Passive Wireless Sensor Technology Workshop (#8)
at
Wireless for Space and Extreme Environments(WiSEE2018)

December 11-13, 2018

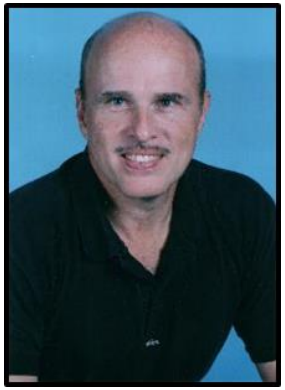
Overview

http://sites.ieee.org/wisee/Program/Workshops

PWST Co-Chairs

Co-Chair: NASA/NESC – Omar Torres

- **NASA Engineering & Safety Center**, Langley VA
  - https://www.nasa.gov/offices/nesc/home/index.html
- NESC Wireless Avionics Community of Practice
- Test instrumentation and analysis engineer
- GPS "Signals of Opportunity"



Co-Chair: Pegasense/UCF – Donald Malocha

- University of Central Florida, Orlando FL
- Prof Emeritus Electrical & Computer Engineering Dept.
- Dir. Consortium for Applied Acoustoelectronic Technology
- CTO of Pegasense, LLC
- IEEE Ultrasonics, Ferroelectronics & Freq Control(UFFC)

Co-Chair: NASA/NESC/AMA – George Studor

- NASA Engineering & Safety Center, Langley VA
- Retired NASA-> Initiated:
  - NESC Wireless Avionics Community of Practice(2011)
  - PWST Workshops(2011) ->
  - In-Space Inspection Workshops(2012)->
  - INCOSE Natural Systems Working Group(2013)->

PWST Workshop Overview

- **Indebted to WiSEE 2018 and IEEE Organizers and Sponsors**
  - Organization and Provisions
  - Website development and updates (http://sites.ieee.org/wisee/)
  - Relevant Keynote Speakers
  - WiSEE Main Track and other Workshop IEEE Paper Presentations

- **PWST Workshop Program**
  - **Thanks for NESC support** – in work since WiSEE 2017, October 2017
  - **Thanks to all Presenters for coming** – 62 is a record number!
  - **Printed Program/addendum** to help you find and develop contacts – also on website
  - **WiSEE2018 Website -** PWST Program and (later) Presentations
  - **Demonstrations** – special thanks for extra effort - highlighted on PWST Agenda posted outside of Rooms C and D = Rooms 3 and 4
  - **One-on-One Sessions** – Sign up at Registration Desk before Thurs
  - **3D Print/Additive Manufacturing Panels** – Thurs 1:00-4:15pm
    - 1-2:30pm – Energy and Industry Applications – DOE/ORNL – Tim McIntyre; Panos Datskos
    - 2:45-4:15pm – Aerospace and Remote – NASA/MSFC – Curtis Hill; Charles Wu
  - **WAIC** Commercial Aircraft PWST Applications Panel – Thurs 1-2:30pm
- **All Attendees:**
  - **Help the Session Chairs keep us on schedule**
  - **No video or photos per IEEE** (we don't have approval by individuals for release)

Panel for 3D Printing Additive Manufacturing Applications for Passive Wireless Sensors

	Energy and Infrastructure Applications				Aerospace and Remote Ops Applications			
	Moderator: DOE/ORNL/Tim McIntyre				Moderator: NASA/MSFC/Curtis Hill			
	Secretary: NREL/Panos Datskos Panos.Datskos@NREL.gov				Secretary: Harding Univ/ Charles Wu wu@harding.edu			
Panelist	**Last**	**First**	**Org**	**Discipline**	**Last**	**First**	**Org**	**Discipline**
User 1	Kuruganti	Teja	DOE/ORNL	Buildings	Smith	Robert	Boeing	Aerospace
User 2	Ianotti	Joe	GE Global	Energy/All GE	Johnson	Mont	Orbital/ATK	Aerospace
PWS 1	Carranza	Susana	Makel	Int sensor/ant	Malocha	Don	UCF	PSAW
PWS 2	Morales	Marissa	DOE/ORNL	PSAW	Hanson	Andrew	NIAR	Functional HW
3D/AM	Brogan	Jeff	Mesoscribe	Mesoplasma	Church	Ken	nScrypt	Direct Digital
3D/AM	Germann	Bryan	Optomec	A-jet/LENS	Tabor	Chris	USAF/AFRL	3D Print R&D
Materials	Drye	Thomas	Techner	Materials	Estrada	David	Boise State	Materials
RF	Pour	Maria	UAH	RF/Antenna	Abedi	Ali	Univ Maine	RF/Wireless
	Key Metrics to consider for Panel 1				**Key Metrics to consider for Panel 2**			
	User Needs – High Volume, Near Term payback				User Needs-Critical Aerospace, Unique Environments			
	Niche Applications: not able to be met otherwise				Niche Applications: not able to be met otherwise			
	Take advantage of COTS & IOT devices(eg phones)				Take advantage of DOD or Industry Investments			
	OEM breakthrough technologies vs applications				OEM breakthrough technologies vs applications			
	TRL – years to maturity in field				TRL – years to flight test			

What's the Problem?
"Wired" Connectivity

- WIRES
- CONNECTORS
- PENETRATIONS

→

WEIGHT
SIZE
DESIGN
INSTALLATION
MAINTENANCE

→

INTEGRATION
CAPABILITY
CAPACITY
RELIABILITY
FLEXIBILITY
MODULARITY

→

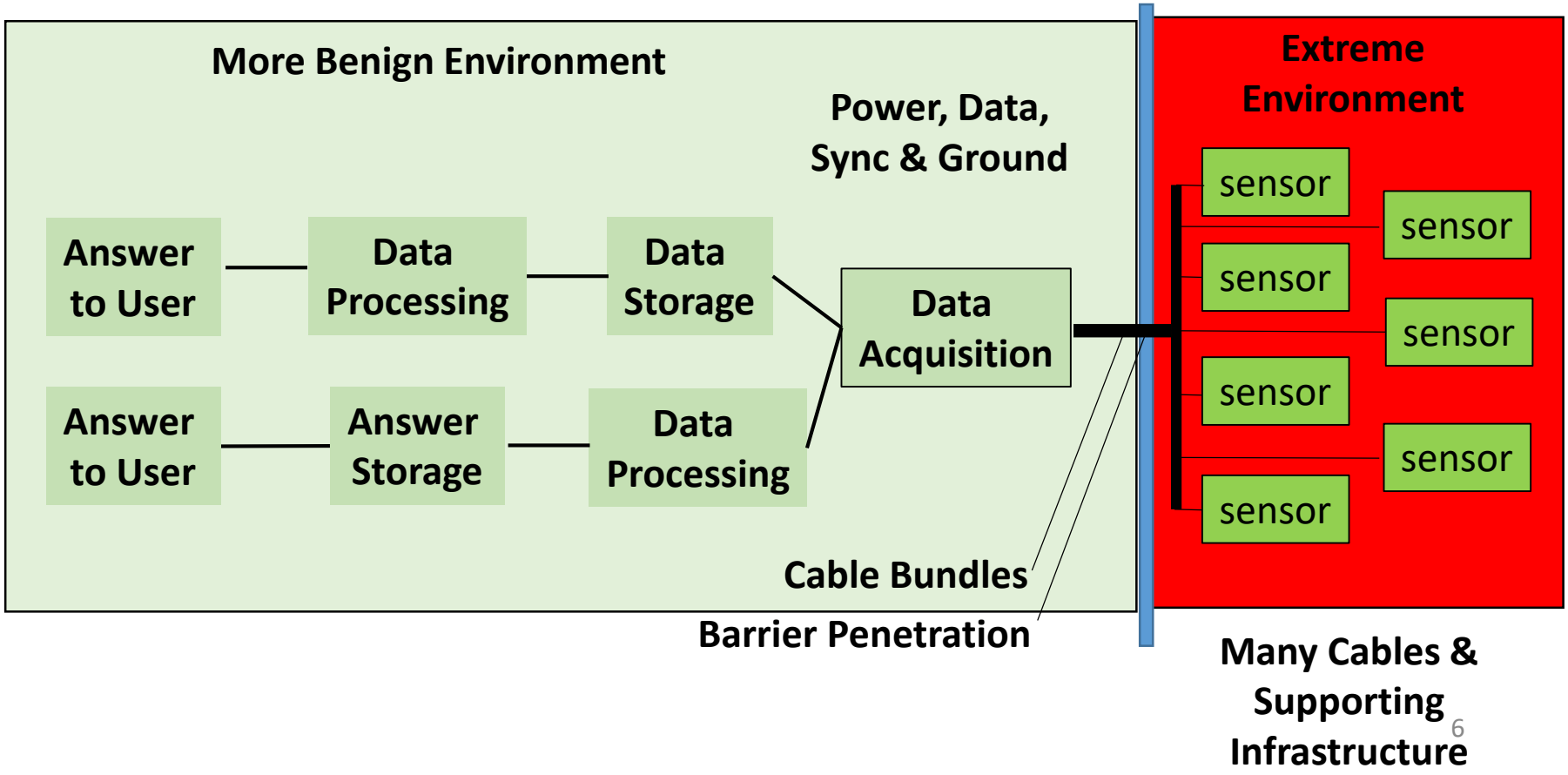
COST
SCHEDULE
PERFORMANCE
RISK

1. Mission Cost/Performance
   - Increasing each year
   - Increasing with missions beyond LEO
2. Contractors LOVE Change Traffic
   - Not incentivized to accommodate change
   - All past programs exhibit this problem

What's the Problem?
"Wired" Connectivity

- Wires – most are to the sensors
- Connectors – most everywhere
- Penetrations – very costly/adds risk

Barriers and Extreme Environments just make the problems WORSE:
Enter
Passive Wireless Sensor Technology



Passive Wireless Sensors

Generally:

- **NO Wire from the Data Acquisition System**
- **NO Battery**
- **NO/limited Electronics**

Benefits:

- **Low Size, Weight and Integration**
- **Low Production cost**
- **Low Operations cost**
- **Low Safety concerns**
- **High Modularity**
- **Extreme Environments**
- **3D Printable, Embeddable in various materials?**
- **Wide Applications in industry, government and IOT**

Some Passive Wireless Sensor Technologies What's Next?

- EM-coupling: RLC, Magnetic Field/Ultrasonic
- RFID-based: Including Tuned and remotely "powered"
- NFC-based: Near Field Communications
- SAW-based: Surface Acoustic Wave reflection(s) + Antenna
- BAW-based: Bulk Acoustic Wave
- Antenna Impedance-based
- Dielectric Resonators
- Backscatter RF
- Radar Response Tags
- Power & Comm In/Across Metal: Mag Field, Acoustic, Ultrasonic, mmwave
- Software Defined Radios and COTS devices (eg Cell phones)
- Broadcast Power-assisted: Meets many of the objectives of PWST
- Optical: Active & Passive(Spatial Phase Imaging-no illumination required)
- 60GHz: V-Band metal dipoles in spray-on patches
- Hybrid – Active Wireless Nodes with Passive Wireless Interrogators
- 3D Print/Additive Manufacturing adding tailoring and imbedded PWS
- Visual Light Communications(VLC): Li-Fi -> LiFD (Light-based RFID)?
- X-Ray: Solid State Xray Comm -> Backscatter X-ray sensing?

What Do the 2 sides of Aerospace Have in Common?

Wires!!

Aviation		Space
Aircraft	wires	Manned Spacecraft
Helicopters	wires	Launch/Landing Systems
Unmanned Aerial Vehicles	wires	Unmanned Spacecraft
Internal/External Robots	wires	Internal/External Robots
Balloons	wires	Inflatable Habitats
Crew/Passenger/Logistics	wires	Crew/Scientists/Logistics
Jet Engines	wires	Rocket Engines
Airports/Heliports	wires	Launch Sites
Engineering Validation	wires	Engineering Validation
Ground Support	wires	Ground Support

Energy, Oil &Gas, Internet of Things, Wireless Home, Transportation, Infrastructure, Building, Agriculture & Food, Medical, Security

What do these have in common?

1. **Data, Power, Grounding Wires and Connectors for: Avionics, Flight Control, Data Distribution, IVHM and Instrumentation.**
2. **Mobility & accessibility needs that restrict use of wires.**
3. **Performance issues that depend on weight.**
4. **Harsh environments.**
5. **Limited flexibility in the central avionics and data systems.**
6. **Limited accessibility.**
7. **Need to finalize the avionics architecture early in the lifecycle.**
8. **Manufacturing, pre and post delivery testing.**
9. **Schedule pressure, resource issues, security and reliability.**
10. **Operations and aging problems.**
11. **Civilian, military, academic & international institutions.**
12. **Life-cycle costs due to wired infrastructure.**
13. **Need for Wireless Alternatives!!**

What's the Problem?

No Direct Incentives to invest in R&D:

- **NASA Limited Funding overall for many programs and centers**
- **Human Spaceflight Transitions and new Mission Challenges**
- **Program-Oriented justification needed for most R&D:**
- **Competition in/between NASA Centers => collaboration, duplication**
- **Very Limited Conference Participation – how to learn "what's new"**

NESC brings discipline experts together to identify & assess capability(CLTS) and problem areas(TDTs) before and after they appear:

=> Avionics TDT => Wireless Avionics Community of Practice

PWST Workshop Approach enables NASA to:

move from "develop our own" to "evaluate, test and modify"

1. **PWST Workshop helps NASA and others outside NASA to:**
   - **Find out what is "out there"**
   - **Initiate conversations about evaluation, test and partnering**
   - **Avoid cost of developing something totally new**
2. **Helps initiate R&D & Applications totally outside NASA**

PWST Purpose and Objectives

Promote PWS Technology Maturation and New Applications by:

1. **Socializing/Networking between:**

   Users with Needs and

   Technology Developers with Potential Solutions

2. **Leveraging from IOT, other Industries, Agencies and Countries**

3. **Facilitating "Next Step" Thinking with:**
   - **Demonstrations and Displays**
   - **"One-on-One" sessions between Users and Developers**
   - **Interactive Panels for focusing interests of attendees**

4. **Broadening PWST Workshop Usefulness with:**
   - **"Library" of past PWST workshop programs & presentations**
   - **Intentionally bringing in new material & focus each workshop**

Passive Wireless Sensor Technology Workshop Vision

Publicly Released Presentations and Demonstrations

+ Private Conversations

What we enable together at PWST Workshop

Awareness:
- Technologies
- Products
- Integrators
- Other Users
- Applications

+

Networking
- With-in NASA
- Other US Gov
- Industry
- Universities
- International

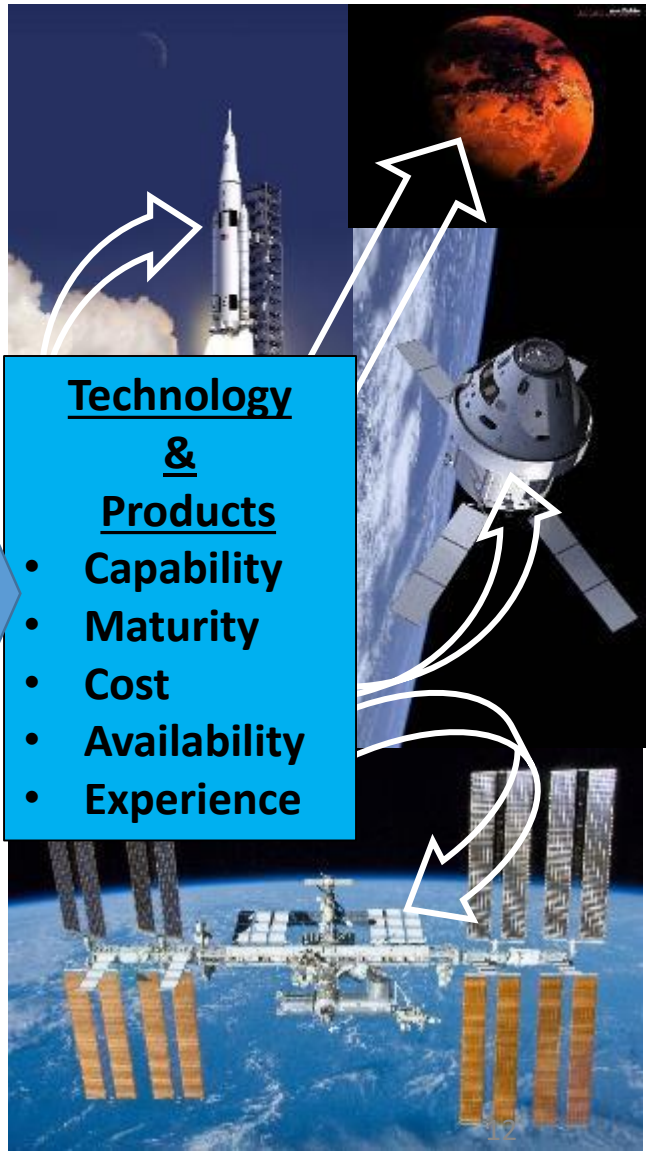
Relationship
- Synergy with WiSEE Conf.
- 1-on-1
- Panels
- Tours

What we produce from a series of PWST Workshops

On-line Library
- Presentations
- Summary
- Brochures
- Contact List

+

In-Person
- Contacts
- Ideas
- Trust
- Pursuits



Technology & Products
- Capability
- Maturity
- Cost
- Availability
- Experience

WiSEE 2019
October 8-11, 2019
Ottawa, Canada

- **2019 PWST Workshop**:
  - **Co-Chairs: NESC Wireless Avionics CoP + _____ + _____?**
  - **Potential Sessions: Your Input?**

Technologies	**Applications**
• Updates on Previous PWS	All Industries/Agencies
• Flexible Sensors/Antennas	Human Factors and Suits
• Hybrid Data Loggers	Flight Test
• Standards & International	WAIC and other Aircraft Applications
• Optical & Imaging	Secure PWST
• 3D Printed	Drones and Cubesats
• Hybrid Active/Passive	Local Ottawa/Montreal Interests

  - **Make Your Plans to Join Us Now!**

- **Talk to us at the One-on-One Table (or before) about your ideas and networking needs.**