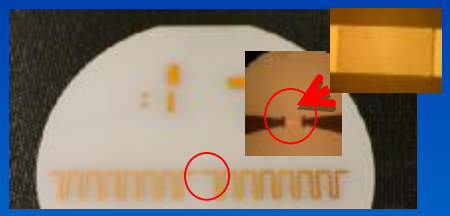
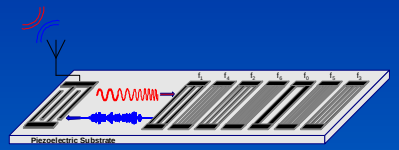
University of Central Florida STTR/SBIR Experiences





Donald C. Malocha
Department of Electrical Engineering & Computer Science
University of Central Florida
Orlando, Fl. 32816-2450
http://caat.engr.ucf.edu

donald.malocha@ucf.edu

Mnemonics, inc.
COMMUNICATIONS AND INFORMATION TECHNOLOGY

FLORIDA SPACE GRANT CONSORTIUM

NASA

CAAT

Don Malocha
University of Central Florida

- **Professor, UCF EECS Department**
- BS, MS and PhD, Univ. of Illinois, UIUC
- Texas Instruments, Corporate Research Laboratory, Dallas, MTS
- Sawtek, Orlando, Mgr. of Advanced Product Development
- Motorola, Visiting/Member of the Technical Staff, Phoenix and Ft. Lauderdale
- Visiting Faculty, ETH, Switzerland, and Univ. of Linz, Austria
- Past President, IEEE Ultrasonics, Ferroelectrics and Frequency Control Society
- 30 years of SAW and RF experience at UCF

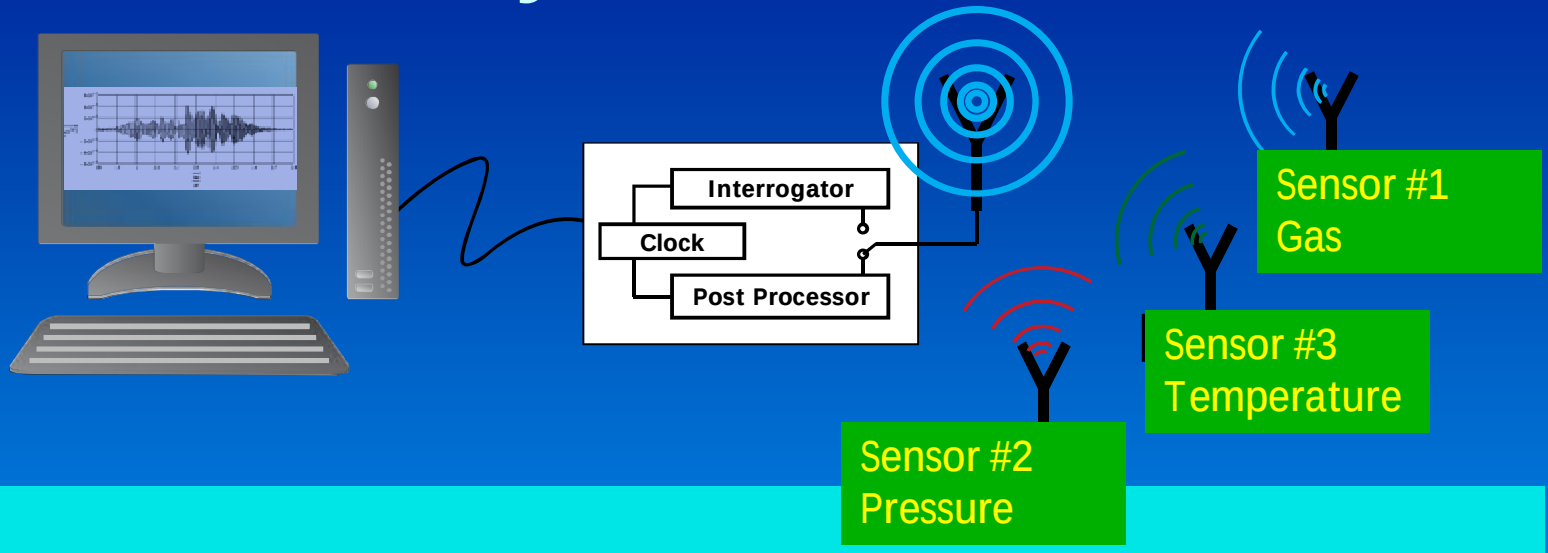
CAAT

- WEB site: http://caat.engr.ucf.edu/

General Background
Passive Wireless Surface Acoustic Wave (SAW) Sensor System

- ***Started at TRL-0 in 2004, high risk, high payoff***
- **Game changing technology- eliminates wiring, no maintenance, harsh environments, RFID, passive, long range, spread spectrum, multi-sensor platform**
- ***Investment will impact space and aerospace sensor applications: reducing cost, size, weight and more***
- **Wide range of industrial and commercial applications**
- ***Currently at TRL 4-5, demonstrations of devices, hardware and complete system in 2010***
- **Currently finishing 1-STTR –II, and ongoing 1 STTR –I and 2 SBIR –I**
- ***NASA is the primary agency champion***

Basic Passive Wireless SAW System



Goals:

- Interrogation distance: 1 – 50 meters
- # of devices: 10's – 100's - coded and distinguishable at TxRx
- Aerospace applications – rad hard, wide temp., solid state, etc.
- Single platform and TxRx for differing sensor combinations

What is a typical SAW Device?

- A solid state device
  - Converts electrical energy into a mechanical wave on a single crystal substrate
  - Provides very complex signal processing in a very small volume
- Approximately 4-5 billion SAW devices are produced each year
- Triquint, Orlando, produces 1M devices per day

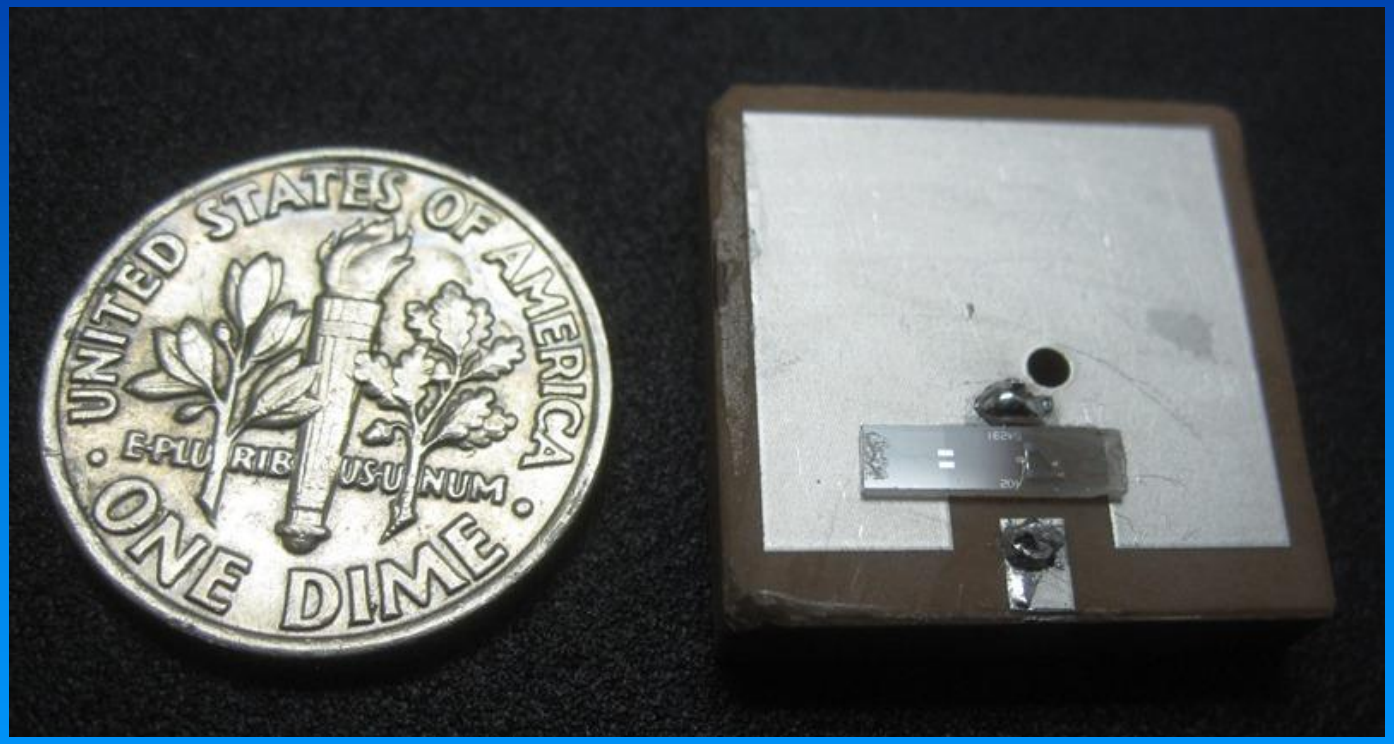
Applications:

Cellular phones and TV (largest market)

Military (Radar, filters, advanced systems

Currently emerging – sensors, RFID

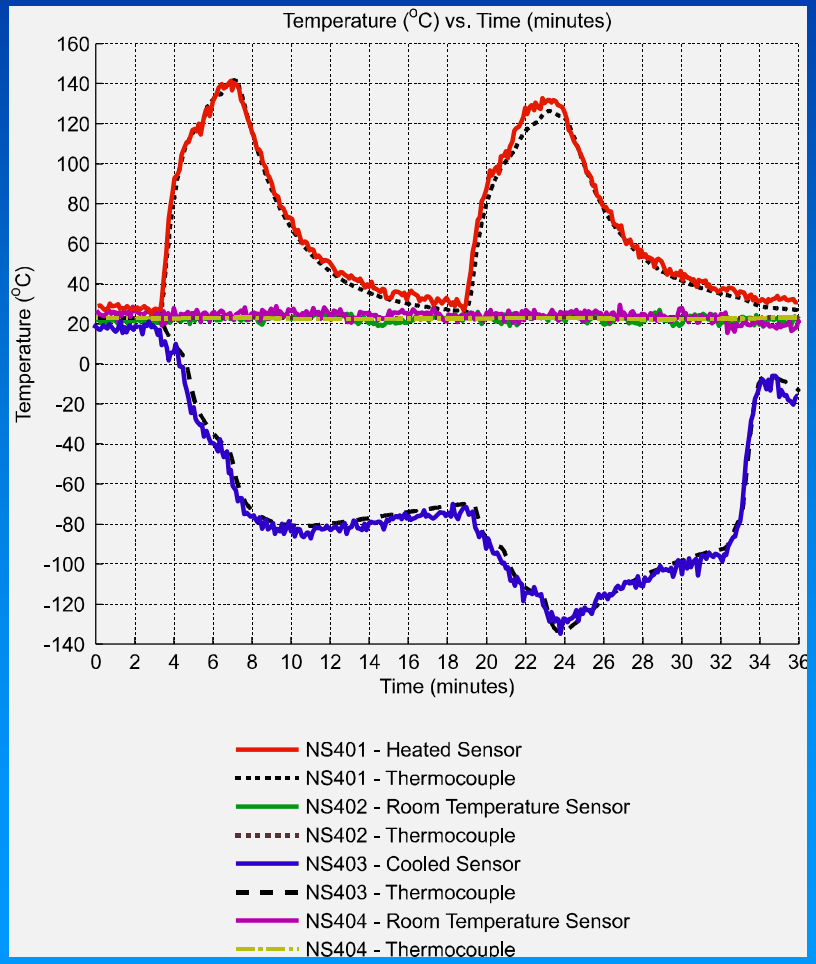
Miniature 915MHz Integrated OFC SAW-Patch Antenna



Mnemonics, inc.
COMMUNICATIONS AND INFORMATION TECHNOLOGY

CAAT

915 MHz four-sensor simultaneous wireless operation



- Four OFC SAW sensors are co-located in close range to each other at a distance of 0.8m to 1.2m
- Sensors NS402 and NS404 remained at room temperature
- Sensor NS401 heated to 140°C
- Sensor NS403 cooled to -130°C
- Data was taken simultaneously from all four sensors and then temperature extracted in the correlator receiver software
- Error is within ±5°C (±3.5% for given dynamic range)

NASA -UCF Teaming

- Contracts span 2005 until present
- 4 different companies spanning several STTR and SBIR contracts from 2005-present
- KSC initiated and continues to support program
- LaRC and JSC are now actively supporting SAW OFC wireless
- Conference presentations with various NASA sites and companies
- NASA has been exceptional in support and promotion of SAW OFC sensors

NASA-KSC/UCF Interactions

- **Dr. Bob Youngquist, KSC, COTR and guide through most STTR programs.**
- **Bob has maintained support and confidence through several difficult times – advocate and challanger.**
- **Bob is excellent, helpful, engaging, competent and an enabler.**
- **Ms. Joni Richards, KSC, Technology infusion Mgr.**
- **Joni was champion for the SAW Wireless Workshop held in August 2011.**
- **Joni has helped promote technology within centers, and is the main reason I am here today.**

Interactions
NASA-LaRC, JSC, others

- **Cy Wilson, LaRC, COTR SBIRs from LaRC and JSC**
- **Cy has been very helpful and supportive in the Phase I programs and is collaborating with UCF on the use of SAW OFC strain sensors.**
- **George Studor, JSC, promoting wireless technology**
- **CANAEUS, JANNAF, Wireless Workshop Houston July 2011**
- **George is advocate and promoter of wireless technology inside and outside NASA, and has kept us involved**
- **In addition, have met, presented and discussed SAW OFC wireless with many folks from Glenn, Marshall, and JPL**

UCF SAW OFC Contracts & Intellectual Property

A. 7 – Phase I and 4 –Phase II STTR/SBIRs on SAW OFC Sensors

B. NASA KSC, Langley, and JSC contracts

C. Fellowships from NASA, UCF, McKnight, and Florida Space Grant

D. *Patents on SAW OFC Sensor Technology:*

#7,642,898 D.C. Malocha and Puccio, Orthogonal Frequency Coding for Surface Acoustic Wave Communications, Tag, and Sensors, Jan. 5, 2010.

#7,623,037 D.C. Malocha, Multi-transducer/antenna surface acoustic wave device sensor and tag, November 24, 2009.

#7,825,805, D.C. Malocha and D. Puccio, Delayed Offset Multi-Track OFC Sensors and Tags, Nov. 2, 2010.

#7,777,625, D.C. Malocha and D. Puccio, Weighted Reflectors for OFC Coding, Aug. 17, 2010.

#7,791,249, D.C. Malocha and N. Kozlovski, Coding for Surface Acoustic Wave Devices, Issued May. 31, 2011

Several in process

Lessons Learned with Industrial Interactions

- Need a strong commitment from industrial partner
- Company has to have a focus for research-to-product
- Partners should have non-competitive roles in research
- Good communications required for success
- IP can be contentious
- Industry goals not always inline with university goals
- Industry/university operate under different SOP-contracting and payment conflicts
- Industry and NASA supply applications
- Industry provides great marketing
- Desirable having close physical proximity with KSC and industry

SBIR/STTR Difficulties

- NASA SBIR/STTR funding allocations this year have been real problem –cash flow
- NASA SBIR Phase I funding for 2011 is small for university involvement -$30K max
- Contract award dates
- Industry contracts and IP are difficult to negotiate
- Industry drives SBIR, university can be cut out
- Phase III is difficult in this economic climate

Malocha-UCF
STTR-SBIR Experience

SAW OFC STTR & SBIR NASA Contracts - Overview

4 different companies

2005-2011 Contracts

- **Microsystem Sensors Inc (MSI) 2005-2007 STTR Phase I & II**
- **Applied Sensor Research & Development (ASRD) 2008 -2009, 2 – STTR Phase I & II**
- **Mnemonics, Inc (MNI) 2008-2011, STTR Phase I & II**
- **Mnemonics, Inc (MNI) 2011, STTR Phase I & SBIR I**
- **Krystal Engineering (KE) 2011, SBIR Phase I**

UCF/MSI – Background

Microsystem Sensors Inc (MSI) 2005-2007
STTR Phase I & II - first contracts

- **Company of ~ 50 people manufacturing SAW chemical analyzer. Familiar w/SAW and system integration, based in Kentucky**
- **Early stages of SAW OFC sensor development**
- **UCF to provide devices**
- **MSI to provide initial RF transceiver design and prototype by Phase II**

UCF/MSI Comments

Microsystem Sensors Inc (MSI) 2005-2007
STTR Phase I & II

- **Company was purchased by large corporation and lost SBIR status as well as interest due to new management**
- **ASRD spun off with program manager**
- **First wireless demonstration of SAW OFC sensors by UCF**
- **Complete failure in transceiver effort by MSI**

UCF/ASRD - Background

Applied Sensor Research & Development ASRD 2008 -2009, 2 – STTR Phase I & II

- **Startup company to continue pursuing SAW OFC, based in Maryland**
- **2 technical people with SAW background**
- **STTRs were initial funding source for company**
- **ASRD needed to build facility and capabilities**
- **ASRD would be responsible for transceiver and antenna development**
- **ASRD would begin SAW sensor development**
- **UCF would be primarily responsible for SAW OFC device: coding, prototyping, design, fabrication and other**

UCF/ASRD - Comments

Applied Sensor Research & Development ASRD 2008 -2009, 2 – STTR Phase I & II

- **UCF IP was an issue –"new" ASRD device approach**
- **"New" ASRD transceiver approach**
- **Antenna and transceiver subcontracted to small firm**
- **Cooperation and trust decayed**
- **Subcontractor for transceiver unfamiliar with spread spectrum and broadband antenna design**
- **ASRD transceiver never demonstrated or delivered**
- **Next generation of SAW UCF devices demonstrated**
- **UCF developed prototype 250 MHz antenna**
- **UCF built 250 MHz prototype correlator transceiver to dispel the impression of any fundamental flawed concepts**

UCF/MNI - Background

Mnemonics, Inc (MNI) 2008-2011, STTR Phase I & II

- **DOD radio design company, ~150 people, sales ~$10-20M /year, Melbourne, Fl.**
- **Genuine interest in expanding in new business and working on STTR/SBIR programs and UCF**
- **Experienced technical staff in RF and radio receiver design – well versed in spread spectrum**
- **UCF responsible for 915 MHz SAW devices, antenna and software**
- **UCF builds prototype transceiver in parallel**
- **MNI to design 915 MHz transceiver system, and MNI/UCF will integrate software**

UCF/MNI - Comments

Mnemonics, Inc (MNI) 2008-2011, STTR Phase I & II

- **UCF develops 915 MHz devices/antennas in year 1**
- **UCF prototype receiver at 915 MHz built and demonstrated in year 1**
- **MNI accelerates development and 1st prototype spread spectrum correlator receiver built in 1st year**
- **Devices, antennas, RF transceiver and software all integrated in 2010**
- **NASA SAW Wireless Workshop, Orlando, August 2010, first successful SAW OFC sensor system demo**
- **Demonstration at multiple companies, agencies and conferences to promote technology**
- **Boeing, Loral, Florida DOT showing strong interest**

UCF/MNI - Comments

Mnemonics, Inc (MNI), STTR Phase I & SBIR Phase I

- **UCF to expand model and and fabricate new prototype devices from lessons learned**
- **MNI to build a high performance correlator receiver with lessons learned**
- **UCF to demonstrate a closure and temperature sensor operation on same device**
- **UCF to build a SAW OFC strain sensor**
- **MNI/UCF to enhance computer program code and hardware for faster acquisition times**

UCF/KE Overview

Krystal Engineering (KE) 2011, SBIR Phase I

- **Startup with 1 PhD (C. Klemenz Rivenbark) crystal grower, located in Titusville, Fl.**
- **KE will grow high temperature crystals; new enabling technology crystals for US and world market**
- **Has experience and demonstrated crystal growth**
- **UCF/KE will expand SAW harsh environment wireless sensor development**
- **Combining crystal grower and device technologists provides synergy and a unique collaboration**

UCF/KE Comments

Krystal Engineering (KE) 2011, SBIR Phase I

- **UCF was first US group to fully characterize and extract fundamental material parameters of LGS, LGT and LGN over temperature in 1999-2000 (Army)**
- **UCF fabricated first US SAW devices on these new materials and reported results (Army)**

- **Phase I in early stages**
- **First growth of LGT crystal is underway**
- **Device technology at UCF progressing**
- **So far, progress is good**

Concluding Remarks

- NASA STTR program is an excellent way to couple university research to industry and government agencies
- Contracting problems in 2011 are significant
- Positives far out way the negatives
- NASA has been an outstanding promoter and supporter of the UCF technology
- University, industry and agency collaboration can yield great technology benefits
- Technology development is multi-year, multi-contract and may have some missteps along the way

Acknowledgment

- The author wishes to thank continuing support from everyone who has aided us at NASA, and especially Dr. Robert Youngquist, NASA-KSC.
- The foundation of this work was funded through NASA Graduate Student Research Program Fellowships, the University of Central Florida – Florida Space Grant Consortium, and NASA STTR and SBIR contracts.
- Continuing research is funded through NASA STTR/SBIR contracts and industrial collaboration:

Mnemonics Inc. (MNI), Melbourne, Fl.

Krystal Engineering