthouses") is required to generate line-of-sight measurements for lunar surface navigation.

NASA has previously investigated Surface Acoustic Wave (SAW) Radio-Frequency Identification (RFID) technology for surface navigation. These passive chips do not require batteries and survive the extreme thermal environment on the lunar surface. The chips are mated to a puck and then deployed on the surface, creating a grid boundary that defines the cartesian coordinate system. A prior terrestrial field test of pucks embedded with SAW RFID passive chips using an unmanned rover was conducted successfully at NASA JSC in 2012 (IEEE 978-1-4577-0557-1/12). Newer chip models, with more scientific sensor capability, will enhance the practical effectiveness of this technology. This project, supporting NASA's initiative to return to the Moon by 2024, will create a terrestrial field test to demonstrate relative navigation using current RFID chip(s) on an unmanned rover in 2020.

Background:



Dr. Michael Evans Michael Evans is a planetary scientist in the Astromaterials Research Exploration Division (ARES) at NASA's Johnson Space Center (JSC). His recent geochemistry research studies carbonate minerals formed on meteorites to determine ancient climate conditions on Mars. He previously worked for 20 years in the Mission Operations Directorate (MOD) developing trajectory designs and staffing the Mission Control Center (MCC) for the Space Shuttle and Space Station programs. He is also an attorney licensed in California and Texas with experience in civil litigation, estate planning, contract negotiation and real estate transactions. Within ARES, he is currently developing science concepts for the Artemis Program that plans to place humans on the Moon by 2024. He has proposed an interstellar dust collector experiment for Gateway (in lunar orbit), and a superconductivity magnetic energy storage system for the lunar surface (currently funded for prototype development). He is hoping to develop future proposals using RFID technology to enhance lunar science surface measurements and mission operations.

What We Want to Sense: Manufacturing and In-Service Aircraft Structure

Gary Georgeson **Senior Technical Fellow in Nondestructive Evaluation**
gary.e.georgeson@boeing.com **Boeing**
(206) 713-4313 **Seattle, WA**

Abstract: Nondestructive Evaluation (NDE) and Structural Health Monitoring (SHM) have been used for many years to verify the quality of manufactured and in-service structure. At the same time, the gradual introduction of more and more composite structure to the field of aerospace has encouraged the development of NDE/SHM technology and practice.

NDE of end-item structures has traditionally been viewed by designers, manufacturers, and even maintainers as a “necessary evil”, or a cost and time burden that is required to do business. However, the complex nature of aerospace structure fabrication and verification has led to the concept of sensor-enabled and in-process data-enabled NDE, which reduces the time and cost of end item verification of manufactured structures. In addition, in-service structural monitoring and damage detection could also benefit from intelligent and robust sensor networks and systems, in support of new Structural Health Management (SHM) approaches.

With the right kind of sensor data and analytics, NDE and Structural Health Monitoring (SHM) for aerospace structures will be much more than just a part quality check. NDE and SHM can be used in new and innovative ways to directly reduce the cost and time to design, build, test, verify, or maintain aerospace structures. This presentation will highlight some of the monitoring needs that are of direct interest to Boeing and the aerospace industry as a whole.

Background:

Dr. Gary Georgeson is the Senior Technical Fellow in Nondestructive Evaluation (NDE) at Boeing, where he has worked since 1988 in Seattle, Washington. He holds a Ph.D. in Mechanical Engineering/Materials Science from the University of California at Santa Barbara.

Gary is the technical leader to Boeing NDE scientists, engineers and technicians, advancing methods for evaluating aerospace structures, particularly composites, during manufacturing and aircraft service. As Boeing’s most prolific inventor, he has developed or co-developed numerous NDE systems and methods (200+ patents). For example, Gary is the co-inventor of the Boeing X-ray Backscatter System, the Boeing Rotorblade Crawler and the Boeing ROVER Robot, which were each developed for automated inspections of various aerospace structure.

His work has supported numerous Boeing programs, and helped win contract R&D programs from the USAF, USN, NASA, TTCI, and the FAA. He is a Fellow of the American Society of Nondestructive Testing, and a regular keynote speaker, having spoken about the importance of NDE in Spain, Singapore, Germany, Brazil, China and France, as well as the U.S.

On a personal note, he has been married to his wonderful wife Lori for 35 years, and has three adult children and a two year old granddaughter. He also holds a Masters in Theology, and is the pastor of a church he founded in 1990 that serves the poor in his community.

Requirements for Autonomous Unmanned Aerial Passive Wireless Multi-Modal Sensing Systems for Energy Applications

Aaron Wilson
wilsonaj@ornl.gov
(423) 326-8180

DarkNet Research Team, researcher
Oak Ridge National Laboratory
Electrical and Electronics Systems Research Division

Abstract:
The interconnected and interdependent nature of the bulk power system requires a consistent and systematic application of risk mitigation across the entire grid system to be truly effective. The increasing threat of frequent extreme events such as a super storm or coordinated cybersecurity attacks present significant challenges to the nation's power system. The need for the development of autonomous unmanned aerial systems (UAS) combined with low cost passive wireless sensors becomes apparent to assess, mitigate and recover asset operations found in industrial control systems. Although there are limitations to the current UAS platforms, sensor development enables the technology to become much more than a camera. Oak Ridge National Laboratory's current efforts demonstrated the capabilities of these systems to become a fully integrated platform to include sensors, communications and data processing systems. In this presentation the results of these demonstrations will be discussed, in addition to the requirements for the integration of passive wireless sensors integration with UAS to enable an autonomous platform.

Background:

Mr. Aaron Wilson received his MS and BS degrees in Electrical Engineering from the University of Tennessee at Chattanooga in 2019 and 2017, respectively. He has previously worked with Electric Power Board (EPB) of Chattanooga in which he assisted in the development of a software-based classification system of electric power disturbance waveforms. Since joining Oak Ridge National Laboratory, he has assisted with the DarkNet team's efforts in developing a simulation of substation communications architecture for various cyber security applications. He is currently attending the University of Tennessee at Knoxville in pursuit of a Ph.D in electrical engineering with a focus in power systems while working at Oak Ridge.

Opportunities for Remotely Piloted Aircraft System (RPAS) Remote Sensing Using Passive Wireless Sensor Technology (PWST)

Ian Glenn
Ian.Glenn@ingrobotic.com
(613) 482-9427

CTO/COO ING Robotic Aviation Inc.
Orleans, Ontario Canada
www.INGrobotic.com

Abstract:
Well into his third decade as a leader in the UAV/UAS/RPAS sector, Ian Glenn will discuss the opportunities for PWST employment in a wide variety of commercial and defence sector RPAS missions.

Background:

Mr. Ian Glenn is an engineer, a veteran, a builder, a creator, an inventor, a team builder, a leader, a visionary - in short, an entrepreneur.
When the eminent Canadian Aeronautical and Space Institute (CASI) honoured him as a Pioneer in Canadian Aviation - a first for Unmanned Aviation - with its prestigious Roméo Vachon Award, the citation read:

"Ian has led the creation of Canada's most dynamic growth sector unmanned aviation. His leadership in the field started over two decades ago, driving the creation of national drone standards with Transport Canada to enable the creation of the industry. Along the way he launched UVS Canada, the organization that grew into Unmanned Systems Canada which is Canada's national sector organization.

As the Chief Executive and Chief Technology Officer of his company, ING Robotic Aviation, over the past 15 years he has developed and integrated UAV systems and provided services across the globe in harsh conditions including war zones. ING Robotic Aviation often has undertaken technically difficult projects that moved the regulatory yardstick forward by demonstrating safe, robust, and validated results that served to expand the operational envelope for all the civil and commercial sector. ING has also been highly and consistently visible as a sponsor of student activities.

As a pioneer of industrial drones, he has created new markets and capabilities introducing UAVs to the resource, agriculture, forestry, utility, film, construction, and defence and public safety sectors. Ian is a true pioneer in a technology and aviation emergence that will happen only once in our professional lifetime. He has grasped this evolution, and expended considerable energy in guiding it for the benefit of all Canada."

Seeker 1.0 Prototype Free Flying Inspection Robot Mission Results and Next Steps

Brian Banker
brian.f.banker@nasa.gov
(281) 483-7907

Seeker External Inspection Vehicle
Principal Developer
NASA Johnsons Space Center
Houston, TX.

Abstract: This talk will focus on a new robotic, external inspection capability, dubbed Seeker, being developed at the NASA Johnson Space Center. **The Purpose** of the talk will be to discuss the need for advanced inspection capabilities and what impact they will have on the safety of human spaceflight. The talk will also provide a mission overview and results of the first test flight, Seeker 1.0. Finally, the talk will discuss how wireless sensing technology fits into the Seeker architecture and where the future technology needs are in hopes of spurring future collaborative efforts.

Background:

Mr. Brian Banker is an engineer at the NASA, Johnson Space Center in Houston, TX. He has over ten years of experience designing, developing, testing, certifying, and flying spaceflight systems. His expertise includes advanced cryogenic bi-propellant rocket engines, integrated fluid architectures, in-situ resource utilization, miniature propulsion, and CubeSat technology. Mr. Banker serves as the Principal Developer of the Seeker 1.0 mission funded out of the International Space Station Program Office.

AI, Machine Perception and Advanced Sensing in Autonomous Robotic Systems Used in Industrial Asset Inspection

Aaron Singer
aaron@automodality.com
(415) 272-6540

CEO
Autonomous Mobile Robotics
400 Smith Ranch Rd, San Rafael, CA

Abstract: One of the most compelling advancements in mobile robotics in the last few years has been the application of fully- autonomous unmanned aerial vehicles (UAV) with advanced machine-perception for industrial asset inspection.

• Artificial intelligence utilized in defect detection and feature recognition.
• Machine-sensing and perception utilized for high- precision localization of actionable data.

These AI-based, autonomous technologies are becoming more mature in their terrestrial use cases on earth such as: bridge inspection, aircraft inspection, industrial plant monitoring, oil & gas platform/rig inspection and electrical power station inspection to name a few. With the rapid development of cubesat technologies, such as Astrobee, and access to the ISS as a space-based testbed for advanced technology development and demonstration, it is a fairly linear transition to a similar robotic inspection use case on the International Space Station (ISS) and other satellite platforms. Passive and RAIN RFID are also revolutionizing the efficacy of these robotic technologies for uses in industrial asset monitoring and maintenance.

Background:

Mr. Aaron Singer Aaron Singer's early professional career began in hi-tech in the early 1990s, where Singer was CEO and Co-Founder of The adhoc Group, an emerging technologies consulting group serving Fortune 100 clients across a wide spectrum of vertical markets. Singer merged adhoc with Proxicom, Inc. in 1998 and helped take the combined company public in 1999, achieving a market capitalization of over $1 billion by 2000. From 2006-2011, Mr. Singer was founder of Living Space Labs, a cleantech/greentech investment group and then CEO and Co-Founder of the Pacific Carbon Exchange (PCarbX). PCarbX was the West's leading environmental commodities exchange serving California and the Western Climate Initiate compliance markets for carbon, renewable energy and energy efficiency. Prior to PCarbX, Singer had returned to academia to earn a Masters in Architecture from California College of the Arts where Singer wrote extensively on energy efficiency and technology integration in buildings. Mr. Singer has over 25 years experience in technology, energy and environmental markets, as well as serving on the boards or as advisor to several NGOs. Singer has been author, commentator and contributor to numerous edited volumes on interactive technology, energy efficiency, robotics, carbon markets and aerospace. Mr. Singer also is a frequent speaker and presenter at international conferences across the globe. In 2018, Singer joined startup Automodality, as the new Chief Executive Officer. Automodality (AM) is the global leader in fully-autonomous, advanced flight control software for UAVs. Singer is helping lead this new company into its next new phase of development and growth.

Wireless High-Temperature Surface Acoustic Waves Sensors: Material Challenges

Thierry Aubert
thierry.aubert@centralesupelec.fr
+33(0)628257975

CentraleSupélec
LMOPS Laboratory
Metz, FRANCE

Abstract: Surface acoustic waves (SAW) devices, not only being key components of modern telecommunication systems, are also very attractive to achieve passive and wireless (PW) sensors able to be operated from the ambient to possibly 1000°C. SAW sensors are basically made of a piezoelectric substrate on which are patterned interdigited thin film electrodes. Operation at very high temperatures requires a suitable choice of these materials. During the two last decades, many piezoelectric materials and structures have been investigated for this purpose leading to effective PW sensors operable up to at least 700°C. This talk provides an overview of the main achievements in the topic and describes some promising prospective solutions to reach higher operation temperatures.

As the main piezoelectric bulk crystals used for SAW filters technology (quartz and congruent lithium niobate) are limited in terms of temperature to the 300-450°C range, new crystals have been investigated from the late nineties. In particular, SAW resonators based on langasite ($La_3Ga_5SiO_{14}$, LGS) crystals have been developed and implemented in various industrial and military systems. Despite an outstanding stability at high temperatures, these crystals are limited for the intended application to 600-700°C due to low quality factors resulting from oxygen ion transport and diffusion in the lattice. Moreover, because of low electromechanical coupling K^2 coefficient and fast increasing propagation losses with temperature and frequency, LGS crystals cannot be used as 2.45GHz ID-Tags sensors. Recent results show that this drawback could be overcome by the use of stoichiometric lithium niobate (LN) crystals which remain stable up to 1000°C, contrariwise to congruent LN.

As shown by our group, another very promising way consists in using bilayer structures based on wide bandgap III-N thin films, such as AlN/Sapphire or more recently $Sc_xAl_{1-x}N$/Sapphire. Indeed, since $Sc_xAl_{1-x}N$ films are softer than AlN, they provide the possibility when combined with a fast substrate like sapphire, to generate higher order-modes which often show a much higher K^2 than zero-order modes. Finally, thin film technology makes it possible to develop refined *3less* (wireless, batteryless, packageless) solutions.

Background:

Mr. Thierry Aubert received the M.Sc. degree in Physics and the Ph.D. degree from the University of Nancy I, France, in 2007, and 2010 respectively. His Ph.D. thesis work was focused on the possibility to use AlN/Sapphire bilayer structure for high-temperature SAW applications. Between November 2010 and July 2011, he was with the CTR, Villach, Austria, where he obtained new results by achieving in situ electrical characterization of langasite and AlN-based SAW devices in high-temperature environment, up to temperatures above 1100°C. He then has been an Associate Professor with the Université de Savoie, Annecy, France. Since September 2014, he is with CentraleSupélec, an internationally-reputed French Higher Education and Research Institution, in the LMOPS laboratory (Metz, France), of which he is deputy director since March 2017. His research activities are focused on the investigation of new materials and structures for high-temperature SAW applications (WLAW structures, Ir/Rh thin film electrodes, piezoelectric ScAlN thin films and stoichiometric lithium niobate crystals).

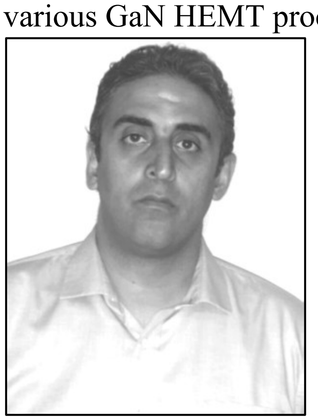
Integrated Circuits for Extreme Environments using Gallium Nitride Transistors

Jean-Paul Noël — **National Research Council Canada**
Jean-paul.noel@nrc-cnrc.gc.ca — **Advanced Electronics & Photonics Research Centre**
(613) 990-7415
Alireza Loghmany — **National Research Council Canada**
Alireza.loghmany@nrc-cnrc.gc.ca — **Advanced Electronics & Photonics Research Centre**
(613) 990-7482 — **Ottawa, Ontario, Canada**

Abstract: Deployment of gallium nitride high electron mobility transistors (GaN HEMTs) is now global, with applications ranging from rf power amplifiers for 5G networks to power conversion switches for hybrid vehicles. This feat was made possible by the inherent properties of GaN: high bandgap energy (3.4eV), high electrical breakdown strength and high thermal stability, to name a few. The work reported here seeks to extend the application space of GaN HEMTs to extreme environments, particularly at high temperatures (500□C). This would be without the use of a cooler, which adds weight, cost, complexity and risk of failure to any electronics solution. We have identified two wafer fab process parameters (extraneous to the robust GaN material itself) that limit GaN HEMT IC reliability at 500□C: metal contacts and dielectric deposition. We report on DOEs that explore variations in these parameters, toward enabling reliable GaN HEMT IC operation at 500□C without the use of a cooler. In contrast, coolerless Si-based ICs become swamped with intrinsic carriers above ~ 200□C, due to the significantly lower bandgap of 1.1eV.

Background:

Dr. Jean-Paul Noël graduated from the University of Illinois at Urbana-Champaign (Ph.D. Materials Science and Engineering, 1990) where he was a member of the Thin Film Physics Group under the direction of Dr. Joe Greene. He went on to do his post-doc at NRC Canada, working in materials and device characterization of SiGe grown by molecular beam epitaxy, including the world's first electroluminescence from SiGe diodes. In 1994 he returned to the private sector for several years (Bell-Northern Research, Nortel, JDS Uniphase), first developing various wafer fabrication technologies for volume production of InP-based laser diodes and avalanche photodetectors used in Nortel's OC48 and OC192 fiber-optic telecom systems, then waveguide switches at JDSU. In 2013, he rejoined NRC Canada to work on GaN HEMT technologies for rf power applications. Most recently, he has been designing and performing wafer fab experiments to modify various GaN HEMT processes, toward enabling reliable coolerless IC operation at 500 °C.



Dr. Alireza Loghmany received the M.S. and Ph.D. degrees in Electrical Engineering from Concordia University in Montreal, Canada. He was a member of Reliable Electron Devices (RED) group working on design and fabrication of Nitride-based High Electron Mobility Transistors (HEMTs). In 2014, he joined National Research Council (NRC) Canada to work on GaN-based HEMT technology. He is currently a Research Council Officer at Advance Electronics and Photonics (AEP) Research Centre (RC) of NRC Canada where he is working on GaN-based HEMT technology for harsh environment applications and enhancement-mode AlGaN/GaN HEMTs.

Passive Wireless Sensors for Power Distribution Grid Monitoring

Jackie Hines
jhines@sensanna.com
(410) 544-4664

SenSanna Incorporated
7468 Candlewood Rd., Suite A
Hanover, MD 21076 USA

Abstract: LineSenS™, a passive wireless sensor-based system that measures current, voltage, and line temperature on power distribution lines, was introduced by SenSanna in Oracle's booth at DistributTECH 2019 in New Orleans, LA in February 2019. Data from the line sensors was used in "Tiny Town", Oracle's grid visualization software booth demonstration. The line units operate without batteries, with a pole mounted data aggregator activating the sensors and collecting data via RF signals. Reduced data and alarms are backhauled to grid operators via customer selected standard FAN/WAN networks. This presentation summarizes SenSanna's work on power line sensors and sensor systems for monitoring the health of other grid assets, from technical, application engineering, and market perspectives..

Background:

Jackie Hines received a B.S. in Applied and Engineering Physics from Cornell University, and a M.S. and Ph.D. in Electrical Engineering from the University of Central Florida. Jackie served on active duty with the U.S. Navy from 1984 through 1988 as an instructor at the U.S. Naval Nuclear Power School in Orlando, FL and remained in the Reserves thereafter, obtaining qualification as an Engineering Duty Officer and leaving service with the rand of Lt. Commander. After leaving active duty, Jackie joined Sawtek Incorporated, where she led R&D activities for more than a decade. Jackie established a SAW sensor technology group at Sawtek, that developed a SAW-based chemical sensor system that is capable of detecting, identifying, and quantifying volatile organic chemical vapors alone and in mixtures of up to two vapors plus water. This work was supported by DARPA and DOE, and the sensor system was demonstrated at DOE's Savannah River site in June 1998. Jackie left Sawtek in 2000 to found her own consulting company. In August of 2005, having served as PI on two NASA contracts, Jackie founded Applied Sensor Research & Development Corporation (ASR&D), to advance passive wireless acoustic wave sensor technology. In November 2014, ASR&D was merged into SenSanna Incorporated. Located near Baltimore Washington International airport (BWI) in MD, SenSanna is an application engineering, contract research, and wireless sensor manufacturing firm specializing in developing measurement solutions for challenging environments using innovative acoustic wave sensor technology. Jackie has been active in a range of professional activities, including serving in numerous positions with the IEEE Ultrasonics, Ferroelectrics and Frequency Control Society (UFFC-S).

Miniaturized Langasite-Based BAW/SAW Resonant Sensors in Hash Environments

Haifeng Zhang
Haifeng.zhang@unt.edu
(940) 642-9485

Associate professor, Smart material lab
Department of mechanical and energy engineering
University of North Texas

Abstract: Harsh environmental conditions, including extremes of pressure, temperature, vibration, shock, radiation, etc., pose a great challenge for conventional sensing devices. Accurate monitoring of pressure and temperature in such extreme environments is critical to several modern industrial segments such as the automotive, aerospace, gas turbine, nuclear power, and gas and oil exploration. However, most existing sensing elements on the market could not survive in such harsh environments. Langasite ($La_3Ga_5SiO_{14}$), or LGS, is a promising new piezoelectric material that combines many of the advantages of quartz, barium titanate and lithium niobate in having high electromechanical coupling and good frequency-temperature characteristics. One of the most important features of langasite is that it will not undergo any phase transitions up to its melting temperature of 1473°C, which makes it very promising for applications in high temperature environments. This talk will present several key issues on the design of langasite-based BAW (Bulk Acoustic Wave) and SAW (Surface Acoustic Wave) resonant gas sensors and pressure/temperature sensors. The discussion includes the introduction of the new piezoelectric material, sensor design principle and experimental validation. Future research directions and challenges in this emerging field will be discussed as well.

Background:

Dr. Zhang is an Associate Professor of the Department of Mechanical and Energy Engineering at the University of North Texas (Denton, TX). His research interests include innovative sensing and energy harvesting devices in harsh environments, MEMS gas sensors, novel piezoelectric material characterization, structural health monitoring and nondestructive test methods. Dr. Zhang has been the PI or a co-PI of $7.6M grants (his own share $2.3M) from a variety of federal funding agencies such as USDA, NSF, DOE, ARO, DOD, and US Army NATIC. He has published more than 70 journal and conference papers. He received his B.S. in Engineering Mechanics from Hunan University, China in 1997, his M.S. degree in Solid Mechanics from Northwestern Polytechnical University, Xian, China, in 2001, and his Ph.D. degree in Engineering Mechanics from University of Nebraska, Lincoln in 2007. He was a postdoctoral researcher in the Department of Material Science and Engineering in the Ohio State University before joining in University of North Texas in 2008.

WAIC SAW SDR System and New Technology

Donald "Don" Malocha, CTO
dcmalocha@cfl.rr.com
donald.malocha@ucf.edu
(407) 758-4446

Pegasense, LLC
1511 E State Road 434 STE 2001
Winter Springs, Fl. 32708

Pegasus Professor, Emeritus
University of Central Florida
Electrical & Computer Engineering Department
Orlando, Fl 32816

Abstract: The WAIC band at 4.3 GHz provides intra-communications within a single aircraft for safety-related applications and a primary focus is on passive wireless sensor technology. In response to this opportunity, Pegasense proposed and awarded a NASA 2018 SBIR Phase I for a 4.3 GHz SAW sensor system and partnered with the University of Central Florida's Center for Applied Acoustoelectronic Technology (CAAT). The end of the Phase I resulted in measurements of a 4.3 GHz SAW device, and software defined radio (SDR) interrogation of short-range temperature-sensor operation. Pegasense is currently continuing the system and sensor development under a NASA Phase II SBIR NASA contract. This presentation will show current 4.3 GHz SAW sensor and SDR development and will discuss the current achievements and the important challenges for operation in the WAIC band. In addition, approaches to using SDR for multi-band operation that cross-over multi-technology sensor platforms, such as SAW, BAW, MEMS, LC, dielectric and others. Finally, a short review of emerging sensor and interrogation communication technology will be discussed.

Background:

Donald C. Malocha is currently the CTO of Pegasense LLC, specializing in solid-state acoustic devices, wireless RF communications systems, and sensors. He is also Pegasus-Professor Emeritus in the Electrical and Computer Engineering Dept., University of Central Florida (UCF), Orlando. Don received a dual BS in electrical engineering (EE) and computer science (CS), an MS in EE, and Ph.D. degree in EE from the University of Illinois, Urbana. He was member of the technical staff (MTS) at Texas Instruments Corporate Research Laboratory, Mgr. of Advanced Product Development, Sawtek, and an MTS at Motorola. He has been a Visiting Scholar at the Swiss Federal Institute of Technology, Zurich (ETH), Switzerland, and the University of Linz, Austria. He is an Associate Editor of the IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS AND FREQUENCY CONTROL (UFFC), a UFFC AdCom Emeritus-member, and past-President of the IEEE UFFC Society. He is chair of IEC TC49 for piezoelectric dielectric and electrostatic devices and materials for frequency control standards. He is the 2004 UCF Distinguished Researcher and received the 2013 Dean's Research Professorship Award, the IEEE UFFC 2008 Distinguished Service Award, the 2005 J. Staudte Memorial Award, the 2000 IEEE Third Millennium Medal, and the 1998 Electronic Industries Association's David P. Larsen Award. He has over 250 technical publications, 13 patents awarded, and several pending. Don is a Fellow of the Institute of Electrical & Electronics Engineers (IEEE).

Development of a Wireless Avionics Intra-Aircraft Communication Testbed for Electromagnetic Radiation Measurements

Eduardo Rojas — **Assistant Professor**
rojase1@erau.edu — **Electrical and Computer Engineering**
(386) 226-7701 — **Embry-Riddle Aeronautical University, Daytona Beach**

Abstract: Wireless avionics is envisioned to revolutionize the way airplane sub-systems interconnect by embracing wireless connectivity. Airplanes have miles if wiring and harnessing that can account for up to 30% of its total weight and are frequent points of failures. The engineering community has progressed towards replacing these wired communications by its wireless counterpart, with the promise of reducing the airplane weight, and therefore, providing significant operational cost and carbon emissions reductions due to fuel savings. Steps towards the implementation of WAIC systems include the approval by the Federal Communications Commission (FCC) to use the frequency band 4.2-4.4 GHz and the activities of the RTAC Special Committee SC-236 "Standards for Wireless Avionics Intra-Communication System (WAIC) within 4200-4400 MHz." As WAIC gets closer to implementation, it is essential to test the radiation performance of the WAIC devices to validate models and ensure coexistence with the Radio Altimeter. This presentation covers recent advancements in the development of a UAS-based testbed to measure the radiation performance of WAIC devices on the airplanes, in a real airport environment. The research includes aspects of RF sensing, UAS flight planning and control, and data transmission, processing, and display.

Background:

Dr. Eduardo Rojas earned his M.S. and Ph.D. degrees from the University of South Florida, all in Electrical Engineering; in 2014 and 2017, respectively. He joined the Embry-Riddle Aeronautical University in 2017 where he is currently an assistant professor. His research interests are in the area of microwave/mm-wave circuit and antenna applications of additive manufacturing; and RFID for wireless sensing. He is the Director of ERAU's Wireless Devices and Electromagnetics Laboratory (WIDE Lab www.wide-lab.com). Dr. Rojas has more than 30 peer-reviewed publications, and he is a reviewer for the IEEE MTT-S Transactions on Microwave Theory and Techniques and Proceedings of the IEEE journals. He has four US patents and three active US patent applications. He is a member of the IEEE MTT-S Technical Committee 24 and the RTCA SC-236 committee for Standards for Wireless Avionics Intra-Communication System (WAIC) within 4200-4400 MHz.

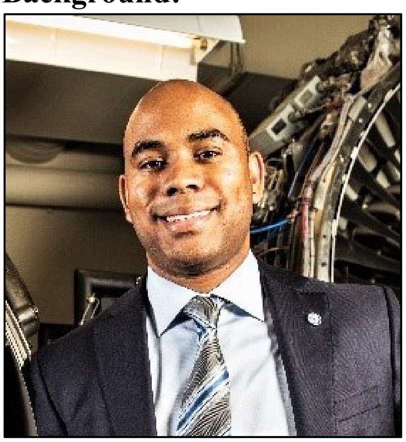
Extreme (-302F to +3732F) Passive Wireless Resonant Sensors: Ground Test to Commercial Flight Instrumentation.

Reamonn Soto
rsoto@sensatek.com
(850 321-5993

Founder and President
Sensatek Propulsion Technology, Inc.
Daytona Beach, FL.
www.sensatek.com

Abstract: While instrumentation sensors have historically been hard-wired to a sensor data acquisition package, it is desirable to have wireless capability for some, if not all, sensors in the instrumentation suite with the potential to work in the Wireless Avionic Intra-aircraft Communications(WAIC) band of 4.2 to 4.4 GHz. Wired systems discourage system flexibility with regards to sensors and sensor locations in jet and rocket turbine test and operations, due to extraneous machining associated with the cables. Additionally, the reduction or elimination of an onboard cable infrastructure would help reduce the overall weight of the propulsion system. About 30% of electrical wires are potential candidates for a wireless substitute, that could achieve high reduction in the time and cost of propulsion systems development and tests. During this discussion Reamonn will reveal capabilities of passive ceramic resonators for wireless high temperature sensors for real-time monitoring inside harsh environments. Potential use cases will be discussed to show how extreme environmental monitoring can accelerate propulsion system development schedules, while eliminating time from wiring sensors through critical hot section components.

Background:



Reamonn Soto is a U.S. Marine Corps Veteran and Founder, CEO of Sensatek Propulsion Technology, Inc. Reamonn holds a Bachelors in Physics from Florida A & M University and Masters of Science in Aeronautics at Embry-Riddle Aeronautical University. He received hands on training in scientific research in the field of astrophysics and condensed matter physics at the Center for Plasma Science and Technology (CePAST) and U.S. Department of Energy's Brookhaven National Laboratory. At CePAST, he conducted research on synthesizing Single Walled Carbon Nanotubes using Chemical Vapor Deposition (CVD) Process to explore material stresses on Airframe for the U.S. Air Force. At Brookhaven, he constructed an antenna for Project Mixed Apparatus Radio Investigation of Atmospheric Cosmic Rays of High Ionization (MARIACHI). He is an active member of the IEEE Sensors Council, Antennas and Propagation Society. Prior to founding Sensatek, he was a Certified Business Analyst and Economic Development Finance Professional with the Florida SBDC at Florida A & M University. His great business acumen assisted over 200 clients in creating 68 new businesses, that raised over $9.6 million in capital, and generated more than $79 million in sales and government contracts. Reamonn is on the ASME International Gas Turbine Segment Aircraft Engine Technology Committee, ASME International Gas Turbine Segment Controls, Diagnostics, and Instrumentation Committee, and a member of the Propulsion Instrumentation Working Group (PIWG).

Status of Standards and Requirements for Wireless Avionic Intra-aircraft Communication (WAIC) Systems for Commercial Aircraft

David Redman
dredman@avsi.aero
(281) 415-3986

Director
Aerospace Vehicle Systems Institute (AVSI)
www.avsi.aero

Abstract: Wireless Avionics Intra-Communications (WAIC) systems will liberate aircraft safety service interconnections from tethered wiring, offering designers and operators opportunities to improve flight safety, reliability, and operational efficiency. By reducing the overall system weight, wireless provides fuel reduction and subsequent environmental benefits, supporting more cost-effective flight operations. WAIC also supports reduced complexity of aircraft design and manufacture, lowers maintenance costs, and yields greater flexibility to enhance aircraft systems that maintain or increase the level of safety, thereby improving an aircraft's performance over its useful lifetime. The AVSI WAIC team worked with various national administrations over the past 7 years to establish an Agenda Item (AI 1.17) at the World Radio Conference 2012 (WRC-12), and then provided thorough analyses and proof of non-interference co-existence through the ITU-R Working Party 5B to successfully obtain an allocation of dedicated spectrum for WAIC in the candidate 4200-4400 MHz band at WRC-15 under this Agenda Item. The 4200-4400 MHz band was exclusively reserved for radar altimeter applications prior to this allocation. Under AVSI project AFE 76 – WAIC Protocols, detailed network and hardware architectures, protocols, requirements, and appropriate protection criteria for spectrum sharing are being defined to protect WAIC and legacy altimeter systems from interfering with each other.

This presentation will cover the WAIC overview and current steps being taken and assumptions in work to establish international regulatory and standards ultimately implement WAIC components and systems. The attendees should hear the latest guidance and anticipated schedule for release of several guiding international documents from which a clearer plans for technology development may be derived.

Background:

Dr. David Redman was appointed Director of the Aerospace Vehicle Systems Institute (AVSI) in August 2008. Prior to that, David spent seven years working for Smiths Aerospace/GE Aviation in Grand Rapids, Mich., where he held several positions, including Directorate Staff Engineer of Special Projects and Intellectual Property Development and Acting Engineering Director/Department Manager. Additionally, Redman has worked for Kysor Medallion/Borg Warner in Spring Lake, Mich., and was an adjunct professor of Physics at Idaho State University.

Through-Metal Communications and Power Transfer

Juan Romero
jmro@ucdavis.edu
(530) 383-1635
Anh-Vu Pham
pham@ece.ucdavis.edu
(530) 752-7472

University of California
Department of Electrical and Computer Engineering
Davis, CA 95616

Abstract: We present the design and development of an integrated wireless power transfer (WPT) and data communication system. The power and data transfer share a common inductive link that consists of two identical Helical coils placed on both sides of a carbon composite barrier or a metal barrier. Both carbon composite and metal barriers are very lossy media. We've achieved power transfer efficiency of 10% and 34% through a 3.1 mm thick Aluminum and 5-mm thick carbon composite, respectively. To achieve high efficiency (the highest to date for these lossy media), we have resonated the coils at around 200 Hz for power transfer. Using this technology, we are able to deliver more than 5 W received through the metal or carbon composite barrier to power up the communications system. Using the same inductive link, we have developed a bidirectional half-duplex data communication with a data rate of 4.8 Kbit/s. To the best of our knowledge, this is the highest data rate reported for metal and carbon composite barrier. The inside transceiver (the side that harvests the power from the inductive link) uses exclusively the power harvested from the inductive coupling system without any batteries. At the presentation, we will demonstrate the development of each component and the full integrated power transfer and data communications through metal and carbon composite where batteries are not allowed for the inside transceiver. In addition, we will show initial results of our research on the development of an integrated wireless power transfer and data communication system for mobile coils. These mobile coils have much smaller form factor and can be used in application where the metal thickness is in order of 1 mm.

Background:

Juan Romero-Arguello received his B.Sc. degree in Computer Engineering (honours) from Tec de Monterrey, México, in 2011 and his M.Sc. degree in Communications Engineering (honours) from the University of Manchester, UK, in 2015. He was lecturer from 2016 to 2018 in the Polytechnic University (ESPOL) of Ecuador. His research interests include wireless power transfer, communication systems, RF IC and power amplifier design.

Anh-Vu Pham (SM'03) received a Ph.D. degree in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1999. Anh-Vu is currently a professor at the University of California, Davis. Anh-Vu is conducting research in microwave and millimeter wave integrated circuit design, power amplifiers, electronic packaging, sensors, energy harvesting and phased array antennas. His research has been supported by DARPA, NSF, AFRL, ONR and numerous companies. He has published ~190 peer-reviewed papers, several book chapters, and two books. He received the National Science Foundation CAREER Award in 2001 and the 2008 Outstanding Young Engineer Award from the IEEE Microwave Theory and Techniques Society. He was a Microwave Distinguished Lecturer of the IEEE MTT for the term 2010-2012. Anh-Vu co-founded RF Solutions and Planarmag, Inc which was acquired by TE Connectivity in 2010.

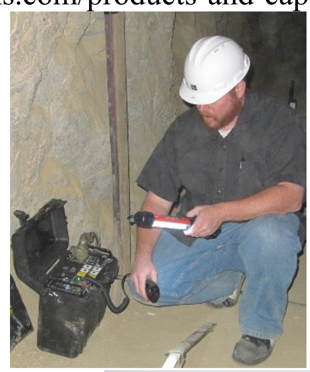
Applications for COTS Magneto-Inductive Systems: 'Rockphone', 'Diver Comm', 'Terra Comm'

Pierre Poulain
Pierre.Poulain@Ultra-MS.com
(902) 466-7491

Vice-President of Sales and Marketing
Ultra Electronics Maritime Systems Inc
Dartmouth, Nova Scotia, Canada

Abstract: Mr. Pierre Poulain from Ultra Electronics Maritime Systems (Ultra) in Dartmouth, Nova Scotia, will introduce Ultra's Magneto-Inductive (MI) technology products, giving an overview of MI technology itself, the benefits of using MI over radio for communications, some of Ultra's products, and their use and application in a range of environments.

MI technologies are COTS today: Rockphone, Divercomm and Terracomm:
https://www.ultra-ms.com/products-and-capabilities/magneto-inductive-communications.aspx



Background:

Mr. Pierre Poulain served in the Royal Canadian Navy as a Combat System Engineer, retiring in 2007. Since then, he has taken on roles of increasing responsibility in customer-facing roles in high-technology companies in the maritime domain, and is currently Vice President of Sales and Marketing with Ultra Electronics Maritime Systems in Dartmouth Nova Scotia.

Frequency Selective Surface-Based Sensing for Concurrent Temperature and Strain Measurement: Benefits, Challenges, and Applications

Kristen M. Donnell
kmdgfd@mst.edu
(573) 201-3862

Associate Professor
Director, Microwave Sensing (μSense) Laboratory
Missouri University of Science and Technology

Abstract: This talk will introduce the basic concept of frequency selective surfaces (FSSs) and recent developments in FSS-based sensing. Generally speaking, FSSs are periodic arrays of conductive elements that cause a particular reflection or transmission response when illuminated with high frequency electromagnetic energy. These arrays have been used historically as high frequency filters and for stealth and advanced antenna applications, and more recently, as sensors as a next-generation structural health monitoring (SHM) approach. FSS sensors are **inherently wireless and passive**, and are **interrogated remotely** via microwave energy. These sensors can be embedded in layered dielectric (non-conducting) structures during manufacture or installed during the service lifetime on the surface (conductive or dielectric). Microwaves penetrate through dielectrics, so in the case of layered structures, FSS sensors can be placed on materials/layers of interest that may be covered by additional dielectrics (such as reentry heat tiles covered with insulation). **Multiple sensing parameters can be concurrently sensed** through proper sensor design and interrogation, as will be illustrated in this talk through a **multi-functional** unidirectional strain and temperature sensor.

Also included in this talk will be a general **discussion of the potential applications** for FSS-based sensing. In addition, specific advantages and disadvantages of the FSS-based sensors approach with respect to other existing approaches will be mentioned. Practical concerns such as **cross sensitivity** to environmental parameters such as temperature, humidity, strain, etc., will be addressed, both in general and as it relates to the specific design of the concurrent temperature and unidirectional strain sensor. Sensor **fabrication and subsequent installation concerns** (bonding, unintended delamination, etc.) will also be discussed.

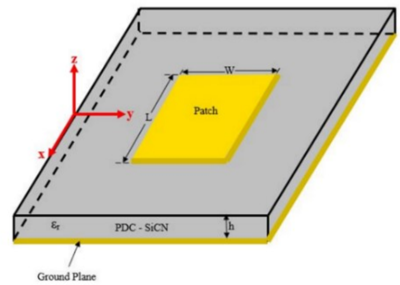
Background:

Dr. Kristen Donnell (S'07-M'11-SM'12) received her B.S.E.E. degree in May 2001 from Colorado State University, her M.S.E.E degree in December 2003 from the University of Missouri-Rolla, and her Ph.D. degree in Electrical Engineering at Missouri University of Science and Technology (Missouri S&T) in December 2010. Her Ph.D. research was conducted at the Applied Microwave Nondestructive Testing Laboratory (*amntl*). She is currently an Associate Professor in the Department of Electrical and Computer Engineering at Missouri S&T, the Director of the Microwave Sensing (μSense) Laboratory, and a previous faculty member of the *amntl*. Her current research interests include thermography, frequency selective surfaces, materials characterization, embedded sensing, and microwave and millimeter wave nondestructive testing. Prior to starting her Ph.D. work, Kristen was employed by Raytheon Company, Tewksbury, MA, from 2003 to 2006 as a Systems Engineer and Electrical Engineer. Dr. Donnell is a Senior Member of IEEE, and is also involved with the IEEE Instrumentation and Measurement Society, where she served as an appointed member of the AdCom from 2007-2011 and is currently serving her second term as an at-large AdCom member. She is the recipient of the IEEE Instrumentation and Measurement Society 2012 Outstanding Young Engineer Award, the Missouri S&T Outstanding Teaching Award for the 2011-2012 academic year, the 2014 Faculty Excellence in Teaching award, and the 2017 Faculty Excellence in Service award.

Wireless Passive Microstrip Patch Antenna Temperature Sensor in High-Temperature Applications

Cheryl Xu, Fuh-Gwo Yuan, Auston Gray
Cheryl.xu@ncsu.edu, yuan@ncsu.edu
(919) 515-5271, (919) 515-5947

Department of Mechanical and Aerospace Eng.
North Carolina State University
Raleigh, NC 27695



Abstract: A wireless temperature sensor based on a microstrip patch antenna (MPA) configuration is demonstrated its feasibility in high temperature applications. The MPA sensor either rectangular or circular shape was designed and fabricated with carbon paste applied onto a polymer derived ceramic silicon carbon nitride (PDC-SiCN) substrate. A horn antenna interrogated the patch antenna sensor once inside of a standard muffle furnace at a wireless sensing distance of 0.5 meter. The monotonic relationship between the dielectric constant of the ceramic substrate and ambient temperature is the fundamental working principle for the wireless temperature sensing. Temperature measurement was demonstrated from room temperature to 1000˚C. A comparison was made between the experimental tests and modeling from HFSS. A high survivability of the fabricated patch antenna sensor is achieved as the experiment was repeated for 10 hours. The developed sensor system provides a feasible solution for wireless temperature measurement within extreme environment applications. The MPA has potential to design as pressure and strain sensors for structural health monitoring.

Background:

Dr. Cheryl Xu received her Ph.D. degree in 2006 from Purdue University. Her research interests include high temperature wireless sensing, multifunctional ceramic composites, and artificial intelligence (AI) for process modeling/control. Dr. Xu is active in conducting research in the field of materials and advanced manufacturing and has co-authored a textbook (*Intelligent Systems: Modeling, Optimization and Control,* 2008) and written four book chapters. She has published about 50 peer-reviewed journal articles and 30 refereed conference proceedings. She has nine US patent applications. Dr. Xu won the Office of Naval Research (ONR) Young Investigator Award and was awarded the Society of Manufacturing Engineering (SME) Outstanding Young Manufacturing Engineer Award in 2011. She was the only recipient of the IEEE Education Society Teaching Award in 2015, chaired NSF National Wireless Research Collaboration Workshop in 2015 and serves as an Associate Editor of *ASME Transactions, Journal of Micro- and Nano- Manufacturing* since 2015.

Dr. Fuh-Gwo Yuan has been with North Carolina State University since 1989. His current research interest covers smart structures and materials, vision-based structural health monitoring (SHM), and deep learning applied to SHM/NDE. He published over 300 journals and conference proceedings. He serves on several editorial boards of scientific journals. During his career, he has worked with National Center for Composite Materials Research, Boeing, NASA Langley Research Center (presently Structural Mechanics and Concepts Branch), Air Force Materials Laboratory. In 2008, he was a visiting fellow at Magdalen College at University of Oxford. Currently he serves as a Langley Professor at National Institute of Aerospace, Hampton, Virginia.

Technology Development in the High Operating Temperature Technology (HOTTech) Project

Gary W. Hunter
gary.w.hunter@nasa.gov
(216) 433-6459

HOTTech Project Technology Coordinator
Smart Sensors and Electronics Systems Branch
NASA Glenn Research Center
Cleveland, OH. 44135

Abstract:
This presentation provides an overview of the High Operating Temperature Technology (HOTTech) Project. The primary science objective of the project is to develop and mature technologies that will enable, significantly enhance, or reduce technical risk for in situ missions to high-temperature environments with temperatures approaching 500°C or higher for the robotic exploration of high-temperature environments such as the Venus surface, Mercury, or the deep atmosphere of Gas Giants.

The goal is to develop technology areas that will enable a long-lived lander that can survive at least 60 days at 500°C. HOTTech is limited to high temperature electrical, electronics, electro-mechanical systems that could be needed for potentially extended in situ missions to such environments. The project presently incudes 12 tasks developing technologies such as harsh environment electronics, packaging, and power generation. HOTTech is not meant directly for instrument/sensor system development. A brief overview of the development of an integrated lander system including sensors, the Long-Lived In Situ Solar System Explorer (LLISSE) project, will also be presented.

Background:

Dr. Gary W. Hunter is the Technical Lead for the Chemical Species Gas Sensors Team and Lead for Intelligent System Hardware in the Smart Sensing and Electronics Systems Branch at NASA Glenn Research Center. He presently serves as Co-Investigator for Electronics, Sensors, and Communications in the Long-Lived In Situ Solar System Explorer (LLISSE) project. Since his arrival at NASA Glenn, he has been involved with the design, fabrication, and testing of sensors. He has worked closely with academia and industry in developing a range of sensor technologies and sensor systems using a number of different materials and sensing approaches. This work has included the use of micro/nano technology as well as the integration of sensor technology into smart systems. Dr. Hunter's contributions range from research to technical management in fields of research including high temperature wireless sensors, a Venus lander, asthma monitoring, engine emissions, environmental monitoring, fire detection, and leak detection. Dr. Hunter has taught short courses on chemical sensing and high temperature sensors/electronics; 2 R&D 100 Awards; nominated twice for NASA Invention of the Year; co-authored 7 book chapters; has 11 patents; and a significant number of papers and invited talks. He is a Fellow of the Electrochemical Society.

Instrumentation Needs of Inflatable Space Structures

Doug Litteken **NASA Johnson Space Center**
douglas.litteken@nasa.gov **Lightweight Structures Subject Matter Expert**
(281) 483-0574

Abstract:
NASA and industry are developing inflatable, crewed space structures for large-scale habitats for in-space and surface missions. Space certified inflatables are composed of high strength fabrics that carry the structural loads from internal pressure and replace traditional metallic primary structure. Inflatables can be packed for launch, fit inside a small launch shroud, and expand in orbit to create a large habitable volume for the crew. For safe operation of inflatable habitats, structural health monitoring (SHM) techniques are required to monitor and evaluate the structural loads in both ground and flight tests. Because of the nature of fabric structures, SHM techniques need to be soft, flexible, and be able to interface with softgoods. Litteken's presentation will introduce inflatable structures, their design, and their planned use for future NASA missions. He will discuss SHM needs for inflatables and their specific requirements for implementation with flight hardware.

Background:

Mr. Douglas Litteken is a structural engineer at NASA's Johnson Space Center (JSC) in Houston, TX. He is the Lightweight Structures Domain Lead at JSC and a Subject Matter Expert in the agency for softgoods structures. He is also the sub-system manager for the Orion crew cabin primary structure. His interests include inflatable habitats, parachutes, composite structures, flexible electronics, and structural health monitoring. His experience includes the design, analysis and testing of softgoods structures including lunar surface habitats, airlocks, and deep space transit vehicles. He received both his Bachelor's and Master's degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign, Evans.

Overview of the Large-Scale Test Capabilities of NASA Glenn Research Center at Plum Brook Station

Richard Evans
richard.k.evans@nasa.gov
(419) 621-2238
http://www.linkedin.com/in/rkevans

Instrumentation Lead, Space Power Facility
NASA GRC/Plum Brook Station, Sandusky, OH
http://facilities.grc.nasa.gov/spf/index.html

Abstract:
Very large space environment test facilities present unique engineering challenges in the design of facility data systems. Data systems of this scale must be versatile enough to meet the wide range of data acquisition and measurement requirements from a diverse set of customers and test programs, but also must minimize design changes to maintain reliability and serviceability. This paper presents an overview of the common architecture and capabilities of the facility data acquisition systems available at two of the world's largest space environment test facilities located at the NASA Glenn Research Center's Plum Brook Station in Sandusky, Ohio; namely, the Space Propulsion Research Facility (commonly known as the B-2 facility) and the Space Power Facility (SPF). The common architecture of the data systems is presented along with details on system scalability and efficient measurement systems analysis and verification. The architecture highlights a modular design, which utilizes fully-remotely managed components, enabling the data systems to be highly configurable and support multiple test locations with a wide-range of measurement types and very large system channel counts.

Background:

Mr. Richard Evans is an Electronics Engineer at the NASA Glenn Research Center working for the Plum Brook Management Office at Plum Brook Station in Sandusky, Ohio. He has been working in the large-scale space environment test industry since 2006 as a specialist in Data Acquisition, Data Processing, Sensors and Test Instrumentation. Since 2009 Mr. Evans has been at the Space Environments Complex (SEC) supporting Thermal-Vacuum, Reverberant Acoustic, Sine Vibration, Electromagnetic Effects (EMI/EMC) and other vehicle scale test programs. Before working at NASA, Mr. Evans worked at the Thomas Jefferson National Accelerator Facility (TJNAF/CEBAF) in Newport News, VA working on accelerator and high-power laser instrumentation for the 10kW IR Free Electron Laser (FEL) Programs from 95 to 2006. Mr. Evans has almost 25 years of combined experience in electrical and electronics engineering, mixed-signal RF, analog and digital instrumentation, control systems, Operational IT, high-speed networking systems, real-time embedded signal processing, test data analysis and data post-processing. He holds a Bachelor's in Electrical Engineering from Geneva College and a Masters in Applied Physics and Computer Science from Christopher Newport University. Mr. Evans has also taught Engineering Technology at the Bowling Green State University (BGSU) Firelands Campus.

Distributed Sensing for Mechanical and Biomedical Systems

Haiying Huang
huang@uta.edu
(817) 272-0563

Professor of Mechanical & Aerospace Engineering
University of Texas at Arlington
Arlington, TX. 76019

Abstract: Sensor technologies are the foundation of all "smart" technologies, e.g. mobile health, robotics, smart grid, environmental monitoring, structural health monitoring, etc. A major challenge for sensor research is to achieve densely distributed, wireless, low power consumption sensor networks. This talk presents the study of microwave patch antenna sensors to address this challenge. We discovered that a microstrip patch antenna can be designed to sense various physical parameters, including strain, pressure, shear, and crack etc. Since the patch antenna also serves as a data transmission device, battery-less wireless interrogation of the antenna sensors can be achieved. In addition, frequency-division multiplexing can be exploited to simultaneously interrogate multi-element sensor arrays. These unique characteristics make the microwave antenna sensor an attractive candidate for densely distributed wireless sensor networks. The operating principles of the antenna sensors will be explained first, followed by the discussions of two wireless interrogation schemes. Recent progresses on studying the wireless sensors for condition monitoring in harsh environment and prosthetic socket will be presented.

Background:

Prof. Haiying Huang is a professor of Mechanical and Aerospace Engineering at the University of Texas Arlington. She graduated from Beijing University of Aeronautics and Astronautics (BUAA) with a bachelor degree in 1991 and received a PhD degree in Aerospace Engineering in 1998 and a master degree in Electrical Engineering in 1997; both from the Georgia Institute of Technology. Prof. Huang has published more than 100 journal and conference papers and has 9 patents granted. She is a recipient of the 2009 NSF CAREER award and the 2007 Air Force Summer Faculty Fellowship. Prof. Huang is a member of the ASME, IEEE, and a lifetime member of AIAA and SPIE.

The Future of Near Patient Testing Using Passive Wireless BAW Sensors

Bryan Bothwell **Qorvo Biotechnologies**
bryan.bothwell@qorvo.com **Director- Strategy and Business Development**
(971) 344-4965

Abstract: Qorvo Biotechnologies has developed a biosensor platform that creates a paradigm shift in point of need testing. By combining novel multi-GHz bulk acoustic wave (BAW) detection arrays with microfluidics and electronics integration, centralized lab results at the true point of need are enabled- breaking the technological barrier limiting ubiquitous deployment of liquid-based biosensors across all markets. Sample flexibility and performance across both Immunoassays and Molecular Dx make this a truly universal platform.
This talk will focus on defining the unmet market need, how the technology core was developed, and the data and associated platform maturity that now makes this such an exciting time for liquid based point of need testing.

Background:

Mr. Bryan Bothwell graduated from the University of Portland in 2000 with combined degrees in Biology and Biochemistry. During a 7-year career at Intel Corporation that saw him undertake multiple engineering roles in advanced technology and factory integration, he also received Masters degrees in Electrical Engineering and Business Administration from Oregon Health Sciences University, and Babson College respectively. In 2007, Bryan joined TriQuint, which then later became Qorvo. His roles there included Marketing Manager and then Strategy and Business Development, where he was responsible for customer engagements, new technology development, and worldwide market growth strategy. In 2014, Bryan became the Director of Strategy Business for an internal start-up focused on expanding the corporate portfolio into Healthcare- specifically point of need Biosensors. Bryan has led this business since that time to the point where Qorvo Biotechnologies, LLC has now been created, lead non-human partners are ramping production, and a multi-year opportunity pipeline in the human space is being executed against.

Biometric Wireless Sensors Systems: Current Implementations and Future Needs

Michel Lortie, ing.
michel.lortie@mdacorporation.com
(613) 599-7602

MDA Vision Systems and Sensors
Manager, Business Development

Abstract: This talk will introduce MDA Vision Systems and Sensors work in Autonomous Medicine and Biometric Wireless Sensors. MDA VSS' interest in autonomous medicine dates back to 2012 when it assembled a team of researchers from St-Mary's Research Centre and McGill University to address the Canadian Space Agency's request for proposal for an Advanced Crew Medical System (ACMS). The goal of the ACMS study was to define a concept by which astronaut health could be sustained over the course of an exploration-class mission. The target mission, selected by the CSA, was a manned exploration of Mars.

The ACMS work led to the development of several autonomous medicine technologies including the development of a small wireless sensor to continuously monitor vital signs. The biometric readings are derived from measuring the vibrations in the chest cavity. This technique is known as seismocardiography and has been around since the early 1970s.

The vital signs sensor is small (5mm high by 14mm in diameter) light (less than 10g), encased in a medical-grade silicone and is entirely non-invasive. The sensor currently includes a non-rechargeable battery and a power management circuit that ensures the sensor has a passive shelf life in excess of 12 months. Once enabled, the battery provides two weeks of continuous operation. A rechargeable version of the sensor along with an inductive charging circuit is in design awaiting a battery that provides the necessary power density and small size.

The vital signs sensor is at the leading edge of commercial wearable technology both from a size and functionality perspective. However, researchers world-wide are working with form factors such as polymer tattoos and lithography batteries that point to the future of wearable devices. MDA VSS is aware of these advances and is looking now at both enhancements to the sensor's power system and, in the longer term, to more efficient and effective packaging solutions. Throughout these developments, MDA VSS expect that the emphasis on non-invasive techniques will remain a design imperative.

Background:

Mr. Michel Lortie is a professional engineer registered in Ontario and Québec. A graduate of Mechanical Engineering at the University of Ottawa, he has worked for over forty (40) years as a computer and systems designer. His design activities have led to implementations in all segments of a modern industrial economy including manufacturing, process control, aerospace, pharmaceutical and healthcare industries.

His most recent project, involved the design and development of a multimodal sensor system to investigate cognitive workload and performance prediction for Canadian Armed Forces personnel. This leading edge technology includes Concordia University and the National Research Council of Canada as deveopment partners.

Mr. Lortie is manager of business development at MDA Vision Systems and Sensors and is responsible for leading MDA's efforts in Autonomous Medicine.

Chipless RFID: Design Advances and Measurement Challenges in Identification and Sensing Applications

Katelyn Brinker
katelyn.brinker@mst.edu
(618) 741-1278

NASA Space Technology Research Fellow
Applied Microwave Nondestructive Testing Laboratory
Center for Nondestructive Evaluation (CNDE)
Iowa State University

Abstract: Chipless RFID is a subset of RFID technology where the tags are completely wireless and passive and do not require any electronics. Instead, the information is "stored" in the structure of the tag. This information is extracted by interrogating the tag with an electromagnetic wave and viewing the response, typically either the radar cross-section (RCS) or S-parameter vs. frequency response, of the tag. A binary code is then assigned to this response using a variety of methods. By manipulating the structure of the tag or the environment the tag is in, the response can be manipulated and thus, identification and sensing can be performed.

Due to the lack of electronics and power sources, chipless RFID tags can be manufactured through inexpensive means like inkjet-printing and can be made to be very small. However, being a relatively new technology, with the first chipless tags being reported around 2007, there are still many challenges to be overcome. Some of these challenges include small read range, low bit density, and tag localization.

This talk will provide background on chipless RFID technology, will discuss the various design approaches, and will provide insight into some of the practical challenges that come with the technology. Additionally, chipless RFID tags will be discussed for both identification and sensing applications.

Background:

Ms. Katelyn Brinker is currently a PhD student in electrical engineering at Iowa State University. She is supported by a NASA Space Technology Research Fellowship, and her advisor is Dr. Reza Zoughi. She received bachelor's degrees in electrical engineering and computer engineering from Missouri University of Science and Technology (Missouri S&T) in 2017 and her master's in electrical engineering at Missouri S&T in 2019. She has completed internships at Southwest Research Institute and NASA Langley Research Center, and is also a NASA Pathways Intern at Goddard Space Flight Center. Additionally, she serves as the Graduate Student Representative to the IEEE Instrumentation and Measurement Society and a as a Student Governor to the IEEE-HKN Board of Governors.

Passive Microwave Energy-Harvesting Sensors for Space Applications

Gregory D. Durgin
durgin@gatech.edu
(404) 894-2951

Professor of Electrical and Computer Engineering
Georgia Tech

Abstract: Innovations in low-powered electronics and Radio frequency identification (RFID) are the driving technology behind many compelling applications, such as Internet-of-Things, smart cities, inventory tracking – and now space-based applications! This talk presents the state-of-the-art designs and techniques for building microwave RFID readers and RF microwave-harvesting sensors for low-powered space-based sensing. We will review the mission and design of RF Tag Satellite (RFTsat), which was successfully launched on 26 July 2019, in a partnership between Georgia Tech and Northwest Nazarene University student researchers. This spacecraft carried and tested one of the first microwave-powered, untethered sensors for observing radiation, magnetic field, inertial forces, and temperature. We will track the fundamental limits of this technology and project what will be possible in the near future.

Background:

Gregory D. Durgin joined the faculty of Georgia Tech's School of Electrical and Computer Engineering in Fall 2003 where he serves as a professor. He received the BSEE (96), MSEE (98), and PhD (00) degrees from Virginia Polytechnic Institute and State University. In 2001 he was awarded the Japanese Society for the Promotion of Science (JSPS) Post-doctoral Fellowship and spent one year as a visiting researcher with Morinaga Laboratory at Osaka University. He has received best paper awards for articles coauthored in the *IEEE Transactions on Communications* (1998 Stephen O. Rice prize), *IEEE Microwave Magazine* (2014), and *IEEE RFID Conference* (2016, 2018, 2019). Prof. Durgin also authored *Space-Time Wireless Channels* (2002), the first textbook in the field of space-time channel modeling. Prof. Durgin founded the Propagation Group (http://www.propagation.gatech.edu) at Georgia Tech, a research group that studies radiolocation, channel sounding, backscatter radio, RFID, and applied electromagnetics. He is a winner of the NSF CAREER award as well as numerous teaching awards, including the Class of 1940 Howard Ector Outstanding Classroom Teacher Award at Georgia Tech (2007). He has served as an editor for *IEEE RFID Virtual Journal*, *IEEE Transactions on Wireless Communications*, and *IEEE Journal on RFID*. He also serves on the advisory committee on the IEEE Council for RFID. He is a frequent consultant to industry, having advised many multinational corporations on wireless technology.

REVEALS Activities in Exploration, Graphene-based Antistatic Coatings and Real-time 2D Meta-material Radiation Detectors

Dr. Zach Seibers **REVEALS Research Scientist**
zach.seibers@chemistry.gatech.edu **Georgia Institute of Technology**

Abstract: With growing interests in space exploration and long-term habitation, there is significant interest in developing technologies to monitor and protect astronauts and their equipment from many unique hazards encountered space. Many of these are well understood including static charge build-up, micrometeoroid impact, and extreme mechanical forces; however radiation exposure still poses a significant risk to long term missions in space. Developing technologies that reduce radiation exposure and risks is a major focus of the Radiation Effects on Volatiles and Exploration of Asteroids and Lunar Surfaces (REVEALS) research center at Georgia Institute of Technology. REVEALS is supported by the NASA Solar System Exploration Research Virtual Institute. Efforts within REVEALS focus on mitigating risks associated with radiation exposure by developing new composite materials that passively block as much radiation as possible. By incorporating chemically modified graphenes into polymers, we can alter the material properties so that they are lightweight, mechanically strong, and highly conductive with good thermal transport properties. These properties are also useful for minimizing static charging and damage due to micrometeoroid impact. With respect to radiation attenuators, selected graphene-based polymer composites are among the more promising candidates.

We are also developing real-time radiation monitoring devices and material architectures to help avoid acute doses of radiation. The real-time radiation exposure platforms use novel graphene-based neutron detectors that are sufficiently small enough to be directly incorporated into the design of space suits (to monitor radiation sensitive body areas) or vehicles. These technologies and some proposed deployment strategies to enable the safe execution of longer-term space operations will be discussed.

Background:

Dr. Zach Seibers is a research scientist from The Georgia Institute of Technology where he works as part of NASA based research center focused on Radiation Effects on Volatiles and Exploration of Asteroids and Lunar Surfaces (REVEALS). Zach received his B.S. in Chemical Engineering in 2011 from Tennessee Technological University, and a Ph.D. in Energy Science and Engineering in 2016 from The University of Tennessee – Knoxville, where he attended the Bredesen Center for Interdisciplinary Graduate Research and Education, a joint program between UTK and Oak Ridge National Laboratory. His doctoral research explored ternary additives as a means for controlling the morphology of photoactive materials in polymer solar cells. He then completed a postdoctoral appointment at Oak Ridge National Laboratory where he supported polymer and thin film characterization efforts. Dr. Seibers has research interests developing multi-functional polymer composites for advanced applications including space and additive manufacturing.

Hybrid Wireless Ultrasonic Sensor Networks With Temperature Compensated Thickness Measurement

Shani Lu **Inductosense Ltd., Bristol, UK**
shani@inductosense.com **www.inductosense.com**
+44 (0) 117 403 4047

Abstract: Inductosense's WAND (Wireless And Non Destructive) system, a patented technology for internal corrosion/erosion monitoring, consists of an intrinsically safe, passive ultrasonic sensor that can be permanently embedded in a structure and a handheld data collector that wirelessly provides power to and acquires data from the sensor. This system has been successfully used for thickness measurement of metal structures at normal environmental temperatures.

Sound velocity in all materials changes with temperature, e.g., in steel, this change is approximately 1% per 55 °C change in temperature. Accurate thickness measurement of hot materials requires velocity calibration. The temperature of the test material can be estimated if temperature-dependent electrical/ultrasonic parameters can be identified and measured. The ability to perform temperature estimation while a thickness measurement is taken may help improve measurement accuracy.

This presentation will introduce the latest advances at Inductosense, including integrating the passive ultrasonic sensors with active wireless nodes (e.g., drone, crawler, fixed data collector etc.) that can take measurement from the sensor, process and transmit the data wirelessly back to a central location, and a temperature compensation function that can be applied to both the hybrid wireless system and the WAND system.

Background:

Dr. Shani Lu is a wireless communications/IoT engineer at Inductosense Ltd., Bristol, UK. Prior to this she was a research associate at the Safety Systems Research Centre, University of Bristol. She obtained her PhD in Electrical and Electronic Engineering from the University of Bristol in 2017, and the MPhil and BEng in Electronic and Communications Engineering from the University of Birmingham, in 2012 and 2010, respectively. Her primary area of focus includes wireless sensor networks, Industrial Internet of Things (IIoT) and signal processing.

Building the Bridge Between Science and Business

Chris Cook
C.Cook@ecm-space.com
(343) 291-1096 (office)
(646) 460-9664 (cell)

Business Development Manager
ECM Space
Ottawa, Ontario, Canada
http://www.ecm.space/

Abstract: The bridge from technology invention to applications for users often requires a business vision and plan by an experienced and well-networked expert in the various industries. Based on personal experience and expertise in business development, the presentation will clarify how the ECM Space Canada recent start-up business will provide opportunities to bring Technologies and Users at the PWST Workshop into relationship with each other and other European and North American aerospace businesses.

ECM Space is a recent start-up business, based in Ottawa, to offer business services which will bridge the gap between European engineering and North American aerospace industry. It is a part of ECM Space Group, founded in 2008, which leverages the capabilities of EXOLAUNCH, one of the largest launch service providers for small satellites in Europe, and German Orbital Systems GmbH, at the renowned Institute for Space Technology at the Technical University of Berlin.

Background:

Mr. Chris Cook joined the Ottawa tech community in 1999 as an account executive for a value-added reseller selling Linux servers. Since then, he has worked with thousands of businesses while advancing into more senior sales positions within the tech, banking and advocacy industries. In 2019, Chris joined ECM Space, a satellite launch service provider with a history of producing and launching small satellites in Europe. For example, in 2017, the ECM Space Group launched more than 50 fully functional CubeSats and other small satellites into Low Earth Orbit. ECM Space offers a complete suite of consulting services for the creation and operation of a space program. Working from the idea's inception to the eventual delivery of analytical data to your screen. ECM Space aims to build the bridge between the world of science and the world of business here in North America.

Passive Wireless Sensing in a Wide Range of Applications: Converting Ideas into Reality

Michael Lukin
Michael.lukin@ttp.com
+44 1763 262626

Senior Consultant
TTP plc, UK
https://www.ttp.com

Abstract: TTP works with ambitious clients in a broad range of industries, using its deep knowledge and multidisciplinary approach to invent and deliver groundbreaking solutions across them all. TTP has developed and implemented a wide range of advanced technologies in various industries including wearable sensors, industrial gas detection sensors, low cost satellite IoT, nuclear waste, oxygen therapy, smart implants, machine learning, low cost electrically steerable antenna, IoT point of care reader, wireless air quality sensor, in-flight communications.

This talk will review the wide range of applications where Passive Wireless Sensor technologies have been implemented and will explore where they will be used for in the coming years.

Background:

Mr. Michael Lukin is a Senior Consultant at TTP plc, UK. He is involved in consultancy, business development and project management, with a focus on wireless technologies for various applications, including satcom. He made key contribution into establishing the antenna design and satcom terminals development services within TTP. He was involved in the development of passive wireless sensors, including for medical applications. He was also a part of the TTP's team engaged with the UK Carbon Trust business incubator assisting UK start-ups which operate in the area of energy efficiency. He is currently involved in the IoT systems development based on LEO satellite constellations.

Prior to joining TTP he was working in the radar, RFID and satcom industries in different countries. He was also involved in commercialising technology innovations on international scale. He holds the Master degree in Electronics Engineering and MBA.

One-on-one Sessions

The One-on-One session facilitates private discussions between those Users with potential needs for wireless technologies and the Providers of those technologies and capabilities.

Technology Providers will sign up for 15-minute time slots on the Final One-on-One Sign-up Sheet near the WiSEE 2019 registration desk.

Preliminary Sign-up Sheet Only
- awaiting verification of availability of Users

Room A One-on-One Sign-up							
Last	**First**	**Organization**	**10:45**	**11:00**	**11:15**	**11:30**	**11:45**
Torres	Omar	NASA Engineering & Safety Center					
Daum	Jared	NASA/JSC/EG5					
Hang	Richard	NASA/AFRC Flight Test Instrumentation					
McIntyre	Tim	DOE/ORNL					
Salehi	Mustafa	Giatec					
Abedi	Ali	Univ of Maine					
Yang	Ami	NASA/JSC/EV					
Hill	Curtis	NASA/MSFC					
Adams	Jacob	North Carolina State					
Aimi	Marco	GE					
Kitzan	Christopher	Canada Aviation and Space Museum					

Room B One-on-One Sign-up							
Last	**First**	**Organization**	**10:45**	**11:00**	**11:15**	**11:30**	**11:45**
Gerty	Chris	NASA/JSC/EV3					
Evans	Michael	NASA/JSC/XI					
Wilson	Aaron	DOE/ORNL					
Glenn	Ian	Ing Robotic					
Singer	Aaron	Automodality					
Banker	Brian	NASA/JSC/EP					
Rojas	Eduardo	Embry Riddle University					
Redman	Dave	AVSI WAIC Project					
Hunter	Gary	NASA/GRC/LCS0					
Litteken	Doug	NASA/JSC/ES2					
Evans	Richard	NASA/GRC/Plumbrooke					
Seibers	Zach	GA Tech SSERVI Center					
Cook	Christopher	ECM Space - Ottawa					

Thank you for joining us.

Looking forward to seeing you at PWST 2020 in Vicenza, Italy