Passive Wireless Sensor Technology Workshop
WiSEE 2016, Aachen, Germany
September 27 - 29, 2016

Purpose: To bring Passive Wireless Sensor (PWS) technology developers, manufacturers and potential industry end-users together to understand the larger market drivers that will drive costs down and applications up. At WiSEE, of course we will concentrate on Aerospace and Extreme Environment Applications, but other industries that can benefit from similar technologies are encouraged to participate! Use the presentations from our past workshops to understand what is needed and who has been developing what. At WiSEE 2016 we hope to have another great addition to the library of information and connections for you!

Objectives:
1. Understand various PWS technologies, actual & potential uses, and maturity.
2. Share future applications/advantages/limitations PWS in various industries and agencies.
3. Precipitate individual & group "next step" thinking to further develop/apply PWS.
4. Continue building an accessible library of PWS Workshop publicly released presentations.

Past Public Presentations+Summaries:

PWST 2015 – WiSEE 2016 (Dec '15)
http://sites.ieee.org/wisee/pws-2015-program/
PWST 2015 – DOE FIIW (May '15)
http://futureinstruments.ornl.gov/pdfs/FIIW-2015-Agenda-Website-Agenda.pdf
PWST 2011, 2012, 2013
https://www.isa.org/participate-in-a-technical-division/communications-division/pwst-workshop-vision-and-summary-of-past-workshops/
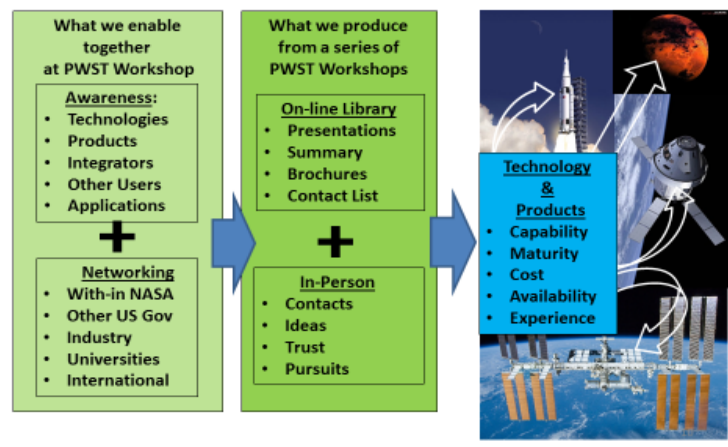
Why Passive Wireless Sensors?
- NO Wire to the sensor
- NO Battery
- NO Complex Electronics
- Low Production cost
- Low Operations cost
- Low Safety concern
- High Modularity
- Extreme Environments
- Wide Application potential

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Passive Wireless Sensor Technology Workshop Vision
Publicly Released Presentations and Demonstrations
+ Private Conversations

Technology examples:
- Passive RFID sensing
- Higher freq wireless SAW/BAW sensors (4.2-4.4GHz)
- Passive Optical Wireless sensing
- Multi-spectral Wireless Sensors (using phase and freq info)
- Through wall (penetrating) and underwater/liquid sensing

Application Examples:
- Spacecraft logistics and low data rate
- Commercial Aircraft On-board wireless
- Industrial/Building monitors, secure RF
- High temperature, chemical, biological
- Aerospace vehicles, Manufacture, Test

- Software defined radios and optimized antennas
- Manufacturing methods for high rate/lo cost
- Location/proximity navigation using passive wireless sensors

- Most application, start with Comm A/C
- High freq SAW, embedded PWS,
- Manufacturing, mapping, operations

Passive Wireless Sensor Technology (PWST): Technology and Applications

Reducing wires, connectors and penetrations has the benefits in every aspect of aerospace and other industry objectives from cost and schedule to capability and performance. Radio Frequency communications between active sensor nodes has been maturing, but now other technologies are emerging that can eliminate the need for electronics/power source at the wireless sensor, eliminate the wire between the sensor and the data acquisition system, eliminate the need for data and some power connectors between avionics, and reduce the need for penetrations and access across bulkheads. Some of the passive wireless technologies have been demonstrated at 1200 Degrees C and others at cryogenic hydrogen temperatures. The cost is a huge factor for industry, both initially and for life-time operations, and yet in most industries, the cost per measurement and cost of connectivity is looked at from a wired point of view, that is mainly installation and other direct impacts. By providing options that eliminate wires, connectors and penetrations the PWST workshops provide a new set of options for both the vehicle, facility and environment monitoring and communication systems engineer. By getting users and stakeholders to discuss their needs, everyone gets to understand the overall potential demand for the technology as well as who might make good partners for research, development and application. The SAW devices are very cheaply produced in large volumes already and advent of 3D printed electronics provides the potential for very low cost passive wireless sensors for SAW and other passive wireless modes as well.

The case for using scavenge power, from physical energy or broadcasted, to charge batteries and capacitors for wireless standalone devices is strong because it can enable longer life for sensing in more benign environments. However the cost for each data point, its infrastructure and physical restrictions on application remain (e.g. temperature, safety, etc) make many applications scavenge power methods impractical. There are cases though where the radiated power can augment interrogation of the passive sensor and provide higher performance from the sensor without the need for a battery. As a guide for our workshops, think of passive wireless as requiring no battery, no expensive electronics at the sensor site and (of course) no need for a wired connection between the sensor and the data acquisition system. Passive Wireless Sensors could be useful at short or long range, mobile platforms or fixed, simply printed for shirt-sleeve environment or sophisticated for high performance and extreme environments. Surface Acoustic Wave(SAW)-based sensors, in a manner somewhat similar to a classic passive RFID tag, responds to a wireless interrogation signal from a reader, but unlike RFID it provides real-time sensor data along with its unique tag id, stored information and range. As time goes on, more interrogation methods are being discovered while the others are being matured. PWSTs should aspire to be manufactured in high volume – even incorporating direct write fabrication - resulting in inexpensive devices. With its considerable potential read-range (separation distance between reader and device), compatibility with extreme environments, small size, autonomy of sensor installation, and "no onboard power" capabilities, PWSs have a wider application arena than current battery-powered wireless sensors. Enabling technologies such as new manufacturing, materials, antennas and interrogators are encouraged to be brought forward.

The PWST workshop will explore these and other motivations for using PWSTs in a variety of fields, present and demonstrate current technologies, explore current and future applications of PWSTs in various industries. A key component of this two-day PWST Workshop is to facilitate discussions between end users and developers/suppliers on application areas of mutual interest.

Examples of Passive Wireless Communication/Sensing

- Surface Acoustic Wave-based
- Bulk Acoustic Wave-based
- RLC-based
- RFID-based
- NFC-based
- Optical Comm-based
- 60 GHz – based
- RF Antenna-based or Antenna only
- Multi-spectral response materials and sensors

Through-Wall Comm & Power:

- Magnetic Field
- Acoustic Emissions
- Ultrasonic
- X-Ray Comm

Passive Surface Acoustic Wave(SAW) & Bulk Acoustic Wave(BAW) Wireless Technologies

- Surface Acoustic Waves and Bulk Acoustic Wave based
- Sensor Performance: data rates, range, multi-sensors, reduced configuration dependencies
- Manufacturing: cost, quality, reliability, configurability, techniques(e.g. 3D) sensor&ant
- Interrogators: cost, size, weight, interrogation rates/# of sensors, antennas, ruggedness
  Maturity/Availability: proven applications, COTS availability, technology readiness level

Applications for Aerospace:
- Otherwise Impractical Measurements:

- Rotating Parts – blades + mechanisms, hot turbines
- Difficult Access: vehicle zones, avionics, tanks/reservoirs, chambers, balloon, parachutes
- Remote interrogation – off-board (grnd-vehicle) and on-board (exterior/interior sensing)
- Interrogation through structures and liquids – avoid penetrations, wiring
- Extreme environments – hot turbines, re-entry protection, cold high altitude/space/winter conditions, vacuum, high radiation, shock/vibration/pressure

- Capability and Performance:

- Light weight/small size – vehicle payload capacity, efficiency, system monitoring
- Multi-path RF, other interferences/configuration dependencies, safety, directional sensing
- Low integration cost/schedule: deferred instrumentation decisions, integrated vehicle test changes, flt/ground test temporary Instr, aging vehicle ops, condition-based monitoring
- Convert Wired Sensors to Passive Wireless – chemical, biological, physical
- Manufacturing/Asset data/location – embedded updatable tags, in-place direct-write tags,
- RF compatibility with Spectrum authorized use and developing Standards
- Use of Optical, XRay and other low/high frequencies, Magnetic field, Electrical Charge, Ultrasonic for free-space and conducted transmission

Applications for Other Industries and Government Agencies

- DOE – Buildings, Grid, Nuclear
- DOT – Roads, Bridges/tracks, Vehicles
- DOD – Vehicles, Weapons, Soldiers, Logistics, Environments, many others
- DHS – Discrete Sensing & Locating
- USDA - Forest Service, Agriculture, Food
- DNR – Wildlife, Soils, Agriculture, Water, etc
- DoC - NOAA – Weather, Quakes, Fires, etc
- DHHS – Health and Medical