Passive Wireless Sensor Technology(PWST)
2012 Workshop Plan

June 6-7, 2012
Hyatt Regency, La Jolla, CA

Chairman: NASA/JSC/George Studor
Sponsors: ISA/Ian Verhappen/Rodney Jones

Agenda

- Background/Motivation
- Approach/Content
- Participants - Statistics
- Follow-on Splinter Groups
- Comments
- Next Steps

Background/Motivation – Why a PWST Workshop?

"Fly-by-Wireless" Vision:

To Minimize Cables and Connectors and Increase Functionality across the aerospace industry by providing reliable, lower cost, modular, and higher performance alternatives to wired data connectivity to benefit the entire vehicle/program life-cycle.

Focus Areas:

1. **System engineering & integration methods to reduce cables & connectors.**

2. **Vehicle provisions for modularity and accessibility.**

3. **A "tool box" of alternatives to wired connectivity.**

What it is NOT:

- **A vehicle with no wires.**
- **Wireless-only for all control systems.**

"Fly-by-Wireless" Focus Areas

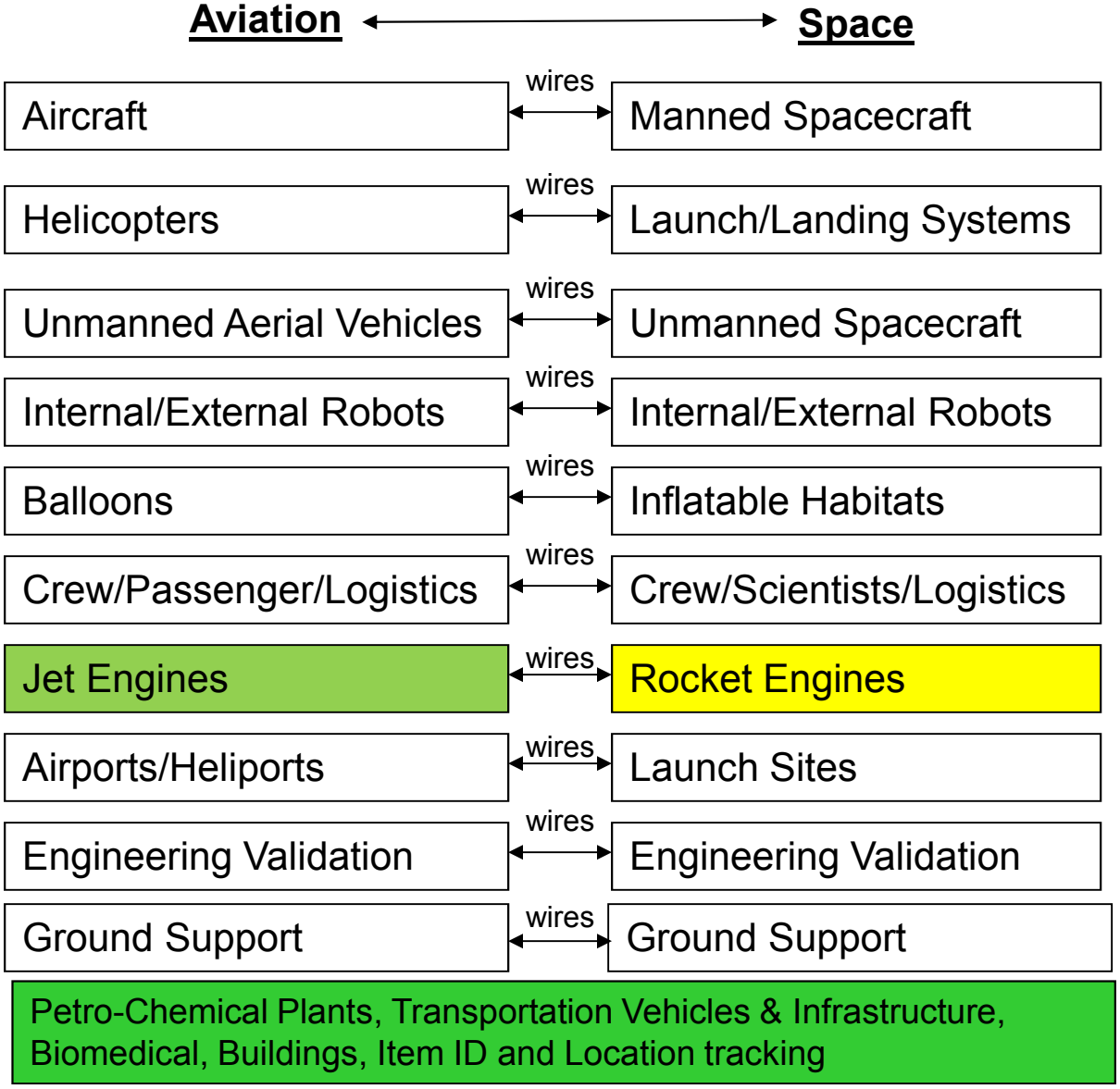
(1) System engineering and integration to reduce cables and connectors,
- **Capture the true program effects** for cabling from launch & manned vehicles.
- **Requirements** that enable and integrate alternatives to wires.
- **Metrics** that best monitor progress or lack of progress toward goals.(# cables, length, # of connectors/pins, # of penetrations, overall weight/connectivity, total data moved/lb).
- **Design Approach** that doesn't assume a wires-only approach, but optimizes all practical options, providing for the inevitable growth in alternatives to wired connectivity.

(2) Provisions for modularity and accessibility in the vehicle architecture.
- **Vehicle Zone Accessibility –** Considers standalone sensors along with system assembly, inspections, failure modes/trouble-shooting, system/environment monitoring, remove & repair.
- **Vehicle Zone Modularity –** Vehicle wired buses provide power, two-way data/commanding, grounding and time in a plug-and-play fashion. Wireless networks are standardized by function and are also plug-and-play.
- **Centralized & De-centralized approaches** are available for measurement & control.
- **Entire life-cycle** considered in addition to schedule, performance, weight & volume.

(3) Develop Alternatives to wired connectivity for the system designers and operators.
- Plug-n-Play wireless devises
- Wireless no-power sensors/sensor-tags
- Standalone wireless smart data acquisition
- Standardized I/Fs, networks & operability
- Wireless controls – back-up or low criticality
- Robust high speed wireless avionics comm.
- Data on power lines, light, structure, liquids
- No connectors for bulkheads, avionics power
- Robust software programmable radios
- Light wt coatings, shielding, connectors
- **RFID for ID, position, data, & sensing.**
- Inductive coupling for rechargeable batteries

What Do the 2 sides of Aerospace Have in Common?

Wires!!



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!!**

Common Motivations

Systems and Vehicles:

- **Reduce Cost/Schedule of Wired Connectivity**
- **Increase Reliability/Maintainability**
- **Increase Safety**
- **Increase Security (some more than others)**
- **Increase System Functionality**
- **Changes in System Engineering & Integration, Vehicle Architecture and Technology Development/Awareness**
- **Decrease Size, Weight and Power**

Wireless Sensors:

- **Cost - No battery and no radio costs**
- **Manufacture In Quantity – Like RFID tags**
- **Life time power – no battery replacement**
- **Safety – little or no stored power**

What Is a Passive Wireless Sensor-Tag(PWST)?

Attributes:

- **No battery**
- **No need for scavenging power over time**
- **No wired connection between sensor and data acquisition unit**
- **Provides a sensor reading along with a unique tag id**
- **Can provide range information for location/orientation**
- **Minimum electronics – can be fabricated for extreme temperature and other environments.**
- **Can be imbedded in/behind structure permanently or added after manufacturing**
- **Multiple industries have use cases – need to bring them together to generate demand.**
- **Compatible with high volume production – leading to low cost per measurement point:**

Generation 1	Generation 2	Generation 3	Generation 4
Wired	Motes	Active Sensor Tags	PWST?
~$10,000 per point	~$1,000 per point	~$100per point	~$10 per point

Basic Types:

- **EM-coupling: Simple – very short range**
- **RFID-based: Antenna for scavenge power for data return – med range**
- **SAW-based: Surface Acoustic Wave reflection(s) + Antenna**
  - **Longer Range, Higher Sample Rate**
  - **Many tags interrogated at one time**

2012 Passive Wireless Sensor Technology Workshop

Purpose:

To bring Passive Wireless Sensor-Tag(PWST) technology developers, manufacturers and potential industry end-users together to understand the larger market drivers that will drive costs down and applications up. We will also discuss logical next steps.

Objectives:

- Understand various PWST technologies, actual & potential uses, and maturity.
- Assess the future applications/advantages/limitations in various industries.
- Assess what is needed for high volume production, standardization & communication.
- Precipitate individual & group “next step” thinking to further develop/apply PWSTs.
- Accumulate contacts for potential partnering activities (start at 2011 PWST)

Methods for growing the Technology without "doing it all myself"

- Make more organizations aware of the technology and it's uses
  - Briefings available to Public – who do I talk to?
  - Opportunities from Private Discussions - details
- Stimulate other organizations to fund and use the technology.
- Identify use cases–technology areas of potentially large volume – as well as combined use cases.
- Facilitate private "one-on-one" discussions for partnering.
- Facilitate next step discussions between members.
- Invite Government and University observers to stimulate thinking and opportunities.
- Follow-up with public availability of the briefings.
- Make the interested community aware of new opportunities

Common Interests that make this format productive

- Understand how to take advantage of new PWST technology.
- Efficient ways to keep up with new technologies at all levels.
- Discover others that are developing/using PWST technology similar to what we need.
- Technology developers need to know what problems need solving.
- "Out of the Box" thinking at System Engineering level.
- Cross "barriers" between Industries, Government Orgs and Countries.
- Combined Business Cases in multiple industries for larger scale production.
- Communication is the key - let's work at it!

2012 PWST Workshop
June 6 & 7, 2012

- Presentations should complement 2011 PWST Workshop
- Maximize the Synergy with co-located IIS Symposium
- Networking Opportunities during Breaks after each set of Presenters - will be at prescribed locations at each break
- I will be available during breaks, lunch and after the workshop each day to discuss feedback and forward actions
- Recommend One-on-Ones happen at Lunch and Dinner (you make it happen)
- Discuss Outcomes of 2011 PWST Workshop and what to do.

- Presentations, Brochure and Updated PWST Summary will be made available on the ISA Comm Division Website
- List of Presenters and Attendees will be available to attendees

2012 PWST Agenda
June 6th AM

8:00am	NASA/JSC/Structures SHM	George Studor	- "Passive Wireless Sensor Technology 2012 Workshop Plan“
8:30am	GE Global Research	Daniel Sexton	- “ISA107.4: Wireless sensor for turbine instrumentation working group”
9:00am	United Tech Research Center	Sanjay Bajekar	- Wireless for Aerospace Applications
9:30am	NAWCWD China Lake	Rob Pritchard	- “Naval Applications of PWST from the End-user's Perspective”
10:00am	Break		
10:30am	BP/chief Technology Office	Dave Lafferty	- “Passive Sensor Needs at BP”
11:00am	Shell	Ron Cramer	- “Oil and Gas Integrity Monitoring”
11:30am	DOT/FHWA	Fred Faridazar	- "Wireless Sensors for Structural Monitoring During Extreme Events"
12:00 - 1:00	Lunch		

2012 PWST Agenda
June 6th PM

1:00pm	Rockwell Automation	Cliff Whitehead	- "Machine-to-Machine Interfaces in Factory Automation"
1:30pm	Arkansas Power & Electric	John Fraley	- "High Temperature Wireless Sensor Systems"
2:00pm	Yokogawa	Penny Chen	- PWST needs at Yokogawa
2:30pm	Break		
3:00pm	Savannah River Nuclear Solutions	Mike Mets	- "PWST/RFID Technology for Material Control and Accountability at the Savannah River Site"
3:30pm	DOE/Electrical Grid	James Briones*	- PWST for the Electrical Power Grid
4:00pm	On-Ramp Wireless	Jake Rasweiler	- Ultra-Link High Capacity, Long Range, Low Power Technology Applications
4:30pm	AVSI Project AFE73 -WAIC	Radek Zakrzewski	- The Status of Wireless Avionics Intra-Aircraft Communications

2012 PWST Agenda
June 7th AM

8:00am Syntonics	Bruce Montgomery	- "Passive Wireless Sensing in a High-Multipath, High-Doppler Environment"
8:30am Albido Corp	Fred Gnadinger	- "Wireless Passive Strain Sensors Based on Surface Acoustic Wave (SAW) Principles"
9:00am Environetix	Mauricio Pereira da Cunha	- "Harsh Environment Wireless Sensor System for Monitoring Static & Rotating Components in Turbine Engines and Other Industrial Applications"
9:30am nScrypt	Ken Church	- "Passive Direct-write Sensors"
10:00am Break		
10:30am RF SAW	Paul Hartmann	- Passive SAW Sensors
11:00am ASRDC	Jackie Hines	- PWST SAW - Sensor System
11:30am Univ of Cntl Florida	Don Malocha	- SAW Sensor Technology
12:00 - 1:00pm Lunch		

2012 PWST Agenda
June 7th PM

1:00pm	Carinthian Tech Research	Heimo Mueller	- "SAW Sensors: Explore New Measurement Horizons"
1:30pm	Vectron	Sabah Sabah	- "Vectron Wireless Temperature Monitoring Solutions"
2:00pm	MIT	Isaac Ehrenberg	- "RFID Tag Antenna-Based Sensing"
2:30pm	Break		
3:00pm	Tag Array	Kourosh Pahlavan	- Passive UWB Location
3:30pm	VTI Instruments	Chris Gibson	- Adding PWST to standard test instrumentation
4:00pm	MaXentric	Don Kimball	- 60 GHz Comm, RFID moving to PWST
4:30pm	Wireless Sensor Technologies	John Conkle	- Wireless Sensors for Gas Turbine Engines
5:00pm	Workshop Closing	George Studor	- Discussion, Conclusions

2011 PWST Workshop Summary

2011 PWST Workshop Objectives

- **Understand various PWST technologies, actual & potential uses, and maturity.**
- **Assess the future applications/advantages/limitations in various industries.**
- **Assess what is needed for high volume production, standardization & communication.**
- **Precipitate individual and group "next step" thinking to further develop/apply PWSTs.**
- **Incrementally develop A PWST COMMUNITY**

2011 PWST Workshop Approach

Day 1:

- **Session 1 & 2: Set Landscape/Vision Of PWST**
  Introduction To PWST Technology
- **Session 3 & 4: Technology Presentations and Demonstrations**
- **Dinner in small groups**

Day 2:

- **Session 5 & 6: End-User Presentations**
- **Session 7: Related enabling technologies and activities**
- **Session 8: Forward Planning Splinter Sessions/Reports**

Note: One On One Sessions facilitated through-out both days.
Hardware Demonstrations Encouraged

2011 PWST Workshop Statistics

- Time from 1st Announcement to Workshop: 3 months
- 34 Presenters: 18 on Day 1 + 16 on day 2
- 52 attendees: 25 + 27
- 13 Technology Demonstrations
- 13 One-on-One Tables
- Overseas: 1 from Germany, 1 Holland, 1 UK, 2 Japan, 2 Canada
- 6 University
- 18 Government
- 4 from JSC besides me – EV(2) and ES and EC
- 6 Forward Planning **Splinter Groups**:
  - Next Workshop - ISA/DOE-ORNL/Peter Fuhr
  - Business Case Development – Radient360/Jeffrey Smith
  - Standards & Inter-operability - RFSAW/Clinton Hartmann(SAW tag-side)
  - Testing And Evaluation - NASA/LaRC/Cy Wilson, with KSC, JSC, MSFC, GRC
  - Communication - RFID Network/Louis Sirico - see first product already posted at http://RFID.net<http://rfid.net/
  - University Participation - MaXentric/UC SanDiego/Don Kimball

2011 PWST Workshop Speakers: Day 1

1-1	Lafferty	Dave	Welcome from BP - Interest, Facilities, Safety, etc	BP - Tech Office - host	Houston, TX	Chief Technology Office - Technology Advisor
1-2	Studor	George	"Fly-by-Wireless and the Passive Wireless Sensor Workshop"	NASA/Workshop Vision	Houston, TX	Staff, Strategic Planning and Partnership Opportunities Office
1-3	Malocha	Don	"Wireless Passive SAW Sensors using Coded Spread Spectrum Techniques"	Univ of Central Florida	Orlando, FL	Prof, Dep Electrical & Computer Eng, Harris Engineering Center (HEC 346)
1-3	Belkerdid	Madjid	Joint Presentation - Demonstration	Mnemonics	Melbourne, FL	Principal Systems Engineer
2-1	Surman	Cheryl	"Multivariable passive RFID sensors: From detailed laboratory evaluations to pilot-scale manufacturing"	GE Global Research Center	Niskayuna, New York	Bioanalytical Chemist- Chemical Sensor Laboratory
2-1	Bloch	Peter	Joint Presentation - Demonstration with GE	Avery Dennison	Madison, WI	Sr. Mgr of Strategic Alliances, RFID Div
2-2	Matthews	Robert Dr.	"Compliance Independence– is this the passive revolution?"	West Wireless Health Institute	La Jolla, CA	Chief Technology Officer
Lnch Spkr	Reindl	Leonhard	"History, Applications, and Market Overview of Passive Wireless Sensors"	Imtek,Institute for Microsystem Tech	Freiburg, Germany	Head, Dept of Electrical Instrumentation, Imtek
3-1	Hartmann	Clinton	"Advanced SAW Devices for RFID and Sensing Applications"	RFSAW	Richardson, TX	Founder and President
3-2	Hines	Jackie	"SAW Sensor and Sensor-tag Developments at ASR&D"	ASRDC	Arnold, MD	President
3-3	Woods	Brian	"VERSA: V-band Enhanced RFID/Sensing Architecture"	MaXentric	LaJolla, CA	R & D Engineer - Note: Also accompanied by the Chief Technology Office Don Kimball
3-4	Brown	Jeffrey K.	"Seeing Through the Fog: Collecting PWST Data in a Harsh Environment"	Radient360	St. John's, Newfoundland	Executive Vice President
3-5	Abedi	Ali	"Location and Temperature Passive Wireless Sensor Tags"	Univ of Maine/CANEUS	Orono, ME	Associate Professor Electrical and Computer Eng.
4-1	Trelewicz	Jason	"Integrated Diagnostics Using Direct Write Sensors"	Mesoscribe	St. James, NY	Program Manager
4-2	Conkle	John	"Wireless Sensors for Gas Turbine Engines"	Wireless Sensor Technologies	Encinitas, CA	Founder and President
4-3	Krawczewicz	Mark	"A New Class of Passive Secure ID Display Card"	Tocreo Labs	Annapolis, MD	Founder and CEO
4-4	Kalinin	Victor	"Wireless Resonant SAW Sensors for Automotive Applications"	Transense	Upper Heyford, Oxfordshire, UK	Chief Scientist
4-5	Ostaffe	Harry	"High-Function, Long-Range PWST"	Powercast	Pittsburgh, PA	Vice President of Marketing & Business Devel

2011 PWST Workshop Speakers: Day 2

5-1	Lafferty	Dave	"Potential Passive Wireless Sensor Tag Applications"	BP - Tech Office - host	Houston, TX	Chief Technology Office - Advisor
5-2	Chow	Ivan	"Proceed with Caution with Disaster Recovery Applications Nuclear Power Plant Control System"	Doosan/HF Controls	Plano, TX	V&V Manager at Doosan HF Controls
5-3	Stieger	Ron	"RFID Sensors in Transportation"	Zonar Systems	Seattle, WA	Director of Engineering
5-4	Faridazar	Fred	"Intelligent Multi-Sensor Measurements to Enhance Pavement Monitoring and Safety"	DOT-FHWA - Turner-Fairbank Admin	McLean, VA	Office of Infrastructure Research and Development - Pavement Design and Construction Team
5-4	Lajnef	Nizar	"A Sub-Microwatt Long-term Monitoring Sensor"	Michigan State Univ	East Lansing, MI	Ass. Prof, Dir. Comp Sensors Lab/Civil&Env. Eng
5-5	Mrad	Nezih	"Potential Applications of PWST"	Department of National Defence (DND)	Ottowa, CA	Defence Scientist,Air Vehicles Research Section (AVRS)
6-1	Gemdjian	Ed	"Passive Wireless SAW Temperature Sensors"	Kongsberg Maritime	Northvale, NJ	Mechanical Engineer
6-2	Hernandez	George	"Sensors and Controls Enabled Solutions"	DOE/PNNL - Building Sensors	Richland, WA/Wash DC	Staff Engineer - detailed to DOE HQ
6-3	Salour	Al	"Use of Passive RFID and Networking Technology in Aerospace Manufacturing"	Boeing – Aerospace Manufacturing Sensors	St. Louis, MO	Enterprise Leader for the Boeing Research & Technology's Network Enabled Manufacturing (NEM) initiatives
6-4	Safa-baksh	Robab	"Passive Wireless Sensors, Vehicle Health Management Applications"	Boeing Research and Technology	Philadelphia, PA	Asso. Tech Fellow for VHM & SHM
Lunch Spkr	Sirico	Louis	"What Works in the World of Wireless Sensors"	The RFID Network	Campbell, CA	Host of The RFID Network, a TV video series dedicated to RFID and wireless sensor technologies
7-1	Vega	Victor	"Interactive Gen2 | Bridging the Gap between Passive RFID, Sensors and Electronics"	NXP Semiconductors	San Jose, CA	Business Development Manager, Marketing Director, RFID Solutions
7-2	Plourde	Rich	"Aerosol Jet Direct Write Technology – A Tool for Printed Electronics"	Optomec - Headquarters	Albuquerque, NM	Aerospace & Defense Business Liaison
7-3	Wilson	William C.	"NASA Testing of PWST"	NASA-LaRC	Langley, VA	LaRC-SAW Device Design, COTR
7-4	Fisher	Fred	"AVSI Cooperative Research in Intra-Aircraft Spectrum Usage"	AVSI - Assist Dir; TEES -Dir Eng& Comp	College Station, TX	Assistant Director, AVSI
7-5	Pimprikar	Milind	"Bridging the Mid TRL Gap through Coordinated Technology Development"	CANEUS	Montreal, CA	Founder and Chairman
Intro	Fuhr	Peter	Motivation and Explanation of Splinter Sessions	DOE/ORNL	Knoxville, TN	Future ISA Comm Chair
Mtg	Splinter Sessions Meet in Separate Locations					
Sum	Splinter Spokesperson		5 minute Report from Each of 7 Splinter Groups			

2011 PWST Workshop Attendees

Last	First	Position	Organization	Location	Type
Adams	Elizabeth	Technology Project Leader - Wireless	BP	Naperville, Il	Ind
Adkins	Andrea	Assist Dir. Commercialization: Tech Transfer	UCF	Orlando, FL	Univ
Bachtel	Russel	Engineer	NASA-JSC - EC	Houston, TX	Gov
Bain	Mark	Systems Engineering Electrical	Space Systems Loral	Palo Alto, CA	Ind
Barton	Rick	Wireless Communication Engineer	NASA- JSC/EV4	Houston, TX	Gov
Baumann	Wolfgang	Sales Engineer	R. STAHL INC	Houston, TX	Ind
Bonneau	Walt Jr.	President & General Manager	Cubic Security Systems, Inc	San Diego, CA	Ind
Chen	Penny	Principal Systems Architect	Yokagawa	Palo Alto, CA	Ind
Citrano	Joseph	Global Product Marketing Manager	Honeywell	Golden Valley,MN	Ind
Cote	Andrea	Chief Technology Officer and VP of PM	Omni-ID	Rochester, NY	Ind
Cramer	Ronald	Senior Advisor	Shell	Houston, TX	Ind
Cuartas	Wilson	Engineer	AW ELECTRONICA	Houston, TX	Ind
Daniel	Alan	Sr. Research Engineer	Southwire Company	Carrollton, GA	Ind
Dodds	Kevin	Land Geological Integrity `	BP	Houston, TX	Ind
Drobshoff	Alex	Engineer	Lawrence Livermore National Lab	Livermore, CA	Gov
Ferguson	Dana	Business Development	Ventyx	Houston, TX	Ind
Goodenow	Debra	Instr. for Heavy Lift Launch Vehicles	NASA - GRC	Cleveland, OH	Gov
Griggs	Steve	Engineer	Weatherford	Houston, TX	Ind
Haines	Mark	Director of Engineering	Mnemonics	Melbourne, FL	Ind
Hartmann	Tom	Director Brand Security & Electronics	Topflight	Glenn rock, PA	Ind
Hartmann	Paul	Vice President, Engineering	RFSAW	Richardson, TX	Ind
Hedtke	Bob	Director of Technology	Rosemount Inc	Chanhassen, MN	Ind
Hines	Andy	Technician	ASRDC	Arnold, Maryland US	Ind
Hines	Jackie	President	ASR&D	Arnold, Maryland US	Ind
Ho	Stephen	Research Scientist	MIT Auto-ID Labs	Cambridge, MA	Univ

2011 PWST Workshop Attendees

Hyde	Scott	Marketing Manager for Strategic Propulsion	Aerojet	Clearfield, Utah	Ind
Kimball	Don	Chief Technology Officer	MaXentric	LaJolla, CA	Ind
Krisel	Robert	Engineering Manager	Panduit Corp	Tinkley Park, IL	Ind
McIntyre	Timothy	Leader, Sensors and Controls Research Grp	DOE/ORNL - Sensors & Controls	Knoxville, TN	Gov
Montgomery	Bruce	President	Syntonics LLC	Columbia, MD	Ind
Nadler	Gerry	President	Wihart systems	Acton, MA	Ind
Oberle	Larry	Instr. For Heavy Lift Launch Vehicles	NASA - GRC	Cleveland, OH	Gov
Oeste	Tom	Technician	ASRDC	Arnold, Maryland US	ind
Ogai	Takashi	Mgr, Gr. Space Dev., Aero Eng & Space Ops	IHI Corporation	Japan	Ind
Oluwatosin	Adedeji	Shell Global Solutions International B.V.	Shell	Rijswijk,S.Holland NL	Ind
Pahlavan	Kourosh	CEO & CTO	TagArray	Palo Alto, CA	Ind
Patterson	Mark	Propulsion Dir., Turbine EngResearch Center	AFRL /RZTE	WPAFB, OH	Gov
Saito	Hiroki	Staff Member - Aero Engines & Space Ops	IHI Corporation	Japan	Ind
Schoenborn	Renee	Senior Instrument Engineer	Shell Global Solutions(US)	Houston, TX	Ind
Scoggins	Doyle	STPNOC Metrology Supervisor	STP Nuclear Operating Company	Wadsworth, TX	Ind
Scott	Jeffrey	Technologist - RFID	Pacific Northwest National Labs	Richland, WA	Gov
Smith	William	Project Engineer	Mesoscribe	Huntington Beach, CA	Ind
Smith	Richard	Shell SEIP	Shell	Houston, TX	Ind
Solie	Leland	Senior Scientist	ASRDC	Arnold, Maryland US	Ind
Song	Gangbing	Director, Smart Materials/Structures Lab	Univ of Houston	Houston, TX	Univ
Struble	Ed	Vice Pres Avionics, Weapons & Sensor Sys	Mnemonics	Melbourne, FL	Ind
Tran	Thanh	NMO Process Engineer	Savannah River Nuclear Solutions	Aiken, SC	Gov
Trott	Aaron	Program Director	Invocon	Conroe, TX	Ind
Wagner	Raymond	Sr. Research Development Scientist	NASA - JSC	Houston, TX	Gov
Ward	Justin	Sr Business Systems Associate	EOG Resources	Fort Worth, TX	Ind
Willoner	Terry	Engineer	Savannah River Nuclear Solutions	Aiken, South Carolina	Ind
Zipay	John	Structural Engineer	NASA/JSC - ES	Houston, TX	Gov

Passive Wireless Sensor Technology
Workshop Web-links
ISA Communication Division

Workshop Program:
http://www.isa.org/Content/Microsites530/Computer_Tech__Division/Home528/Passive_Wireless_Sensor_Workshop/Final2011Program.pdf

Workshop Summary:
http://www.isa.org/MSTemplate.cfm?Section=Passive_Wireless_Sensor_Workshop&Site=Computer_Tech__Division&Template=/ContentManagement/MSContentDisplay.cfm&ContentID=86981

Workshop Presentations:
http://www.isa.org/MSTemplate.cfm?Section=Papers_Presentations&Site=Computer_Tech__Division&Template=/ContentManagement/MSContentDisplay.cfm&ContentID=86991

Communications:
http://rfid.net/applications/energy/289-passive-wireless-sensor-tags-benefit-energy-aerospace-transportation-a-industry

Comments from Attendees

- Overwhelming Appreciation – many unsolicited – several said it was the best that they had been to on this subject!!

- More attendees than anticipated
  - got a little crowded
  - Wireless internet access got maxed out

- Only NASA investment was my time and lots of summer high school intern time(Radina Khalid) plus travel.

- ISA Commitment: June 5-7 2012 Workshop in La Jolla, CA
  - Call for papers expected by mid October

Follow-up

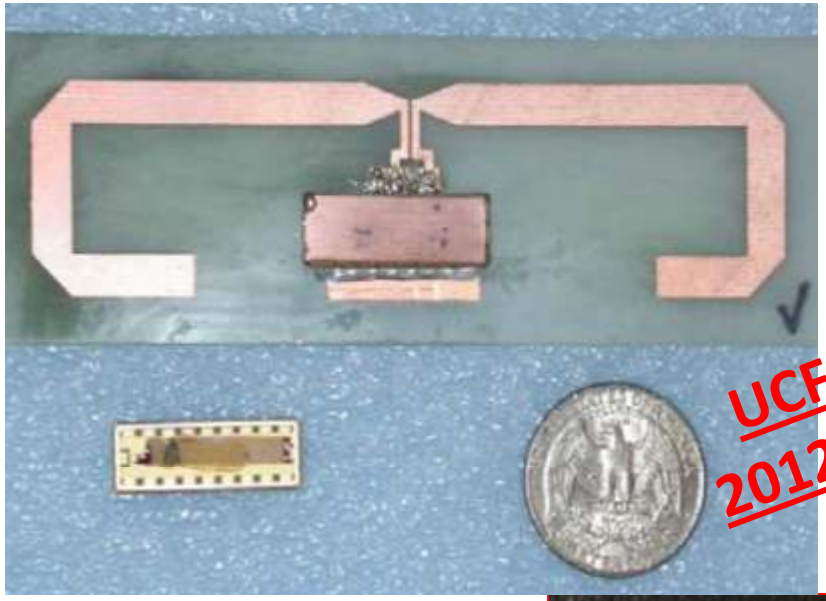
- Committee telecons for next ISA PWST Workshop
  - Call for papers issued:
    http://www.isa.org/Content/Microsites530/Computer_Tech__Division/Home528/Announcements/2012SymposiaPaperCall.pdf
  - http://www.isa.org/MSTemplate.cfm?MicrositeID=530&CommitteeID=5222
- Rack up and assess what we learned from the workshop
  - technologies and applications
- Encourage the Splinter groups to action.
- Encourage attendance at other related meetings.
- Brief other groups on the results:
  - ✓ NASA Wireless Avionics Community of Practice
  - ✓ NASA Aerospace Sensors Working Group
- Work on growing the relationships with the distinguished presenters and attendees and those that couldn't come.
- Contribute as SMEs for Wikipedia (SAW, RFID and Wireless Sensors)

Briefing Summaries

Wireless Passive SAW Sensors using Coded Spread Spectrum Techniques

Univ of Central Florida/Mnemonics

Don Malocha http://caat.engr.ucf.edu/ - Madjid Belkerdid http://mnemonics-esd.com



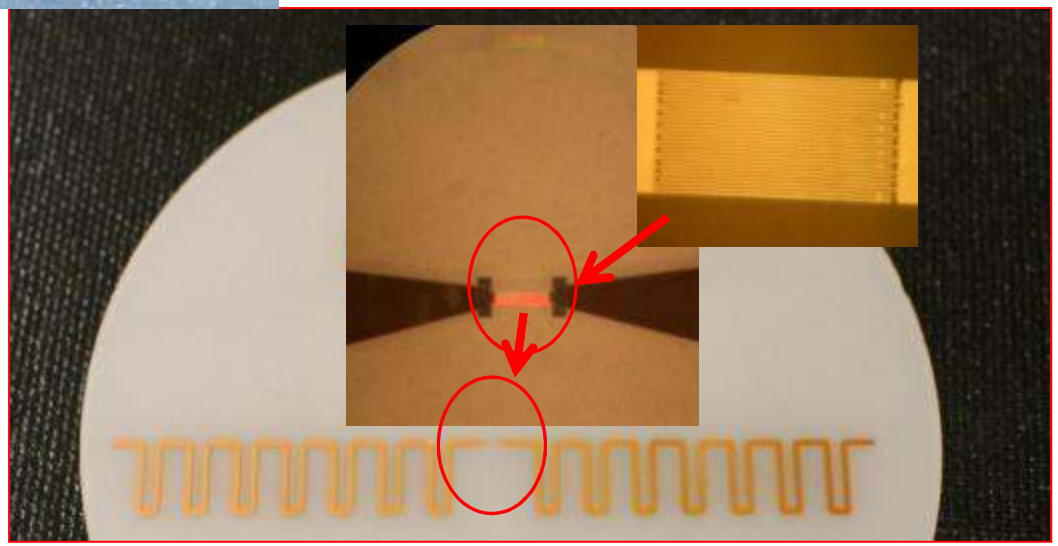
915 MHz Wideband Folded Dipole Antenna

Miniature 915MHz Integrated OFC SAW-Patch Antenna

OFC=Orthogonal Frequency Coded

SAW=Surface Acoustic Wave

UCF will Present at 2012 PWST Workshop

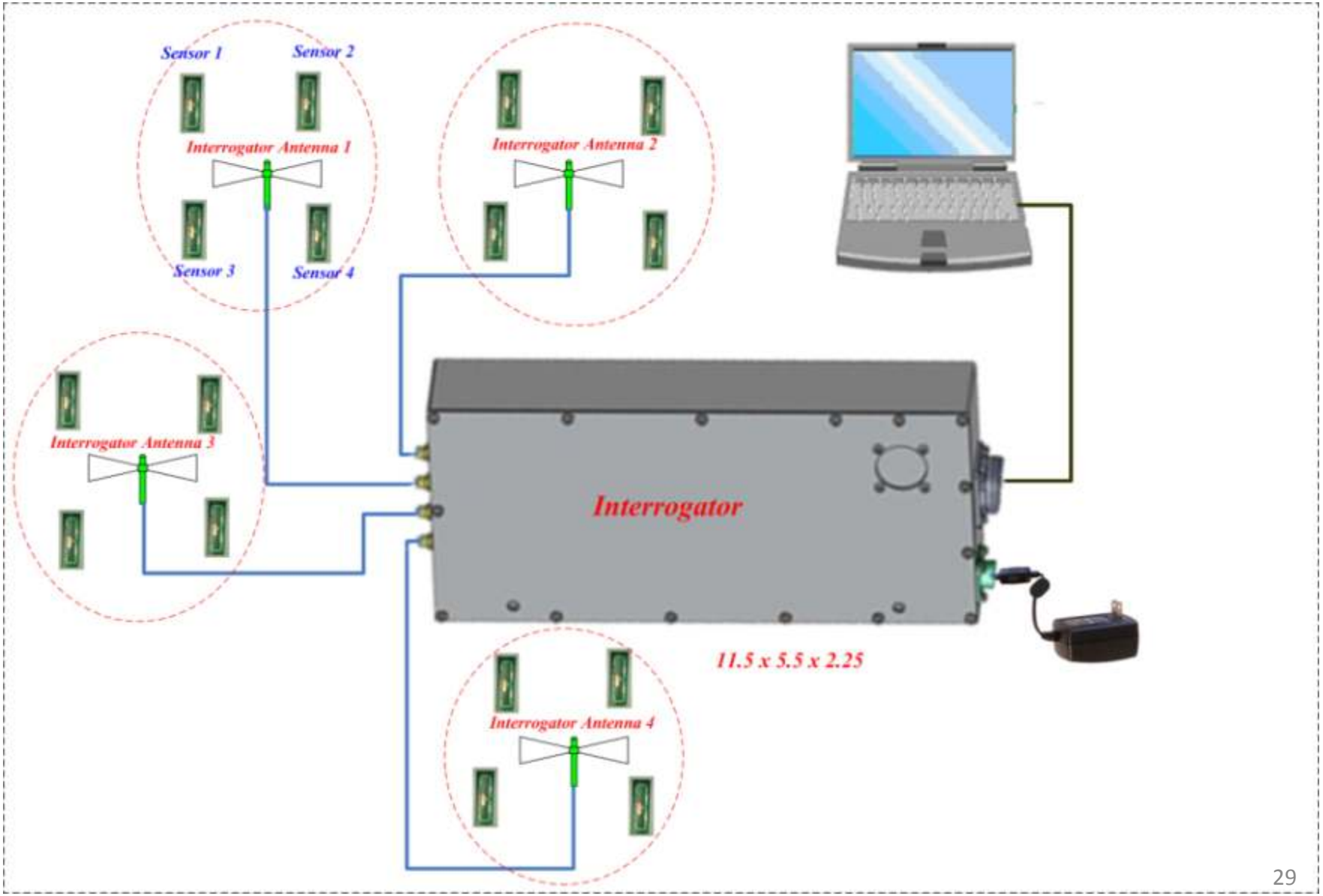


Fully integrated on-wafer SAW OFC sensor and antenna

Wireless Passive SAW Sensors using Coded Spread Spectrum Techniques

Univ of Central Florida/Mnemonics

Don Malocha http://caat.engr.ucf.edu/ - Madjid Belkerdid http://mnemonics-esd.com



NASA Phase 2 STTR Award
UCF & Mnemonics
10-2 T7.01-9980
Wireless SAW Sensor Strain Gauge & Integrated Interrogator Design
Awarded – Apr 27, 2012

TECHNICAL ABSTRACT

The proposed Wireless, passive, SAW sensor system operates in a multi-sensor environment with a range in excess of 45 feet. This proposed system offers unique features in two (2) important areas. The first is in the development of a new sensor type, a strain gauge that is based on OFC techniques and implemented with the low loss characteristics of SAW Unidirectional transducers. The second is in the design of an integrated interrogator system that has DSP-based embedded signal processing. Interrogator will also be capable of rapidly performing multiple interrogations which can them be used to make ibration measurements or averaged to extend the operational range of the system. This proposal extends the Phase I and previous work in two major areas; developing a SAW strain sensor, and dramatically increasing interrogation range, which is applicable to both the new strain sensors and the previously developed temperature sensors. In order to increase SAW sensor range, sensitivity and accuracy, the most important device parameters were identified and initial investigation begun in Phase I and will be put into practice in Phase II. To reduce SAW sensor loss and minimize multi-transit acoustic echoes, low loss unidirectional studies were initiated. Phase I produced three alternative low-loss approaches that will be evaluated in the Phase II work. Success will lower the insertion loss by approximately 15 dB, and multi-transit echoes are predicted to be less than -40 dB from the main signal; doubling the system range and reducing the sensors self-noise. Advanced coding techniques were investigated in Phase I that have led to longer delay path lengths, and shorter codes with less inter-sensor interference.

During Phase II, the interrogator will improve the following critical capabilities: onboard-fully-integrated DSP, extended connectivity options to customer's computer, and rapid interrogation capabilities. This will allow vibration sensing and signal integration.

Multivariable passive RFID sensors:
From detailed laboratory evaluations to pilot-scale manufacturing

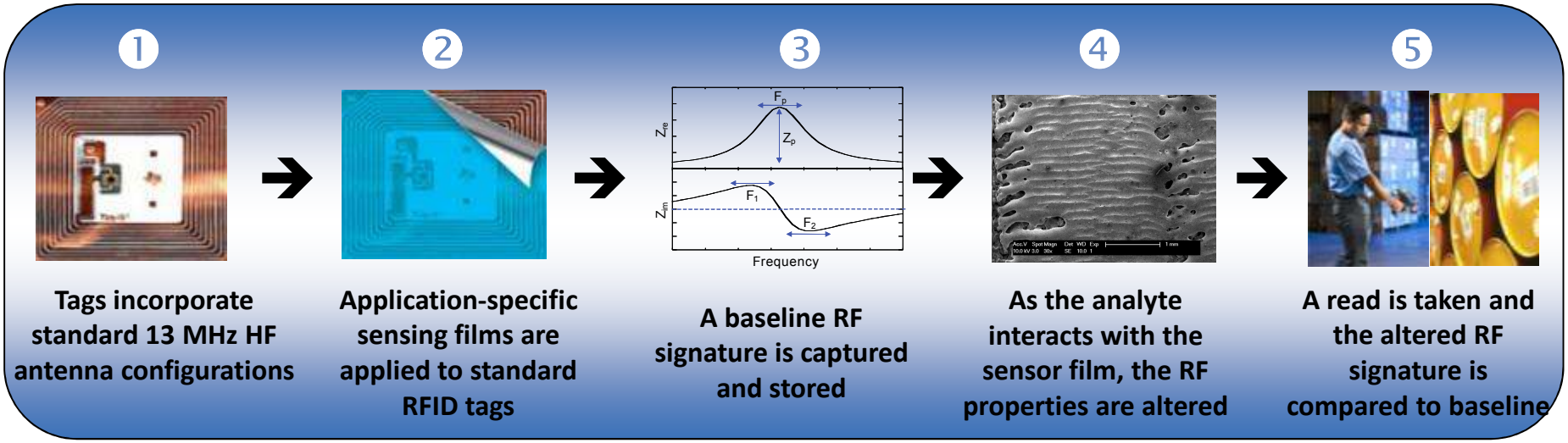
GE Global Research/Cheryl Surman(surman@ge.com)
Avery Denison/Peter Bloch(peter.bloch@averydennison.com) - http://ge.geglobalresearch.com

How it works:

- GE RF Sensing utilizes the complex waveform of an existing high-frequency (HF) RFID technology as a signal transport.
- The reader interrogates the sensor tags, interprets the waveform, and determines measurement value.

Handheld Reader Energizes Tag

Passive Sensor Tag 'wakes-up' & Responds



Tags incorporate standard 13 MHz HF antenna configurations

Application-specific sensing films are applied to standard RFID tags

A baseline RF signature is captured and stored

As the analyte interacts with the sensor film, the RF properties are altered

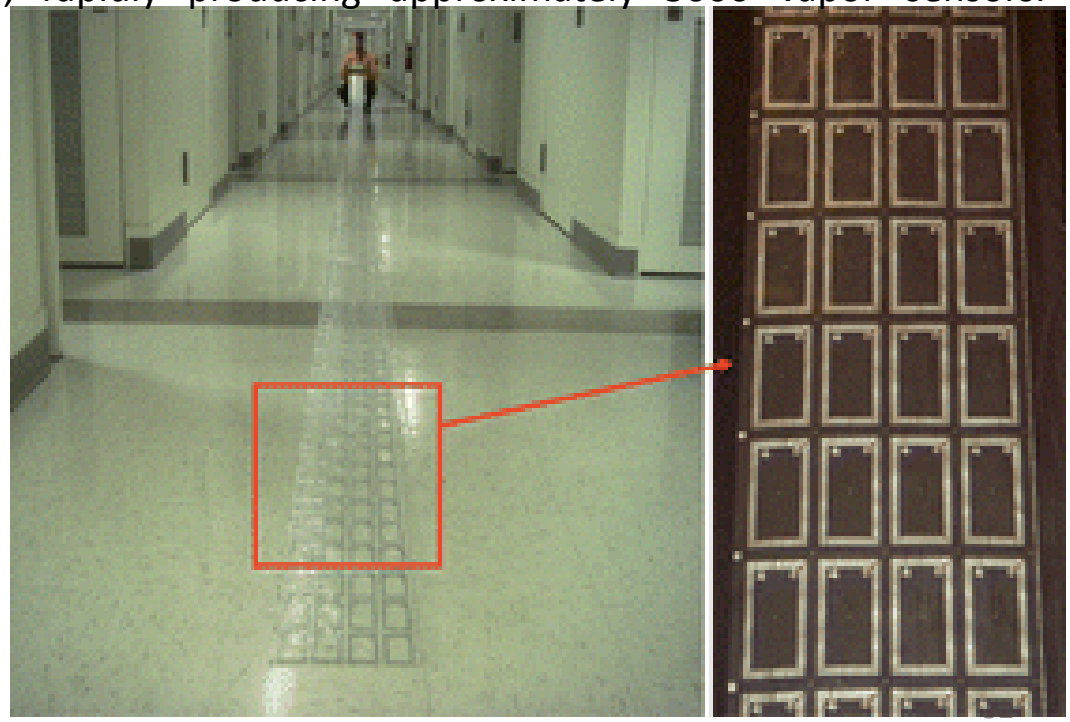
A read is taken and the altered RF signature is compared to baseline

Webinar: http://www.rfid.averydennison.com/rfid-sensor-technology-hf-inlay.php

Feb 2012 Analyst: "Multivariable passive RFID vapor sensors: roll-to-roll fabrication on a flexible substrate" Radislav Potyrailo, Andrew Burns, Cherly Surman, D.J. Lee, Edward McGinniss

We demonstrate roll-to-roll (R2R) fabrication of highly selective, battery-free radio frequency identification (RFID) sensors on a flexible polyethylene terephthalate (PET) polymeric substrate. Selectivity of our developed RFID sensors is provided by measurements of their resonance impedance spectra, followed by the multivariate analysis of spectral features, and correlation of these spectral features to the concentrations of vapors of interest. The multivariate analysis of spectral features also provides the ability for the rejection of ambient interferences. As a demonstration of our R2R fabrication process, we employed polyetherurethane (PEUT) as a "classic" sensing material, extruded this sensing material as 25, 75, and 125-μm thick films, and thermally laminated the films onto RFID inlays, rapidly producing approximately 5000 vapor sensors.

We further tested these RFID vapor sensors for their response selectivity toward several model vapors such as toluene, acetone, and ethanol as well as water vapor as an abundant interferent. Our RFID sensing concept features 16-bit resolution provided by the sensor reader, granting a highly desired independence from costly proprietary RFID memory chips with a low-resolution analog input. Future steps are being planned for field-testing of these sensors in numerous conditions.

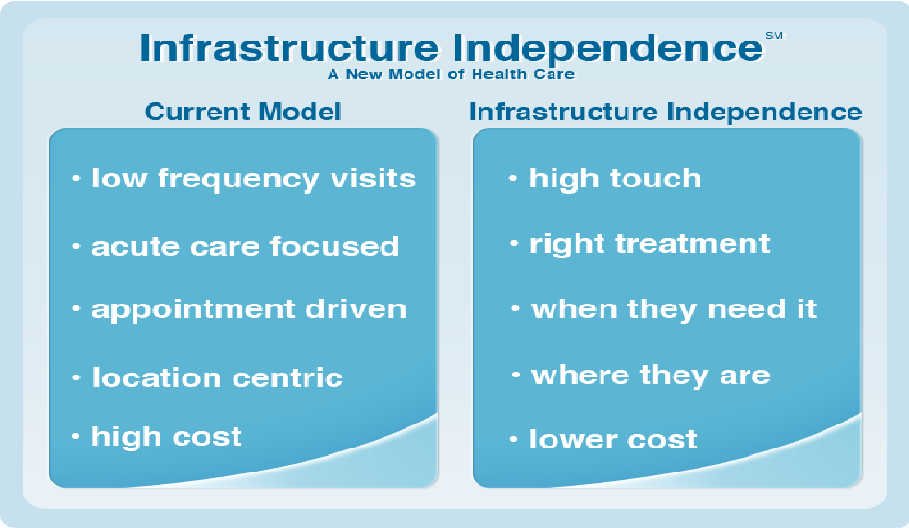


Compliance Independence– is this the passive revolution?

West Wireless Health Institute/Robert Matthews - CTO
http://www.westwirelesshealth.org/ rmatthews@gmwhi.org

- **Primary Mission:**

Lower Health Care Costs



PWST Application Areas:
- Smart patient ID
- In home/office sensors
- On body sensors
- Medication compliance

Sensors in the bed:
Pressure – management of bed sores
Weight – identify weight gain (fluids)
Heart rate – various diseases
Motion -- various diseases
Wetness – need to change bedding

Patient ID – Once a day, some patient is mis-identified.
Patient Info: Who, what, when
- Allergies, genetic information
- What and when medications were take
- What batch of blood etc

Desired PWST Attributes:

Very Cheap -- cents (disposable)
Long range (100's ft)
Non-trivial power for sensors without risk to patients
Buffer power for use whilst not being illuminated
Store significant amounts of data (both read and write)
HIPPA compliant
Very small, Mechanically flexible
Reliable/Robust
Configurable
Easy to integrate

West Wireless Health Institute
2012 Update(from website)

West Wireless Health Council

SAN DIEGO – February 15, 2012

A new coalition of hospital and health system leaders to create a standard approach to installing wireless infrastructure in health care settings and develop innovative solutions that will enable the full potential of wireless health technology to be realized in health care delivery settings, and ultimately lower health care costs.

https://s3.amazonaws.com/wwhi.org/WWHC_Release-02142012.pdf

Sense4Baby:

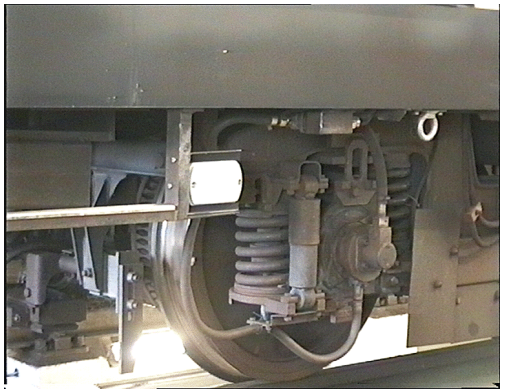
Late Term Home Monitor connects to medical experts via Smartphone tablet Bluetooth and internet. Other functions

http://www.westwirelesshealth.org/index.php/sense4baby

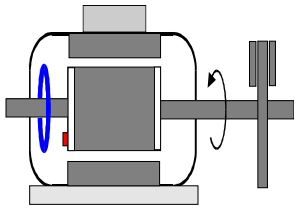
History, Applications, and Market Overview of Passive Wireless Sensors

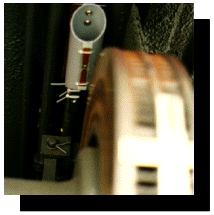
IMTEK - Leo Reindle – Dept Head, Electrical Instrumentation
reindl@imtek.uni-freiburg.de - http://www.imtek.de

- **1st Passive Wireless Sensors: Wolf-Eckhard Bulst**
- **1st Chirped Wireless Sensors: Franz Seifert**
- **1st Phase Information Basis: Valentin Magori**
- **1st Interrogator(Siemens): Patric Heide, Frank Schmid**
  433 MHz by Univ. Vienna
- **Tollway Application in Norway – 500,000 tags**
- **1st Pulse Position Coding: Victor Plessky**
- **SOFIS on SIEMENS rail – Munich Subway (2.45GHz)**
- **Temperature Sensors:**



Motor Rotor **HV Surge Arresters** **Train Brakes**





- **High Temp SAW Sensors with Platinum Electrodes on Langasite**
- **Tire Pressure Sensor(Siemens): G. Schimetta**
- **SAW Sensor for Tire Friction Control(Siemens +)**
- **Torque – Sensor Technology's Torquense System**

SEIMENS Got out of SAW busyness due to assignment of it to EPCOSS

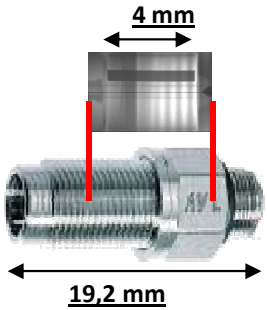
- **SAW Accelerometer – Dart Demo**

- **SAW Current Sensor**
- **SAW Water Content Sensor - Alexander Kiermayer**

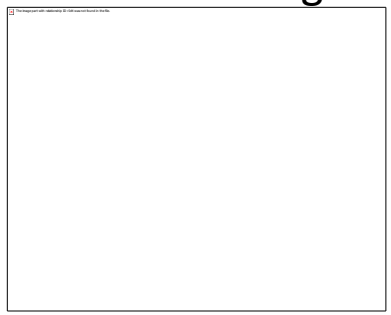
IMTEK - Leo Reindle: European Company Products

Mobile Readers:

AVL – Pressure Sensor with Integrated ID:



RSSI GmbH & Carinthian Technologies



http://www.ctr.at/carinthian_tech_research_english

RHI - RFID and Sensing in a Steel Plant(+1400C)

CTR - Doble Lemke -Temperature Monitoring of Power Transmission Lines

CTR will Present at 2012 PWST Workshop

CTR – Temperature Monitoring of Rotating Machine Elements
Up to 15,000 RPM

IMTEK – Leo Reindle: European Companies

SENSeOR - Unique Features for High Value Applications

Revolutionary sensors

- **Wireless**
- **Passive**
- **Robust**

➔ Enabling measurements

- On moving and rotating parts
- In confined or inaccessible spaces
- Where cabling costs too much or is impossible
- In harsh environments – like: strong fields, explosive, corrosive

➔➔ For measurable benefits

- **Improved productivity**
- **Performance optimization**
- **Security enhancements**

Condition Monitoring - Structural Health Monitoring
Process Control - Precision Metrology

IMTEK – Leo Reindle: European Companies

SAW Temperature Evaluation Kit EVAL KIT T01

Pressure sensor chip

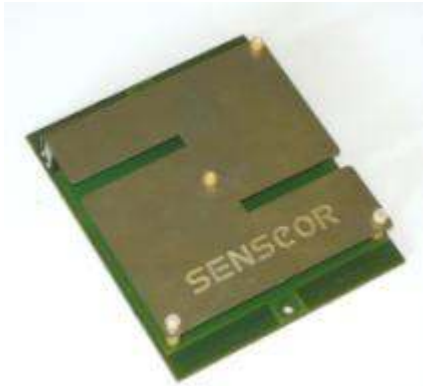
Packaged temperature sensor TSE AS10

Fixture mounted temperature sensor with antenna TSA D031

SENSeOR offers to partner with anyone such as to industrialize such applications and to make the technology known.

Once we find strong applications and/or partners in the US then SENSeOR will establish an office in the USA.

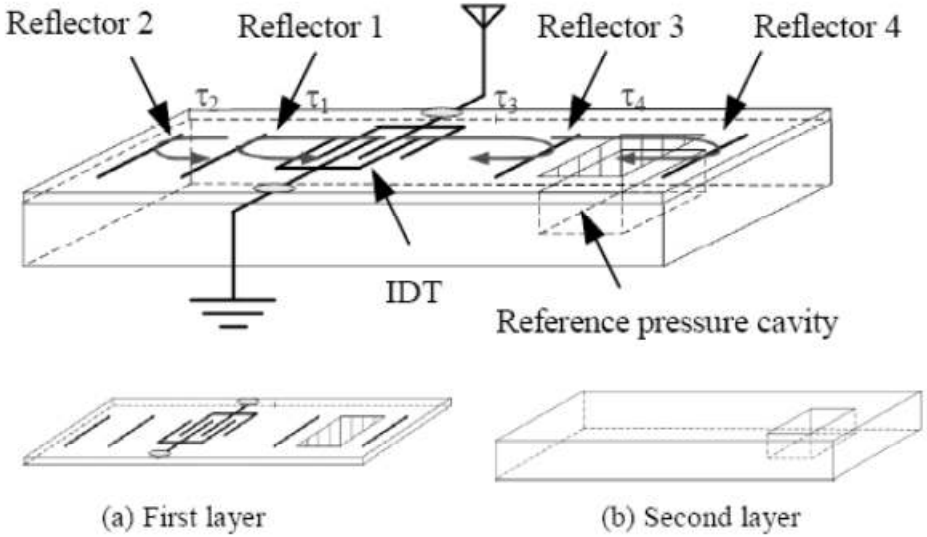
Thermowell packaged temperature sensor TSM D100



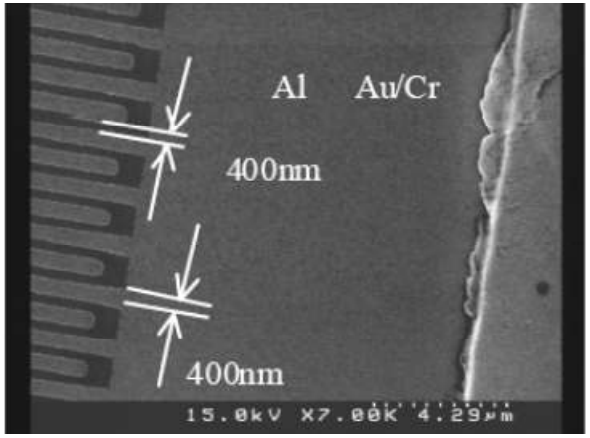
PIFA antenna mounted temperature sensor TSA D003

IMTEK – Leo Reindle: Other Offerings

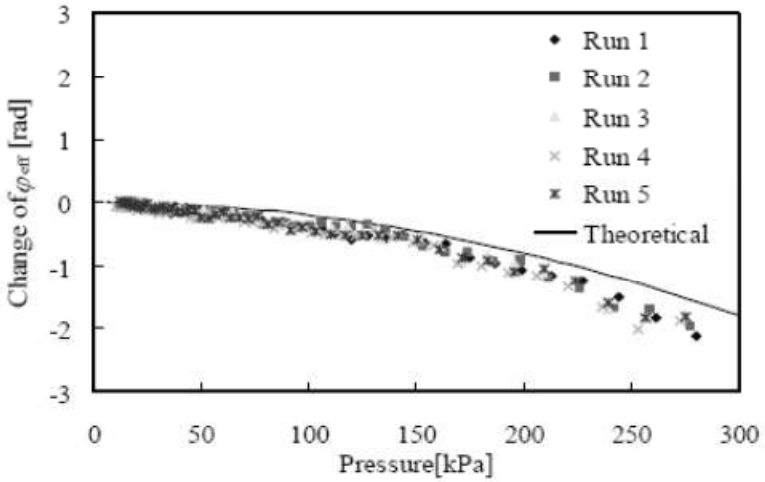
Nissan pressure sensor



Schematic structure of the SAW delay line pressure sensor



Fabricated interdigital transducer

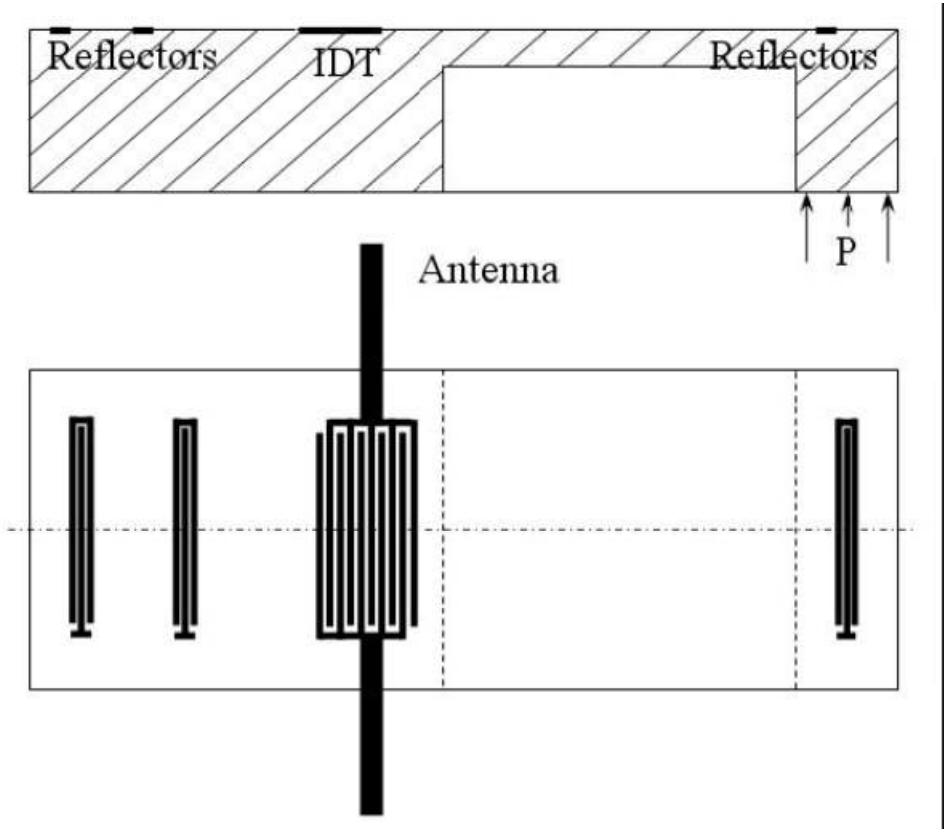


Change of the effective phase ϕ_{eff} by pressure change

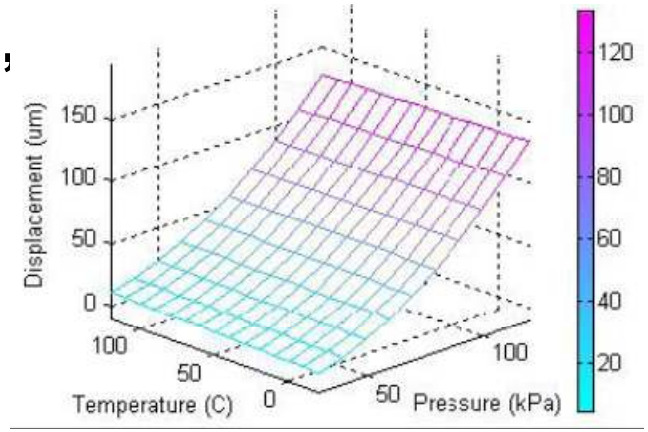
S. Hashimoto, J. Kuypers, S. Tanaka, M. Esashi, „Design and Fabrication of Passive Wireless SAW Sensor for Pressure Measurement “, 2008.

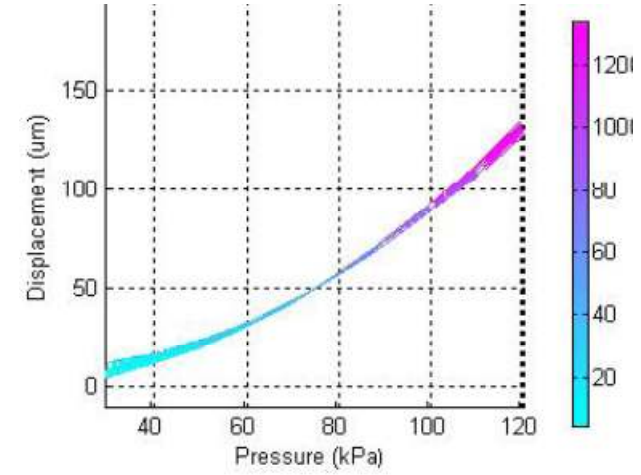
IMTEK – Leo Reindle: Other Offerings

Harbin Institute of Technology, China,



The structure of the wireless passive SAW sensor





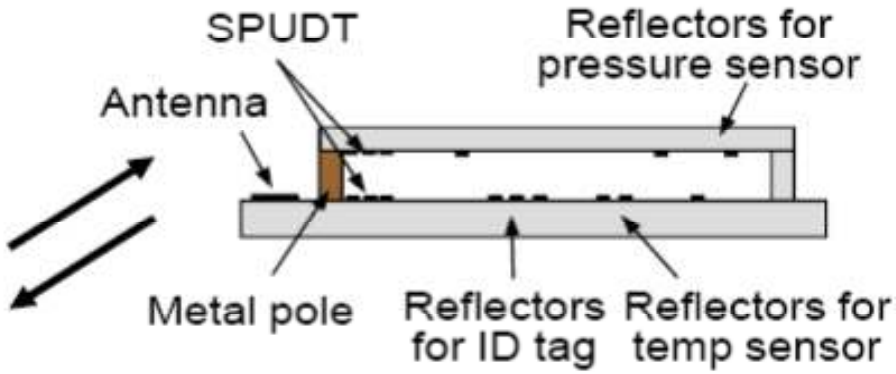
Displacement affected by the temperature and pressure after data processing.

T. Li, L.Zheng, H.Hu, „A Novel Wireless Passive SAW Sensor Based on the Delay Line Theory “, Proc. 3rd IEEE Int. Conf. on Nano/Micro Engineered and Molecular Systems, Sanya, China, 2008.

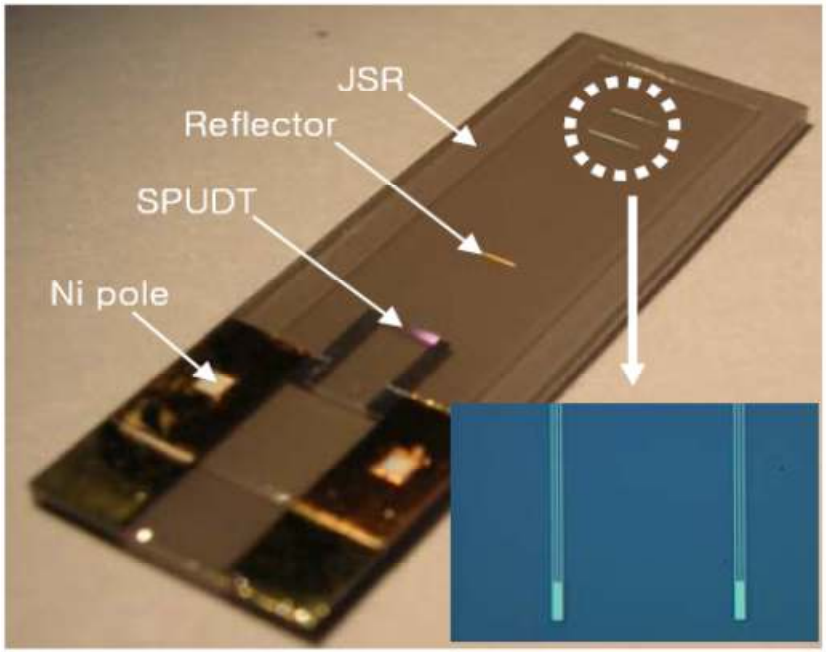
IMTEK – Leo Reindle: Other Offerings

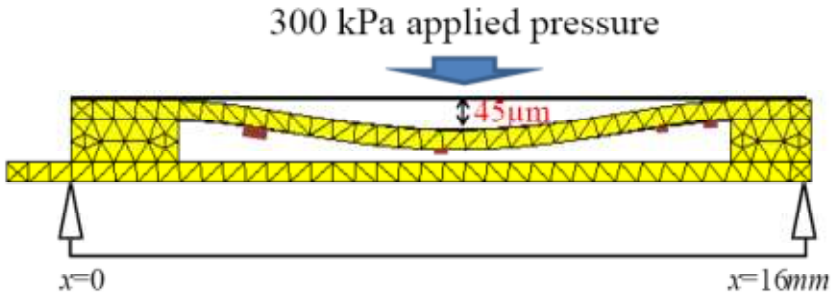
Anyun University, Korea, wireless SAW sensor for simultaneous measurement of pressure, temperature & ID

Cross-sectional view of the fabricated microsensor



views of the top and bottom devices





Calculated diaphragm bending under applied pressure of 350kPa using FEM analysis

Haekwan Oh, Weng Wang, Keekeun Lee*, and Sang Sik Yang
Division of Electronics Engineering, Ajou University, Suwon, S. Korea, 443-749
Email: keekeun@ajou.ac.kr, Tel:+82-31-219-1848, Fax:+82-31-219-1848

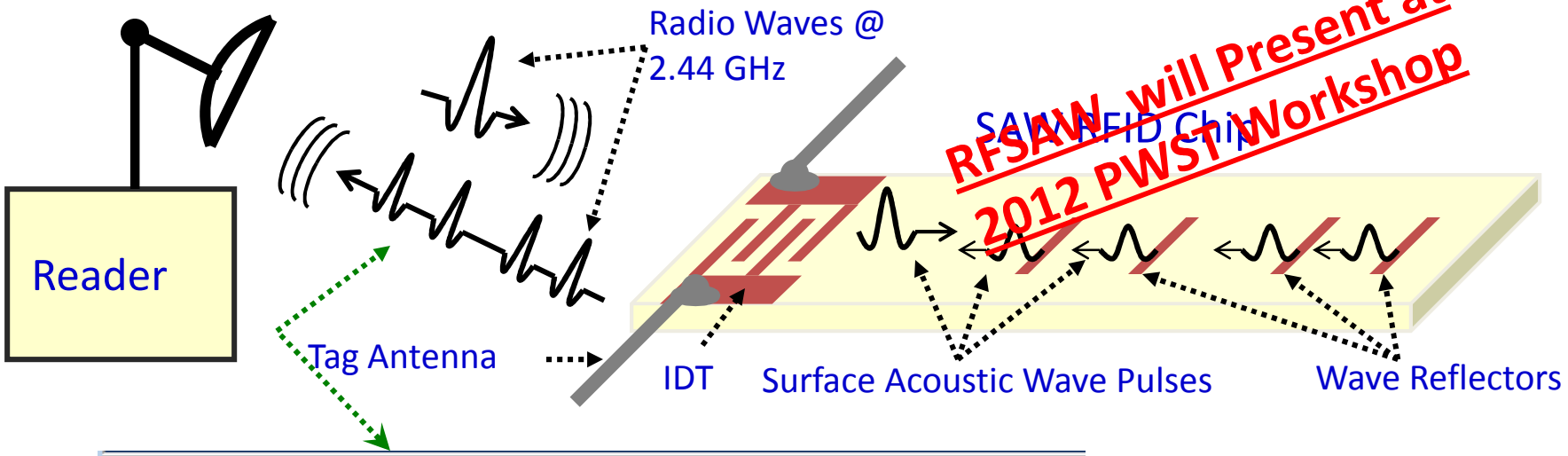
Leo Reindle: Rack-up of Sensor Sources

Company	Temp	Pressure	Stress	Torque	Bio/Chem
Applied Sensor R&D (USA)	☻		☻		☻
Avianamolecular (USA)					☻
Bürkert (D)					☻
CTR (A)	☻				
Doble Lemke (D, CH)	☻				
Electronic Sensor Technology					☻
GVR Trade (CH)	☻				
Heinz (D)	☻	☻	☻		
Honeywell (USA)	☻	☻			
Promicron (D)	☻		☻	(☻)	
SAW Instruments (D)					☻
Sengenuity (USA)	☻		(☻)	(☻)	
sensAction (D)					☻
SENSeOR (D,F)	☻	☻	☻	(☻)	☻
Siemens / GE / NG / Honeywell	(☻)	(☻)	(☻)	(☻)	(☻)
Transense (UK)		☻	☻	☻	
	10	4	5	3	8

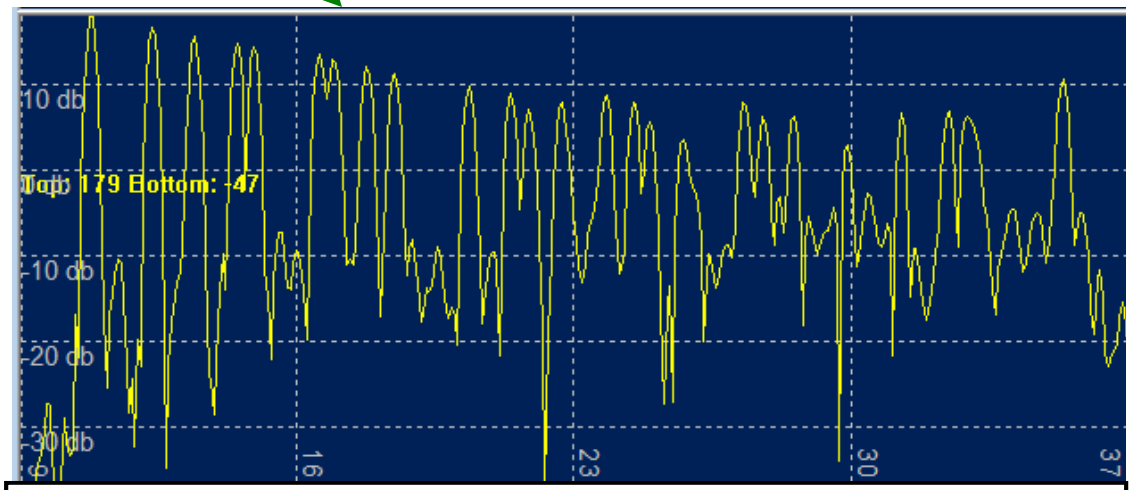
RF SAW's Global SAW Tag System

Clinton Hartman/RFSAW - CHartmann@RFSAW.com - www.rfsaw.com

More than 100 sensors with a single reader



RFSAW will Present at 2012 PWST Workshop



Actual 96-Bit Wireless Tag Waveform

GST Features

- Trillions of Trillions of ID Numbers
- Inherent Temperature Sensing
- Inherent Tag Localization

SAW Sensor and Sensor-tag Developments at ASR&D

Jackie Hines/ASRDC
jhines@asrdcorp.com - www.asrdcorp.com

Demonstrated sensor devices for:

♦ Temperature ♦ Liquid (level) ♦ Humidity
♦ Hydrogen ♦ Sensor-tags (strain, T, V, etc.)

Products under development:

- Coded sensor-tag wireless interface devices
- Humidity sensors
- Hydrogen sensors
- Temperature sensors
- Methane sensors
- Hypergol leak detection sensors (MMH, DMH, NTO)
- Cryogenic Liquid (level) sensors
- Concrete maturity monitor
- Biosensor for infectious agents (CT)

ASRDC will Present at 2012 PWST Workshop

SBIR Phase 2 System

Systems:

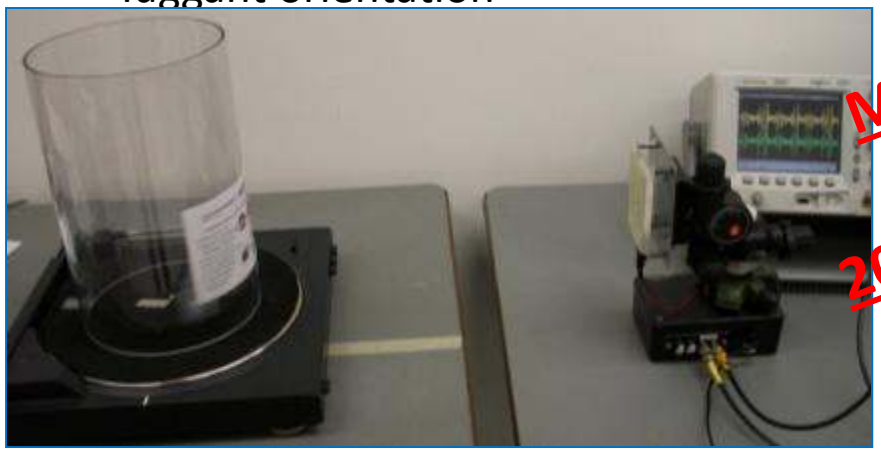
- 32 tag humidity sensor to KSC Sept 29, 2011
- 32 tag temperature sensor system SBIR Phase 2 – begun June 2011 to MSFC

"VERSA" Resonant Passive Tags

MaXentric – Brian Woods
bwoods@maxentric.com - www.MaXentric.com

V-band Enhanced RFID Sensing Architecture(VERSA) Tags: 24 or 60 GHz

- VERSA tags are completely **passive**
- **Potentially** 1-2cents increase in label/tag production cost
- VERSA tags are embedded with **thin metal dipoles called taggants**
  - Length of the taggant and type of material determine resonant frequency (60GHz=2.5mm), several micrometers wide, and hundreds of nanometers thick
- Can be **manufactured on a variety of materials**: paper, wood, plastic
- At 60GHz ISM Band, system uses 7GHz of freq band
- **60GHz is in the Oxygen absorption region** – allowing natural security
- **Unique RF signature** depends on many parameters and pattern
  - Taggant orientation



MaXentric (local) will Present at 2012 PWST Workshop

Business/Use Case Assessments

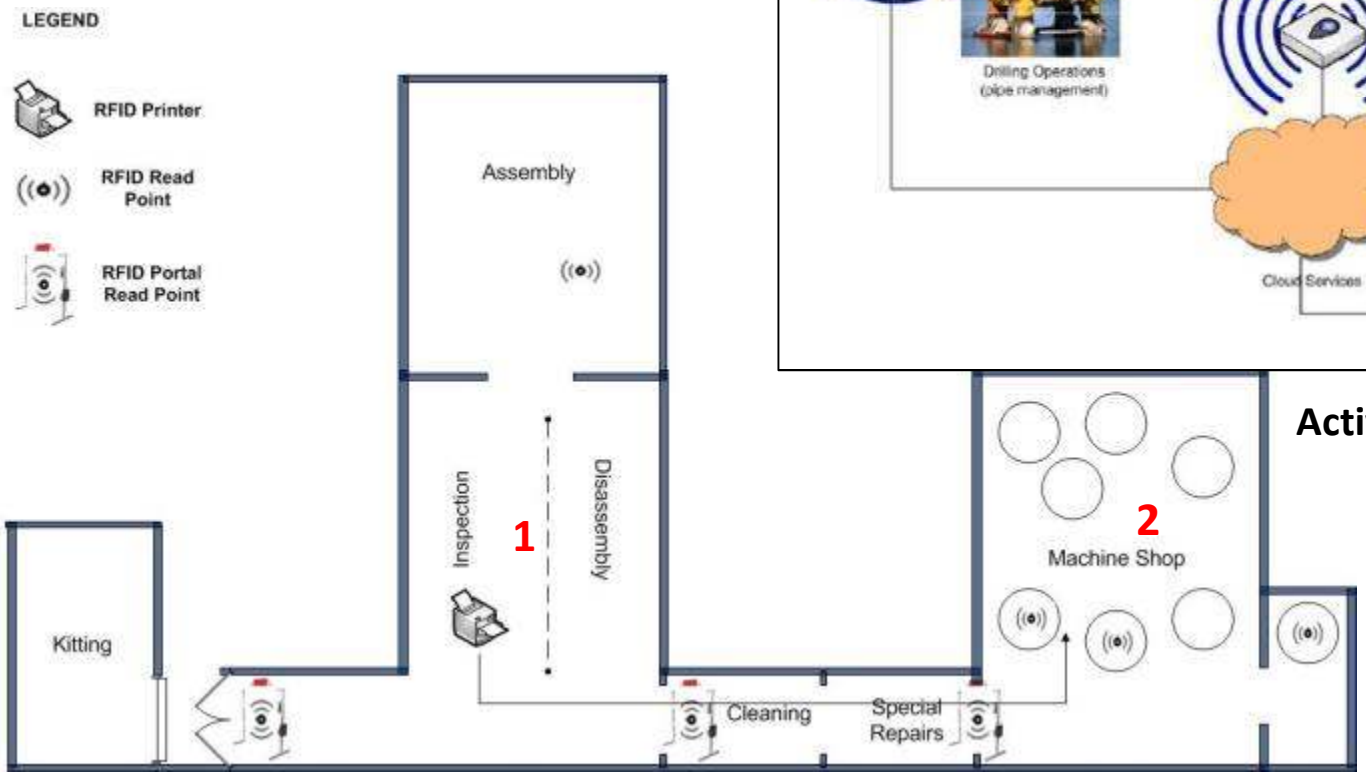
Jeff Brown/Radient360

jeff.brown@radient360.com - www.radient360.com

Tracking Aircraft Engine Parts

Aircraft Engine Parts Repair Process:

1. Tag applied to work order at Inspection (based on activity performed 'business as usual')
2. Part is 'read' instantaneously as it moves through out the facility

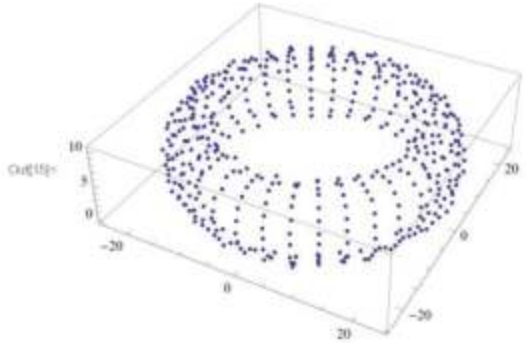


Offshore Oil and Gas

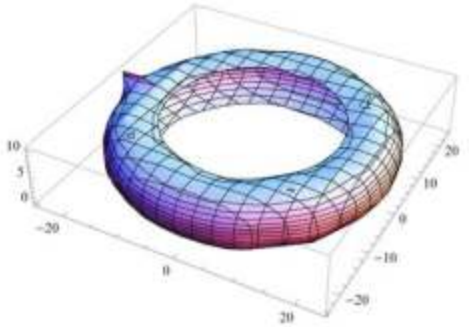
Active and Passive RFID & GPS In Harsh Environments

Location and Temperature Passive Wireless Sensor-Tags

Univ of Maine/Ali Abedi http:\\wisenet.eece.maine.edu - ali.abedi@maine.edu



2D Shape Reconstruction

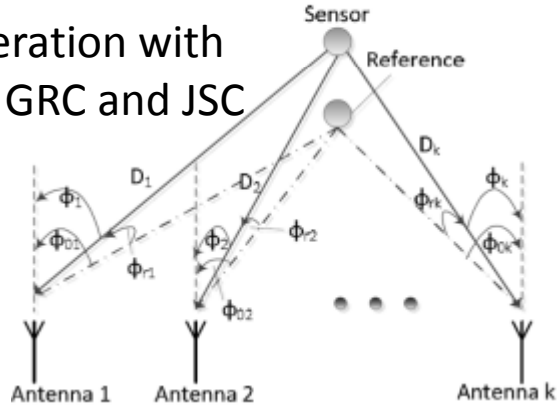


3D Shape Reconstruction

Passive SAW Tag for Location/Shape

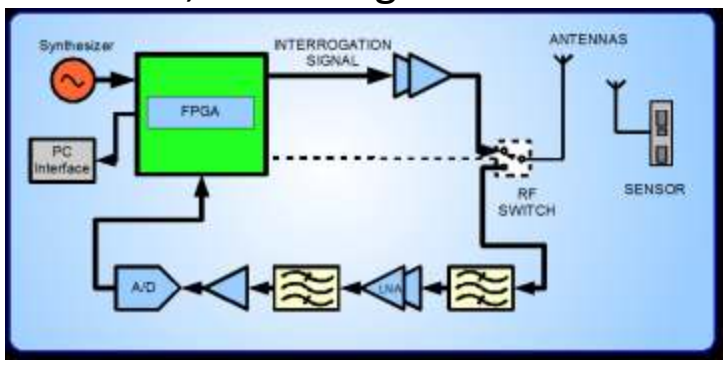
- 860-960 MHz -10 ft read range
- -Passive – no battery
- -EPC Global Gen 2 / ISO 18000-6C Standard
- -Motorola Reader with 70 degree field of view

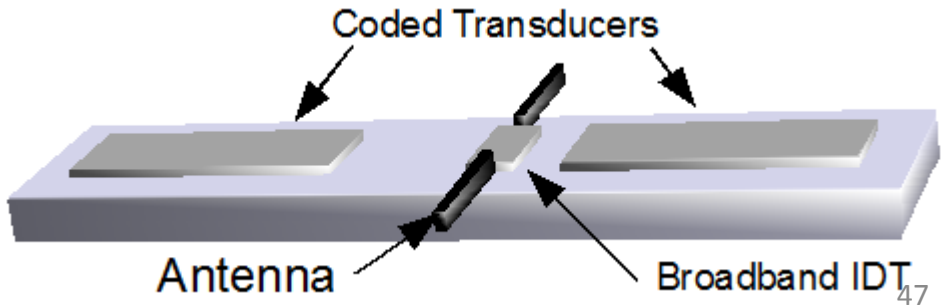
Cooperation with
NASA GRC and JSC



Passive SAW Temperature Tag

- Designed and built at Umaine/Prof Mauricio Pierra da Cunha
- 107 MHz, 18 ft range

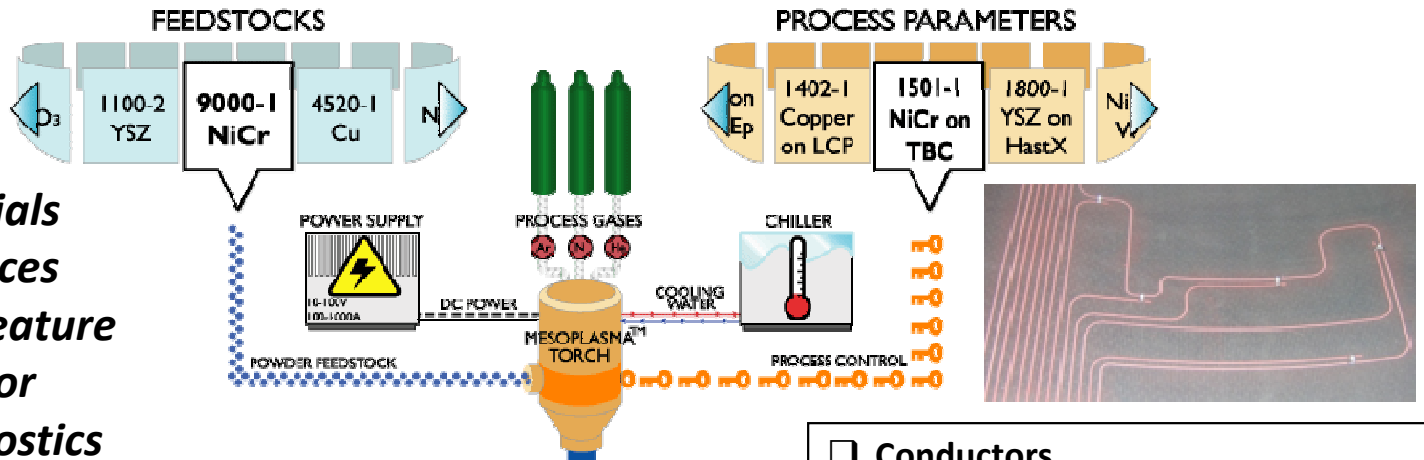




MesoPlasma™ Direct Write Fabrication of Conformal, Harsh Environment Sensors

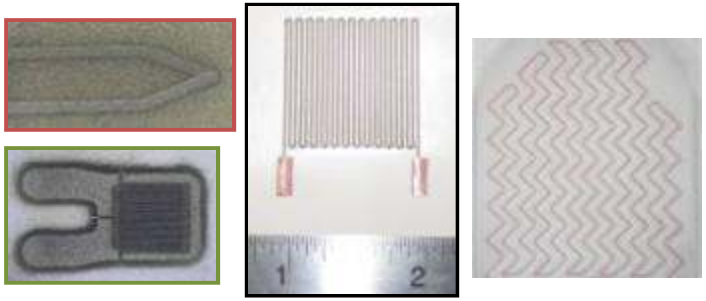
Mesoscribe/JasenTrelewicz www.mesoscribe.com - JTrelewicz@mesoscribe.com

Direct Write:
"print" functional materials on complex surfaces to produce fine feature sensor patterns for integrated diagnostics



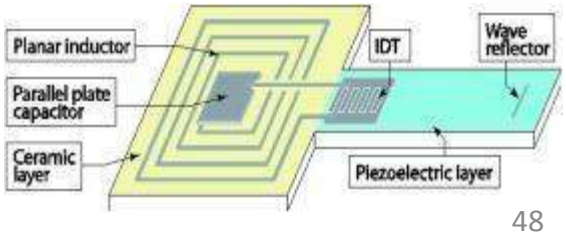
- ❑ **Dynamic trace control**
  - ✓ Trace geometry can be actively tailored for complex patterns
- ❑ **Trace width**
  - ✓ Direct Write trace ≥0.01" (≥250µm)
  - ✓ Laser Scribed trace ≥0.001" (≥25µm)
- ❑ **Trace thickness**
  - ✓ Generally ≥0.001" (≥25µm)

- ❑ **Conductors**
  - ✓ Cu, Ni, Pt, Pd, Ag
- ❑ **Sensor Alloys**
  - ✓ NiCr, NiAl, NiSil, NiCrSil, CuNi
  - ✓ NiCrAlY, FeNi, PdAg
- ❑ **Advanced Sensor Materials**
  - ✓ ITO and other ceramic TE oxides
- ❑ **Dielectrics**
  - ✓ YSZ, $MgAl_2O_4$… proprietary matls



- ❑ Component Health Monitoring
- ❑ Integrated Wiring
- ❑ Structural Energy Storage
- ❑ Damage Detection
- ❑ Antennas
- ❑ Active Control and SHM

Phs 2 SBIR PWST – NASA LaRC



Wireless Temperature Sensor for Gas Turbine Engine Applications

Wireless Sensor Technologies/John Conkle jconkle@wisen-tech.com

Close Proximity Interrogation – Rotating Turbine Blades

Components of Wireless Temperature Sensor - RLC Circuit + Diode Frequency Multiplier – Resonance varies with Temperature

1. Antenna
   - Enables the interrogating signal to be received
   - Sets the frequency of operation of the sensor
   - Enables the return signal to be transmitted back the the Tx/Rx/Signal Processing

2. Diode
   - Causes the generation of RF harmonics of the interrogating signal(as filtered by the antenna) which allow the return signal to be easily separated from the interrogating signal by the Tx/Rx/Signal Processing

3. Alumina or TBC Dielectric
   – possesses temperature-dependent electrical properties(DK, dielectric constant) which alters the antenna center frequency as the temperature changes

Also Developed Wireless Heat Flux Sensor

Supported by SBIRs in Navy, DOE and Air Force

Wireless Sensor Technologies will Present at 2012 PWST Workshop

Thin Film Secure Display Inlay: A Revolutionary new Class of ID card

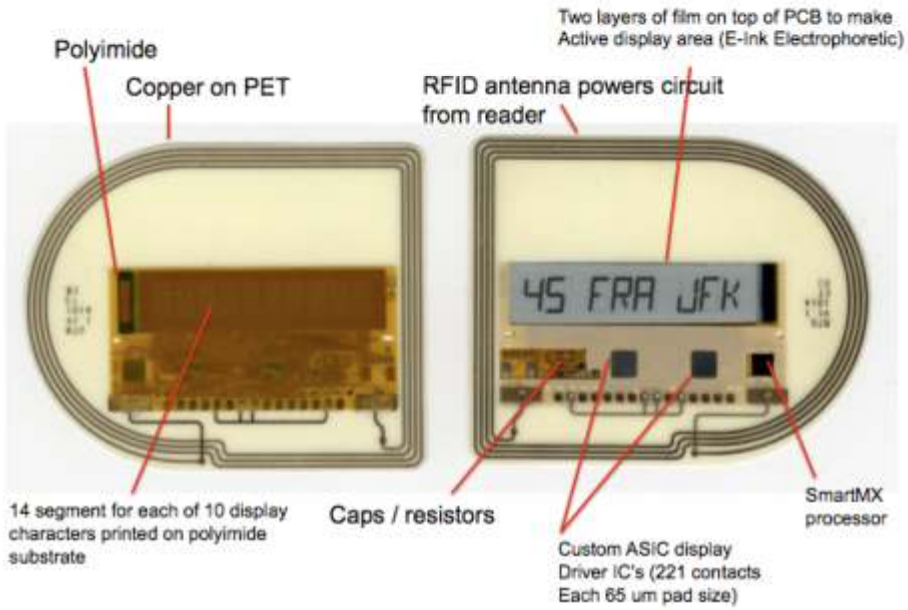
Tocreo Labs/Mark Krawczewicz
mark.kraz@tocreo.com - **www.tocreo.com**

Simple technology: **On-card display – Extraordinary Security - Chain-of-Trust – batteryless**
Applications: **Physical & Logical Access Control, Remote log-in, & Mobile Device Unlock**
Huge Market: **need strategic partners for system integration in Aviation, Transit, National & Commercial network**

Applications for Passive Wireless Sensors used with Near Field Communications???

Capabilites:
Dynamic Bi-State Display
- Users Access -**day / hour / privileges / remaining balance** can be written to the display defining role or access period by access control station
- Display can also show pending **authentication, cryptographic, transactional , or other security process**
- **Visual passport –** user carries auditing trail

Both an visual ID credential and a secure "Container" for data like photo, ID number, name, medical certificate, biometric, audit file, etc. .
Extraordinarily secure – same security processor as in 250 million passports
Uses only reader power – will last indefinitely
Maintains the Chain of Trust - (Users can verify at one terminal and then at a later time, facility, or secured area, prove it} – **Virtual Fence**
Single card bridges physical & network access worlds



SAW Resonant Passive Wireless Sensors for Automotive and Industrial Applications

Over 8 SAW systems per vehicle

Transense/Victor Kalinin

victor.kalinin@transense.co.uk - www.transense.co.uk

EPAS torque sensor (2)

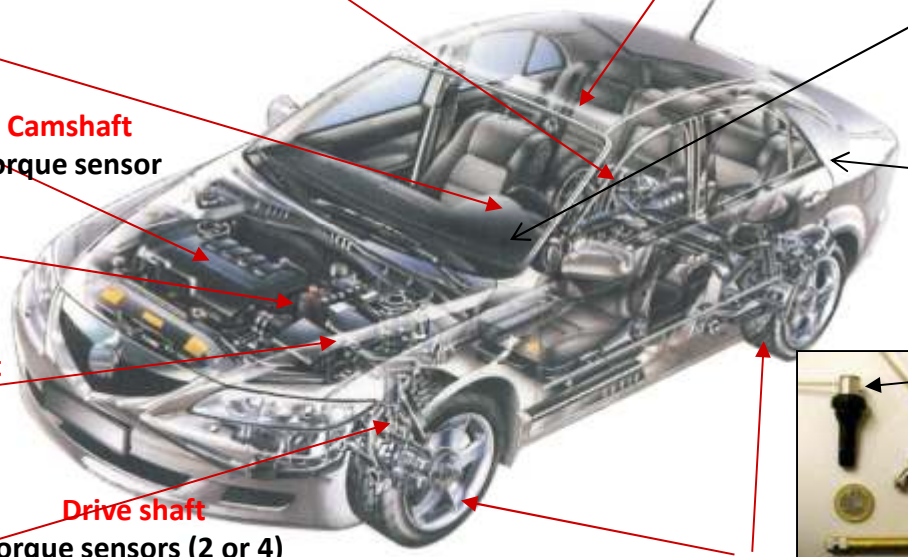
4WD torque splitter sensor

Kinetic Energy Recovery System (KERS)

Display and Interrogation Electronics

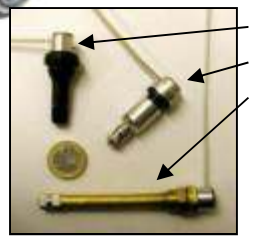
Camshaft torque sensor

Crankshaft or Flexplate torque sensor



Transmission output torque sensor

Drive shaft torque sensors (2 or 4)



Snap-In rubber valve for cars

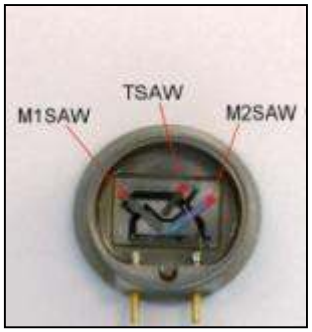
Screw-in metal valve for cars

Long reach truck valve

TPMS sensors (4 or 5)

Torque/Temp: 433-437 MHz sensing element (2005)

- Simultaneous measurement of torque & temperature to achieve temperature compensation.



Transense – GM Flexplate Project

Announcement Sep 26, 2011

http://www.transense.co.uk/news/235-gm-transense-flexplate-project

The Torque drive-line 'flexplate' sensor was " originally developed for eight-cylinder engines and is now being adapted for 4 and 6 cylinder engines.

" As part of this process Transense has successfully negotiated a variation of the otherwise exclusive licence to Honeywell, permitting Transense to deal directly with various named companies including GM preferred Tier 1 suppliers. Since then discussions about the technology have commenced between Transense and a Tier 1 supplier permitted under the Honeywell variation agreement.

The flexplate is an integral part of the vehicle powertrain control system and has the potential to improve vehicle driveability, reduce fuel consumption and improve transmission shift quality. This will be the first time a propulsion system has been able to measure engine torque 'live', enabling optimal control to be maintained throughout a vehicle's life. Current torque management systems rely on simulated models derived from production engine testing which can differ from the actual engine torque output over time. The new flexplate technology provides continuous real-time torque measurement allowing actual torque measurement on a per-vehicle basis for maximisation of engine efficiency.

GM is currently evaluating further applications of the technology for real-time vehicle control."

High Function, Long Range Passive Wireless Sensor Tags

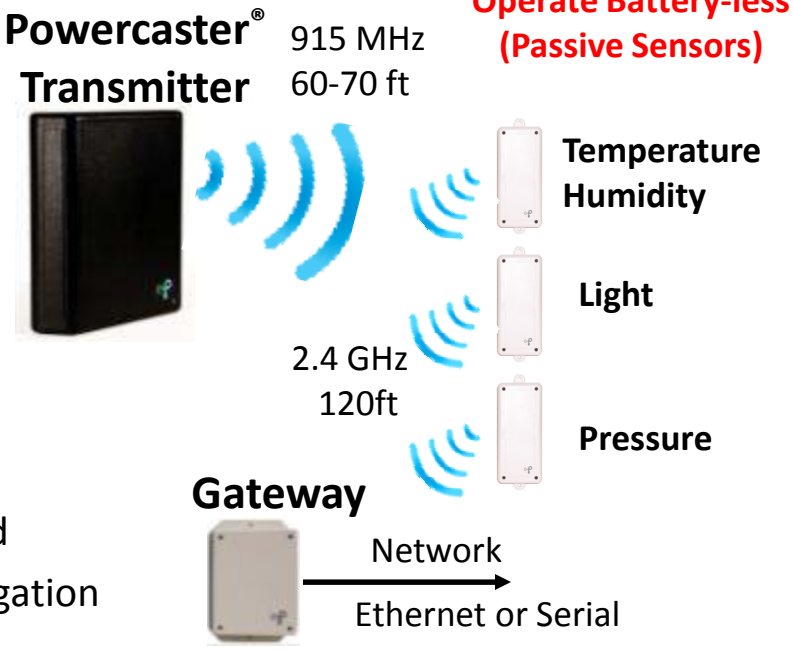
Powercast – Harry Ostaffe

hostaffe@powercastco.com - www.powercastco.com

Scavenge Power alternatives:

- Light / solar energy not always sufficient and rechargeable batteries are required
- Temperature requires large $\Delta T^{915\ MHz}$
- Vibration has narrow bandwidth, moving parts
- **RF-based wireless power**
  - Send power over distance - µW, low mW
  - One-to-many, any-to-any topologies
  - Overcomes lack of light, temp diff., or vibration
  - Controllable: continuous, scheduled, on-demand
- **Future**: Smart Phone-based wireless power - interrogation

Use to Charge Battery
or
Operate Battery-less (Passive Sensors)



P1110

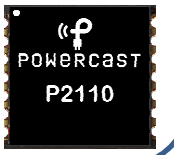
Continuous Power Output

- RF range: -5.0dBm to 20dBm
- Output voltage: 1.8V to 4.2V (configurable)
- Range of at least 3 meters

P2110

Pulsed Power Output

- RF range: -11.5dBm to 15dBm
- Output voltage: 1.8V to 5.25V (configurable and regulated)
- Range of at least 10 meters



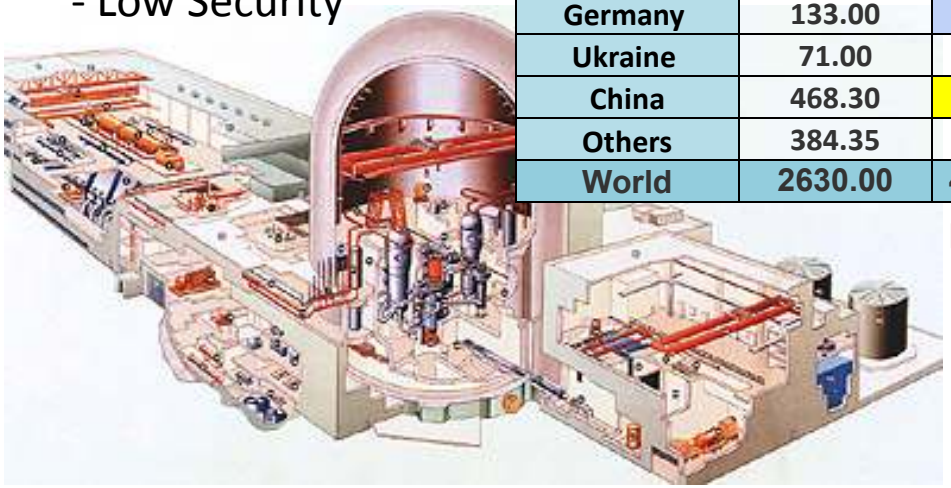
Proceed With Caution: Disaster Recovery (PWST) Applications in Nuclear Control Systems

Ivan Chow - Doosan, HFControls - ivan.chow@doosan.com

www.HFControls.com

Measurement Types
- Temperature
- Radiation
- Others TBD

Use Cases:
- After "Shutdown" sequences initiated
- With or without main power source
- Cover All plant units
- Low Security



Worldwide Nuclear Power Plants

COUNTRY	Nuclear Electricity 2010 billion kWh	Reactors							
		Operable 1 July 2011		Under Contruction 1 July 2011		Planned July 2011		Proposed July 2011	
		No.	MWe net	No.	MWe gross	No.	MWe gross	No.	MWe gross
USA	807.10	104	101421	1	1218	6	7200	28	38600
France	410.10	58	63130	1	1720	1	1720	1	1100
Japan	280.30	51	44642	2	2756	10	13772	5	6760
Russia	155.40	32	23084	10	8960	14	16000	30	28000
South Korea	141.90	21	18716	5	5800	6	8400	0	0
India	20.50	20	4385	5	3900	18	15700	40	49000
Canada	85.50	18	12679	2	1500	3	3300	3	3800
United Kingdom	56.90	18	10745	0	0	4	6680	9	12000
Germany	133.00	17	20339	0	0	0	0	0	0
Ukraine	71.00	15	13168	0	0	2	1900	20	22800
China	468.30	14	11271	26	28710	52	59990	120	123000
Others	384.35	72	52842	9	8770	38	36783	87	106295
World	2630.00	440	376422	61	63334	154	171445	343	391355

Data from World Nuclear Association as of July 1, 2011

RFID Sensors in Transportation

Ron Stieger – Zonar - Director of Engineering ron.stieger@zonarsystems.com
www.zonarsystems.com

Truck Inspection Integrity

Tag placed at inspection locations - add sensors

Odometer from Tire Rotations needs calibration

Payload Weight

Trash Pick-up Management

Battery Voltage on Trailers

Temps in Refrigerated Truck

Engine Temperature

Brake Stroke

Fluid Levels: Fuel, Oil, Others

Intelligent Multi-Sensor Measurements to Enhance Pavement Monitoring and Safety

Fred Faridazar - Federal Highway Administration
Turner-Fairbank Highway Research Center
http://www.fhwa.dot.gov/research/; http://www.tfhrc.gov
fred.faridazar@dot.gov

DOT will Present at 2012 PWST Workshop

1. Exploratory Advanced Research

2. Pavement Sensors
   - Pavement Monitoring
   - Self-powered Pavement Monitoring Sensor
   - Carbon Nanotube Based Self-sensing Concrete for Pavement Materials Tracking
   - Applications of RFID Technology to Asphalt Paving

3. Roadway Renewable Energy

4. Stay-in Lane

5. Additional Application Need

Turner-Fairbank Highway Research Center
Radio Frequency Identification (RFID)

The Solution?

HMA from Plant

Haul Truck

Paver

Encapsulated RFID Tag

Add PWST Temperature?

Compaction

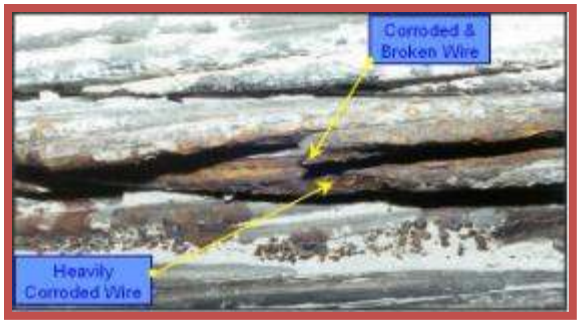
Identifying where loads of material end up in the pavement

Finished Pavement

Tags scanned when convenient after construction

Federal Highway Administration
Turner-Fairbank Highway Research Center

Corrosion of Post-Tensioned Bridge Tendons



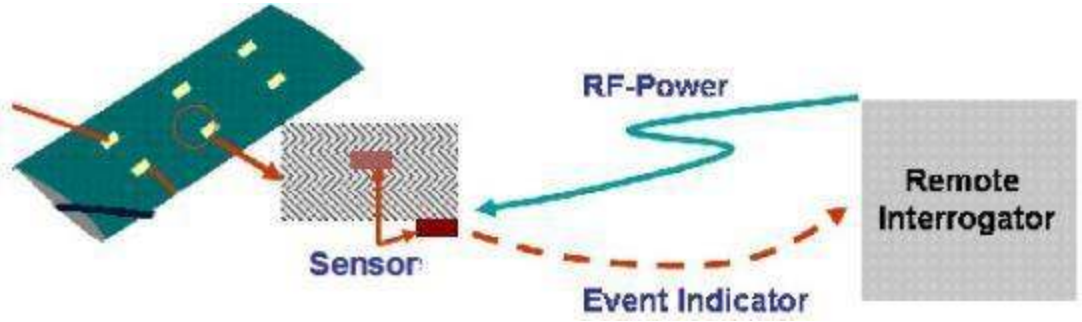
Staying in Lane - Intelligent Fusion of Vehicle Sensor Data

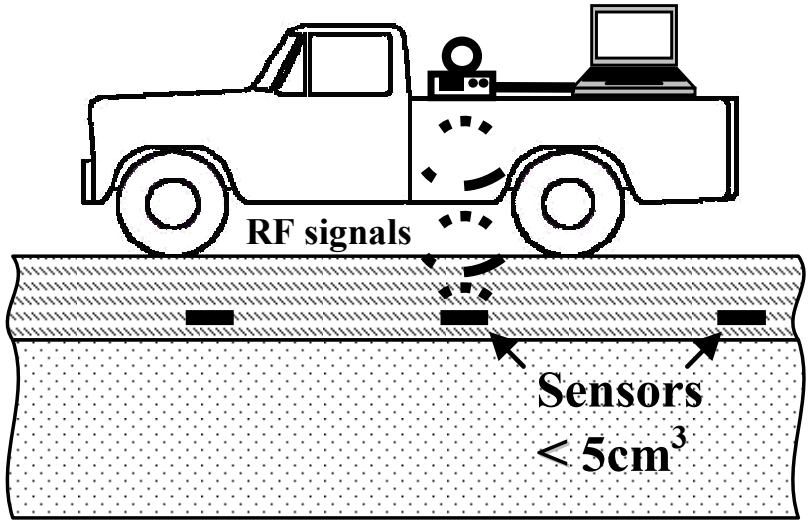
Long Term Pavement Monitoring

- UMD Pavement Monitoring - RFID and active Intelligent Automation Inc. Sensors
- Kinetic to Electric Energy Conversion (KEEC) – VPI/VSU
- Univ of Minn
- Carbon Nanotube (CNTs) Based Self-Sensing Concrete

A Sub-microwatt Long-term Monitoring Sensor

Nizar Lajnef, Ph.D., Michigan State Univ. for FHWA
lajnefni@egr.msu.edu - http://www.egr.msu.edu/cee/people/lajnef.html





Pavement

Potential Applications of PWST

Nezih Mrad, Ph.D.
Defence R&D Canada (DRDC), Air Vehicles Research Section (AVRS)
http://www.drdc-rddc.gc.ca - Nezih.Mrad@drdc-rddc.gc.ca

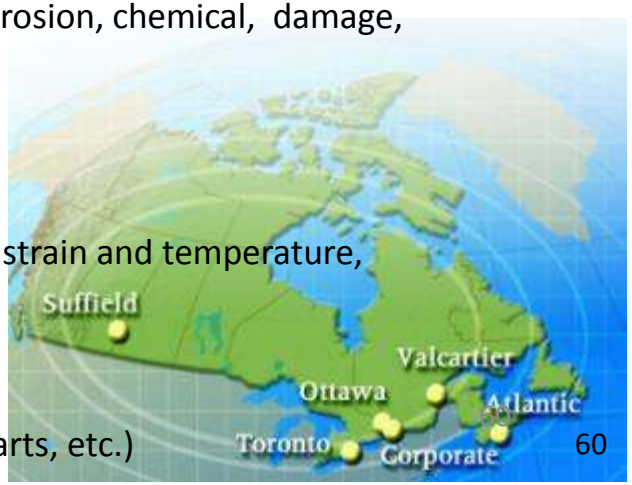
Mission:

To ensure the Canadian Forces are technologically prepared and operationally relevant.

- Advise on Science & Technology
- Conduct Defence research, development and analysis
- Assess technology trends, threats, and opportunities
- Engage industrial, academic and international partners in the commercialization of technology
- Conduct S&T projects for non-DND clients

PWST Interest Areas:

- Advanced Health Monitoring Capability Development and Demonstration
  - Sensors development, evaluation and demonstration (strain, load, corrosion, chemical, damage, cracking, etc.)
  - Modeling, simulation and analysis
  - Experimental capability development
- Engine PHM Capability Development and Demonstration
  - Sensors development, evaluation and demonstration (H/L Temp blade strain and temperature, blade damage and erosion, oil quality/debris monitoring and leak
  - Data fusion and mining, etc.
- Asset monitoring and tracking
  - Materials visibility and condition assessment (e.g. ration, fuel, spare parts, etc.)

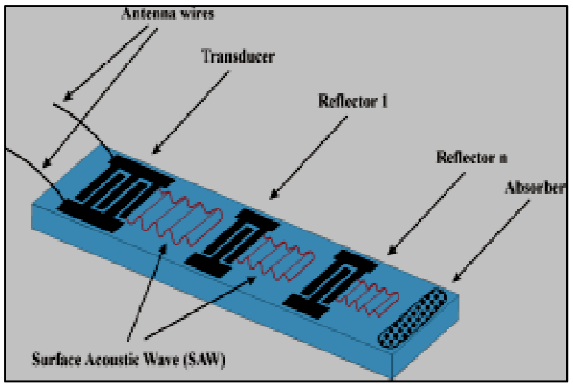


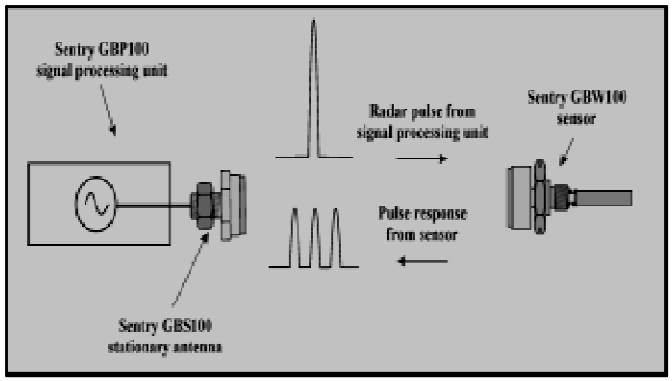
Passive Wireless SAW Temperature Sensors

Kongsberg Maritime NJ (Sensors) - Ed. Gemdjian
www.km.kongsberg.com - KongsbergNJ@verizon.net

SENTRY Wireless Temperature Monitoring – Technology – in use for a decade!

- Fast and reliable temperature monitoring of moving or rotating bearings
- Improved overall operational safety for crew and machinery





SENTRY Applications: "Radar Sensor" Temperature Monitoring of Large Rotating Machinery

- **Diesel Engines and Reciprocating Compressors** – new and retrofit
  - main, wrist/cross pin, crank pin, connecting rod(small end, big end, crosshead) bearings
- **Wind Turbine Gears -** the roller bearings in the planetary unit of the gearbox
- **Paper Machines' Drum** – paper roll shell temps – 6 read by 1 antenna - ID by rpm counter
- **Electric Motors & Generators** – rotor windings
- **High Voltage Power Transformers**
- **Hydraulic Clutches – Oil temps**

Sensors and Controls Enabled Solutions

George Hernandez – DOE/Energy Efficiency and Renewable Energy
Pacific Northwest National Laboratory
eere.energy.gov; George.Hernandez@ee.doe.gov

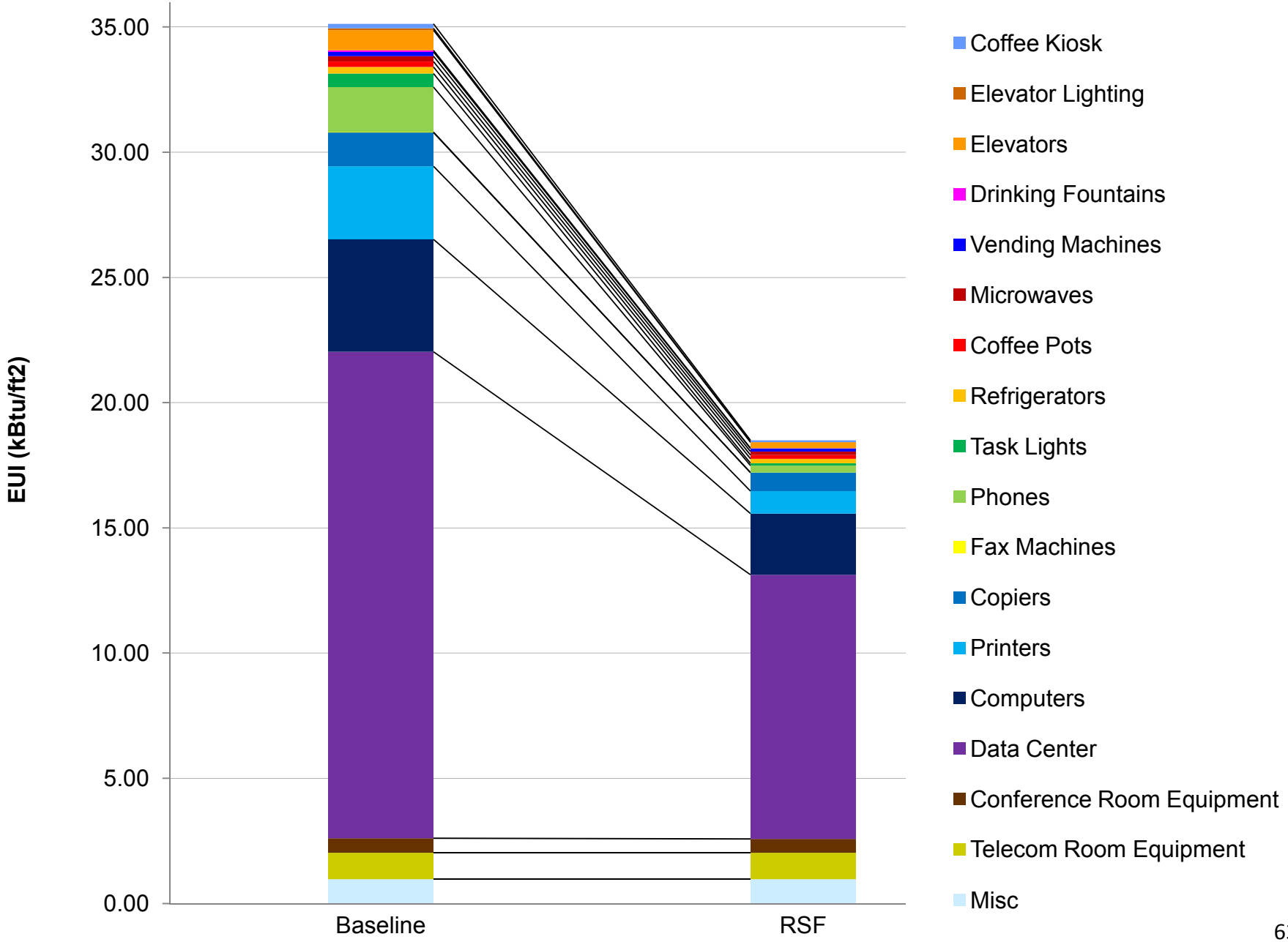
Target Applications:

- **Advanced Controls and Diagnostic Packages for Packaged Air Conditioners**
- **Self-Correcting and Self-Configuring HVAC Controls**
- **Proactive Building Energy Management – automation and occupant participation**
- **MEL(Miscellaneous Equipment Loads) Management**

Attributes Needed:

- **Temperature, Relative Humidity, CO2, Flow (air and liquid), Pressure, Power, Light**
- **Occupancy Sensors - Image Processing-Based – motions sensors don't work well**
- **Inexpensive – much less than $100 typical per measurement location**
  - **Cost is the main deterrent for commercial buildings not installing Efficiency Monitoring/Control sensors**
- **Accurate (+/- 1 deg C is not good enough for diagnostics) - minimum drift**
- **Common interfaces**
- **Relocatable**
- **Location provided**

Baseline vs RSF Annual Plug Load EUI



Network Enabled Manufacturing(NEM) & Passive Wireless Technologies

Al Salour, Ph.D. – Technical Fellow
Boeing Research & Technology
al.salour@boeing.com 314-232-1743

NEM Considerations:

- Multi-disciplined technical skills development team
- Serve the customer needs in changing environment
- Emphasis in Composites materials and processes
- In-house fabrication core competencies "Metallic and non-Metallic"
- Supplier management "Increases in the third party material suppliers"
- Wireless secured networks
- Multi-site manufacturing & replication opportunities
- Latest advancements in real time plug & play autonomous systems

NEM Technology Needs:

- **Sensors:** Location, illumination, temperature, humidity, pressure, flow, vibration, proximity, etc.
- **RTLS:** Chokepoint, Presence, Location
  - Battery powered,
  - $40 per sensor -> apply to high value assets
  - UWB indoor & outdoor system for Tool Kits
- **pRFID (passive RFID): Material Management**
  - Commonly used on high volume items
  - No power source (*No batteries*)
  - Inexpensive ($0.50 or less)
  - Minimal data storage
  - EPCGlobal Standard Passive RFID Tag Inlay
  - Gen 2 Class 1 – WMRM (Write Many-Read Many)

pRFID Applications:
Time & Temperature Sensitive Material - Sealants inventory
-Walk in freezer composite material out time / inventory
Paint - Paint mix room
Receiving - Incoming materials
Shipping - UID Bar codes on selected shipments
Work in process – Tube shop
Tool number, serial number, shelf location
Handheld reader for localization and ID – Biomark tag test

Passive Wireless Sensors Vehicle Health Management Applications

Robab Safa-Bakhsh - robab.safa-bakhsh@boeing.com
Associate Technical Fellow , Boeing Research and Technology

Customers: Boeing Commercial Aircraft, Military Fixed and Rotary Wing aircraft
Objectives: Life-Cycle Cost, Mission Reliability, Availability, Operational Plans, Supply Chain
Life Cycle Applications: Design & Development; Manufacturing, Operation & Sustainment

Sensors:
Flight Control: Electro-Mechanical Actuators, Hydraulic Actuators, Linkage, Hydraulic System
Electrical System: Generators, Converters, Contactors, APU, Batteries, Cooling System
Propulsion: Blades, Bearing, Gas path, valves
Avionic: Power Supply, Electronics
Rotor System: Rotor blades, Rotor hub, Tie bar, Rotor shaft
Fuel System: Fuel Pumps, Motors, Valves
Structures: Airframe Structure, Dynamic Components
Drive System: Gears, Bearings, Shafts, Lubrication, Housing
Electrical Wiring: Wiring insulation, Pins connections
Under Carriage: Landing Gear, Tires, Wheels, Brakes

Challenges: Reliable Comm/cross-talk, EMI, Reliable installations, Harsh environments, Sensor accuracy, life Stability

Passive Wireless Sensor Tag Research Focus:
- Meet min requirements for resolution, accuracy, repeatability & durability of traditional sensors
- System expandability & communication quality as the number of interrogated sensors increases
- EMI for long range interrogation
- Out of sight sensors implementation
- Synchronization of multiple sensors
- Synchronization of multiple interrogators
- Minimize size, weight and power of the interrogators
- Reliable installation and operation over the life of monitored component

What Works in the World of Wireless Sensors

Louis Sirico (Louis@RFID.net), **Host & CTO of The RFID Network, Campbell, CA**

http://RFID.net and www.Rfidwikipedia.org

- **Responsible RFID Benchmarking in a web-based TV Video Series & info source for Wikipedia**
  "We don't publish what people tell us, we make them prove it"
  http://rfid.net/applications/energy/289-passive-wireless-sensor-tags-benefit-energy-aerospace-transportation-a-industry

- **We show you** how Radio Frequency Identification and wireless RF sensors can improve your business. We provide information, tools, and advice that help you decide what to buy and how to get the most out of RFID.
  - Install, Implement and Integrate RFID

- **Durable RFID Tag Benchmarking:**
  - Defining 'Durability' and the RFID Tags Evaluated
  - Vibration Survival TestsSupply Chain Logistics Operations Tests: *Mixed Pallets with an RFID Enabled Portal & Handheld RFID Reader*
  - Asset Tracking Tests: *Maximum Read Range Outdoors with a GPS enabled Handheld RFID Reader*
  - Manufacturing Work-In-Progress Tests: *Maximum Read Range Indoors with a Fixed Position RFID Reader*
  - Overall Benchmark Test Analysis
  - Important Considerations When Selecting RFID Tags

RFID Net Website:

1. Use
2. Benefit
3. Compare / Evaluate / Buy
4. Install / Implement / Integrate
5. Back to #1 – Repeat

RFIDWikipedia Website:

1. Define
2. Explain
3. Educate

- **Call for Content: RFID Network is Looking for Subject Matter Experts(SME's) for RFIDWikipedia.org**

✓ **SAW**
✓ **Wireless Sensors**
✓ **RFID**

NXP Interactive Gen2

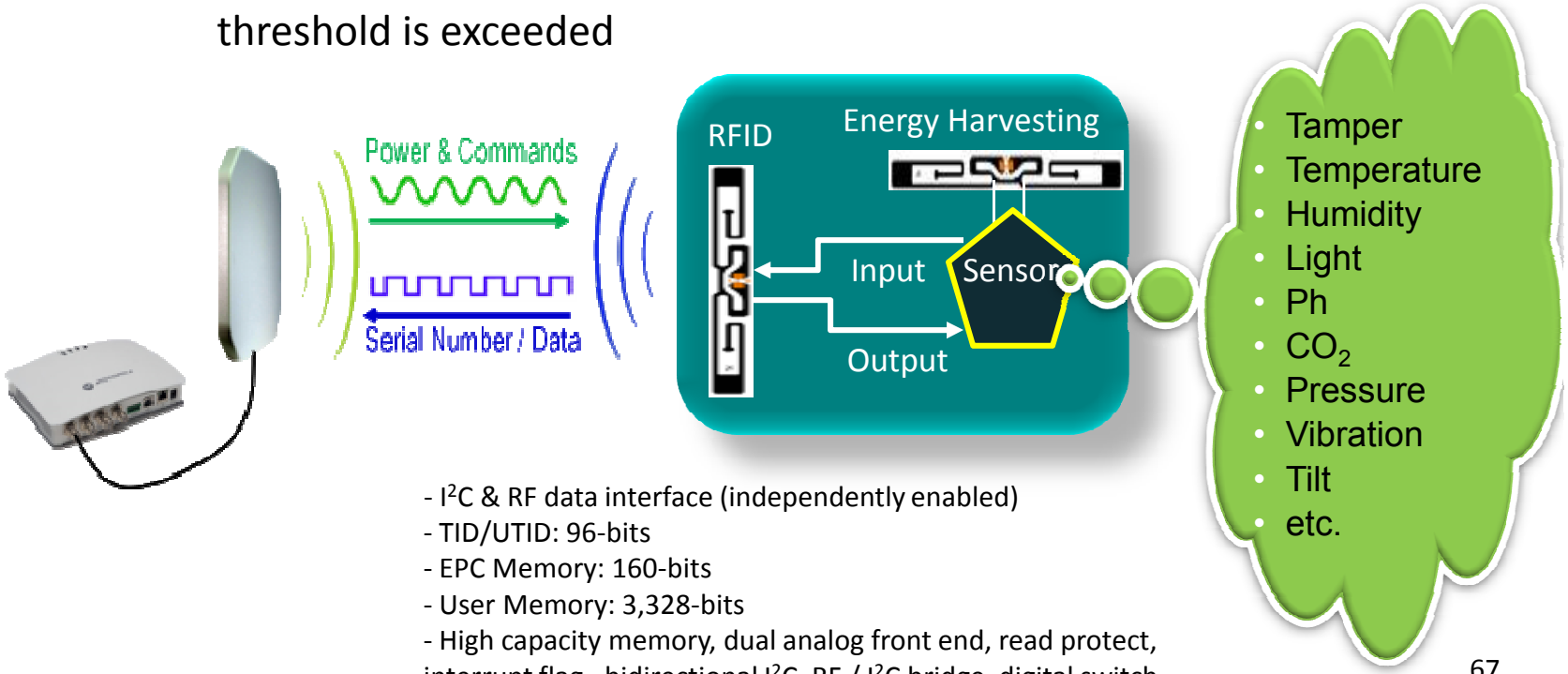
"Bridging the Gap between Passive RFID, Sensors and Electronics"

Victor Vega - Marketing Director, RFID Solutions

www.NXP-RFID.com

UCODE G2iL+ &G2iM+ series ICs **add a digital input / output to RFID**

- Input enables tamper or level detection for simple digital sensors
- State change is transmitted via RF to reader, along with device's unique s/n
- Output may be used as digital switch to assert a remote action
- Use cases may include alerts – for example, if bearing temperature threshold is exceeded



- I^2C & RF data interface (independently enabled)
- TID/UTID: 96-bits
- EPC Memory: 160-bits
- User Memory: 3,328-bits
- High capacity memory, dual analog front end, read protect, interrupt flag, bidirectional I^2C, RF / I^2C bridge, digital switch

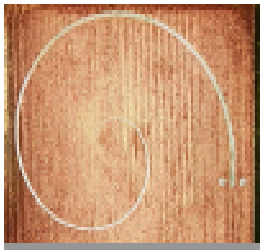
Aerosol Jet® (AJ) Direct Write Technology
A Manufacturing Tool for Printed Electronics

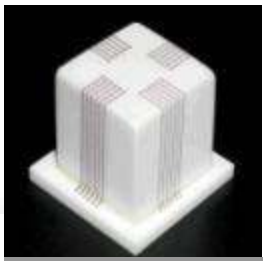
Optomec - Rich Plourde
rplourde@optomec.com

Note: Optomec does not design SAW, RFID, Antennas or Circuits
Contract Mfg: Quest Integrated Inc., Jonathan Kniss, http://www.qi2.com

- **Patented Material Deposition Kernel (atomizers, PCMs, print modules)**
  - Configurable for wide range of Feature Sizes & Multiplexing for volume production
- **Development Platforms Successfully Fielded**
  - for material, process & application development / prototyping
  - Configurable Atomizers, Heads, Motion, etc.
- **High Throughput Multiplexed Heads for Production**
  - ie: 40 nozzle head prints 2400 silicon solar wafers / hour
- **Platform Independent Modular Print Engines**
  - for high volume manufacturing
  - Standardized communications protocols & interfaces
  - Easily integrated with 3rd Party Manufacturing Systems
    - Manz Automation: print 80 solar collector lines on silicon wafers in 2.5 seconds
    - Speedline Technologies: print 20+ die stack interconnects / second


Die Attach


1cm GPS Antenna


3D Interconnects

NASA Testing of PWST

NASA LaRC/William C. Wilson william.c.wilson@nasa.gov
with support from KSC/Emilio Valencia, JSC/Richard Barton, LaRC/Jay Ely

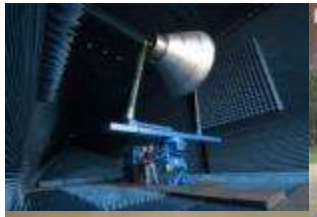
NASA has the capability for most forms of testing!

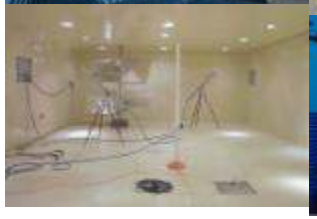
Transducer characterization

Cryostat

Strain Characterization – COPV

RF Testing





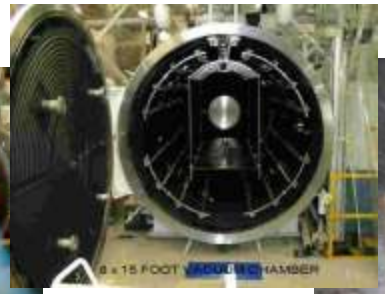
Functional testing

Flight Testing

- **MLAS**
- ***747&A320 Cargo Bays***
- ***747 Landing Gear***
- ***Intl. Space Station***

Compliance Testing

Industry, MIL Spec, Space Qual



Aerospace Vehicle Systems Institute

On-Aircraft Wireless Communications Research at AVSI

A part of the Texas Engineering Experiment Station at Texas A&M

Dr. Fred Fisher, Asst. Director, AVSI www.avsi.aero; Ffisher@avsi.aero

Full Members

- Airbus
- BAE Systems
- Boeing
- DoD
- Embraer
- GE Aviation
- Goodrich
- Honeywell
- Lockheed Martin
- Rockwell Collins
- UTC

Liaison Members

- FAA
- NASA

Associate Members

- Bombardier
- Gulfstream

WAIC Project Status Will Presented at 2012 PWST Workshop

Common problem-Cooperative solution-Immediate need

RFID Relevant Research Projects:

- AFE12 - Wireless Communications for Aircraft Systems
- AFE41 - Mitigating the Impact of RF Emissions from PEDs to Airplane Systems through Aircraft Hardening
- AFE50 - Energy Harvesting Potential Assessment
- AFE 56: Feasibility of Intra-Aircraft Wireless Sensors
- AFE54 - RFID Study
- AFE56s1 - Feasibility of Intra Aircraft Wireless Sensors + Supplement
- AFE73 - Wireless Avionics Intra-Communications (WAIC)

AVSI - RFID Relevant Research Projects

AFE 14: Wireless Communication for Aircraft Systems

- Develop and validate a performance model of wireless comm. within aircraft environment.
- Determine viability of using wireless comm for essential or critical aircraft systems.
- Validate model using a ground based aircraft
- Evaluate the impact of passive and active components within the aircraft (structural components, engines, and existing electronic and electro-hydraulic subsystems) at both physical and protocol layers.

AFE 41: Mitigating the Impact of RF Emissions from PEDs to Airplane Systems thru A/C Hardening

- Determine practical aircraft hardening techniques for mitigation of airplane system susceptibility to RF energy from portable electronic devices .
- Use results of this effort may be to support protective regulatory requirements .
- Select approaches for mitigating the impact of PEDs and experimentally evaluate effectiveness of the approaches.

AFE 50: Energy Harvesting Potential Assessment

• Quantify available energy on aircraft for potential energy harvesting.

• Survey one or two types of aircraft to determine the type and amount of energy that is available for harvest.

• Look at vibration/strain, thermal & RF energy levels.

• Assess energy levels for all status of the aircraft i.e. storage, docked, taxi, climb, cruise, decent, etc., to produce an available energy profile.

•AFE 56: Feasibility of IntraAircraft Wireless Sensors

• Evaluate Current aircraft RF certification process
• Evaluate RTCA SC 202 working group and draft DO-294 T-PEDS status as extensible to wireless sensors.
• Evaluate European work in this area.
• Determine Suitability of the ISM band, Possible alternative bands,
• Determine need for encryption.
• Define next steps and or work needed to fill holes/gaps - in coordination with the FAA
• Collect &evaluate existing Channel Modeling work

AVSI - RFID Relevant Research Projects

AFE 54: RFID Study

Deliver: A quantitative model of tag & interrogator emissions

Activities:

- Select representative tags /interrogators for analysis
- Survey existing work (NASA & others)
- Develop catalog of quantitative tag & interrogator models
- Install tags & interrogators in and around selected aircraft
- Measure tag and interrogator performance on the aircraft at selected locations and correlate with previously developed models
- Develop an avionics interference model for the tag/interrogator emissions
- Measure and quantify levels of interference with aircraft avionics

AFE 56s1: Feasibility of Intra Aircraft Wireless Sensors/Supplement

Prepare an info package to start formal frequency allocation process:

- Perform economic analysis on different band classifications
- Characterize potential usage profile envelope for wireless sensors: bandwidths, data rates, power levels, modulation techniques
- Down select frequency candidates from the already identified list.
- Cost and availability of commercial radio devices that operate in the candidate frequency band shall be included as factors in down-selection.
- Establish on-going contact with FAA spectrum office, FCC WTB and OET, NTIA. Contacts with any regulatory agencies/Washington DC offices shall be coordinated in advance w/AVSI PMC member companies' reg. offices.
- Evaluate pros and cons of the RTCA route
- Involve NASA, European contacts, other industry members (possibly as additional members of this PMC)
- Define and prepare a suitable information package including detailed roadmaps for each of the different band classifications (licensed dedicated, licensed shared, unlicensed dedicated portion) use by a third party to lobby the appropriate authorities (e.g. for licensed dedicated, the FCC and NTIA)

Prepare a specific certification strategy for information assurance:

- Determine actual impact of DoD Directive 8500.1
- Study and recommend strategies to certify security approaches that use randomized techniques
- Study and recommend approaches to facilitate upgrade-able encryption/security solutions with minimal FAA re-certification effort
- Study likely characteristics of jamming and denial of service attacks
- Study likely decrypting capabilities of an information interceptor
- Define a reasonable threat model for information assurance requirements

AFE 73: Wireless Avionics Intra-Communications (WAIC) - **http://waic.avsi.aero/**

• Use of wireless communication technology in safety-critical systems requires that appropriate frequency bands will be available with sufficient regulatory protection against unwanted interference.

• Interact with ITU-R through its Working Party 5B to get their recommendation for an allocation proposal.

• Perform technical studies and analyses necessary to formulate and justify a proposal.

• Formalize previous industry working group / ITU-R interactions.

• Establish a WRC 2015 Agenda Item relative to protected spectrum during the World Radio Conference in 2011.

• Perform all necessary follow-up activities to support allocation of the protected spectrum through regulatory organizations.

• The project serves as an important stepping-stone on the road towards allocation of protected spectrum for wireless avionics system.

- Pending project topics
  - WAIC band sharing studies
  - WAIC/PED/RFID/WiFi coexistence
  - WAIC protocol standard
  - Active/Passive Sensor Networks
  - System architecture virtual integration
  - Integrated reliability processes
  - Certification of RFID applications

Bridging the Mid TRL Gap through Coordinated Technology Development

Milind Pimprikar, Founder & Chairman, CANEUS International

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CANEUS' Sole Purpose: Enable Productive Public-Private Partnerships

CANEUS Proven Capabilities:

- **CANEUS brings together** technology developers, End-users, Governmental policymakers and investors from across the world.
- **CANEUS provides** a public/ private platform of transitioning emergent technologies rapidly and efficiently from concepts to the aerospace systems / products / missions.

CANEUS' Public/Private Consortia:

1. **Fly-by-Wireless Wireless (FBW)**
2. **Small (Nano/Pico/Micro) Satellites** for Civilian and Defence Applications
3. **Reliability** Testing
4. **Devices-** Harsh Environment Sensors,
5. **Nanomaterials** for Aerospace Applications including **Micro-energetic** for power generation, energy conversion, and micro-rockets

Benefits from joining the CANEUS FBW Consortium:

1. Cost/Risk Mitigation: Access to jointly developed pre-competitive technology & proprietary product development.
2. Participation in a collaborative technology, product and business development environments.
3. Licensing access to a fair and equitable IP-brokering service.
4. Reduced time-to-market and rapid system-level product deployment through supply chain collaboration.
5. Participate in the development of global standards in cooperation with leading aerospace corporations & agencies.
6. CANEUS will "harmonize" various National Policies controlling collaborative international technology development and frequency band allocations.
7. Access to CANEUS forums/conferences as key networking platforms for Fly-by-Wireless project members to address the relevant issues.
8. Access to CANEUS' global "technology portal" that identifies state-of-the-art and the technology developers and suppliers.

Industry Canada – Opportunities for Collaboration

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Canada

- **Industry Canada** - Mandate is to help make Canadian industry more productive and competitive in the global economy, thus improving the economic and social well-being of Canadians.
  Website: http://www.ic.gc.ca/eic/site/ic1.nsf/eng/h_00000.html?OpenDocument

- **Strategic Aerospace & Defence Initiative (SADI):** http://ito.ic.gc.ca/eic/site/ito-oti.nsf/eng/h_00023.html
  - To encourage strategic research and development (R&D) that will result in innovation and excellence in new products and services;
  - To enhance the competitiveness of Canadian A&D companies;
  - To foster collaboration between research institutes, universities, colleges & the private sector.

  Note: A US company could be treated as a subcontractor under a SADI agreement with a Canadian company but it is difficult to justify.

- **Industrial and Regional Benefits (IRB's):** http://www.ic.gc.ca/eic/site/042.nsf/eng/00029.html
  - Obligates Prime Contractors who have successfully won defence contracts to place economic activities in Canada

- **Defence Development Sharing Agreement (DDSA):**
  - IC Industrial Technology Office is the contact point for DDSA projects - www.ito.ca