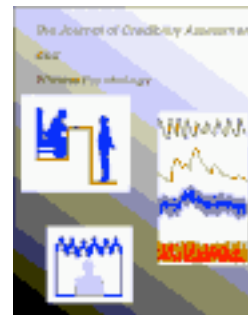


The Journal of Credibility Assessment and Witness Psychology

2006, Vol. 7, No. 2, pp. 127-134

Published by Boise State University



Radar Technology For Acquiring Biological Signals

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Radar Technology For Acquiring Biological Signals

The Ability of Radar to Sense Biological Signals Background of Gene Greneker

- Principal Research Scientist, Georgia Tech Research Institute 33 years
 - Radar Vital Signs Monitor (heart and respiration) Project Director
 - RADAR Flashlight Project Director
 - Through the wall detection of the human respiration radar signature
 - DARPA radar gait analysis program Project Director
 - Identification of a subject by radar sensed gait characteristics
- Retired From GTRI on 12-01-03 and started RADAR Flashlight, LLC.
- Working 49% part-time at Georgia Tech Research Institute
- Working 51% time for RADAR Flashlight, LLC on DARPA SBIR program to develop next generation RADAR Flashlight

The Ability of Radar to Sense Biological Signals

- Types of biological signals that radar can sense at present
 - Heart and respiration (vital signs)
 - Body tremor and very slight movement to maintain balance
 - Gait signature to allow identification of a subject
 - Heart signature (ballistocardiogram) of person hidden in vehicle
- Other attributes of radar sensing of biological signals
 - Detection of slight motion of the human body induced by a biological process
 - Detection of vital signs through clothes and heavy outer wear

The Ability of Radar to Sense Biological Signals Applications of Radar Vital Signs Monitoring

- Medical
 - Tele-medicine no connection required for heart and respiration monitoring
 - Heart disease screening
- Law Enforcement and Corrections
 - Finding persons behind walls and in closed areas
 - Suicide watch monitoring
 - Finding persons in shipping containers and border crossing inspection
 - Deception detection (heart and respiration channels of polygraph)
- Military
 - Clearing buildings in urban warfare scenario (through the wall human sensing)
 - Battlefield casualty assessment (dead or alive)
 - Vital signs monitoring through uniforms and chem/bio suits

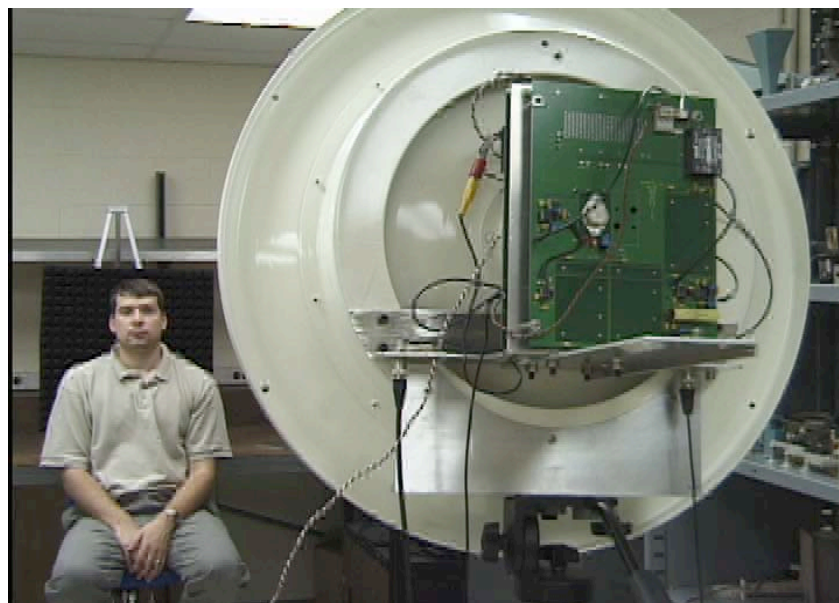
**History of Georgia Tech Research Institute's
Radar Vital Sign Monitoring Research Program**

- RADAR Vital Signs Monitor developed for military applications
 - Remote evaluation of battlefield casualties from 100 meters away
 - Monitoring of vital signs (heart and respiration rate) of injured person
 - Sealed in contaminated chemical or biological suit
 - Monitor of subject without opening suit and contaminating subject
- RADAR Vital Signs Monitor developed for 1996 Olympic application
 - Monitoring of archer and rifle competitor's vital signs at a distance of 30 feet
 - Do rifle competitors shoot between heartbeats?
 - Do archery competitors shoot between heartbeats?

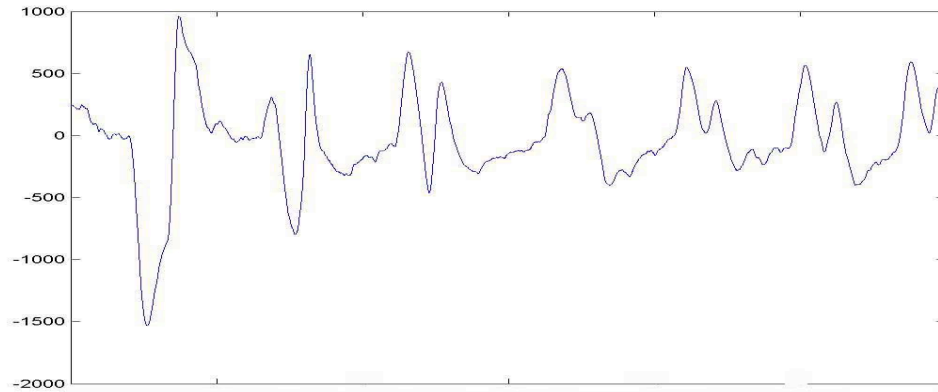
**GTRI Olympic Athlete Monitoring System
Olympic Athlete Monitor - Front View**



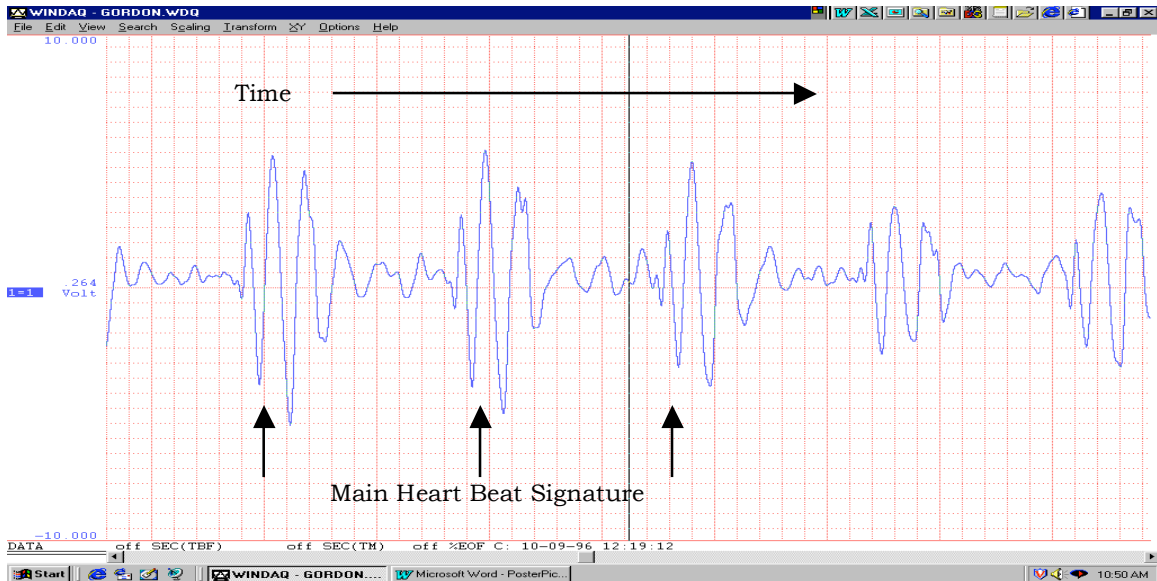
**GTRI Olympic Athlete Monitoring System
Radar Vital Sign Monitor - Rear View**



**GTRI Olympic Athlete Monitoring System
Respiration Signature at 30 feet**



**GTRI Olympic Athlete Monitoring System
Radar Cardiogram Taken at 15 Feet**



Thorax Aspect

Range To Subject = 15 feet

GTRI Human Gait Program Radar Measured Gait

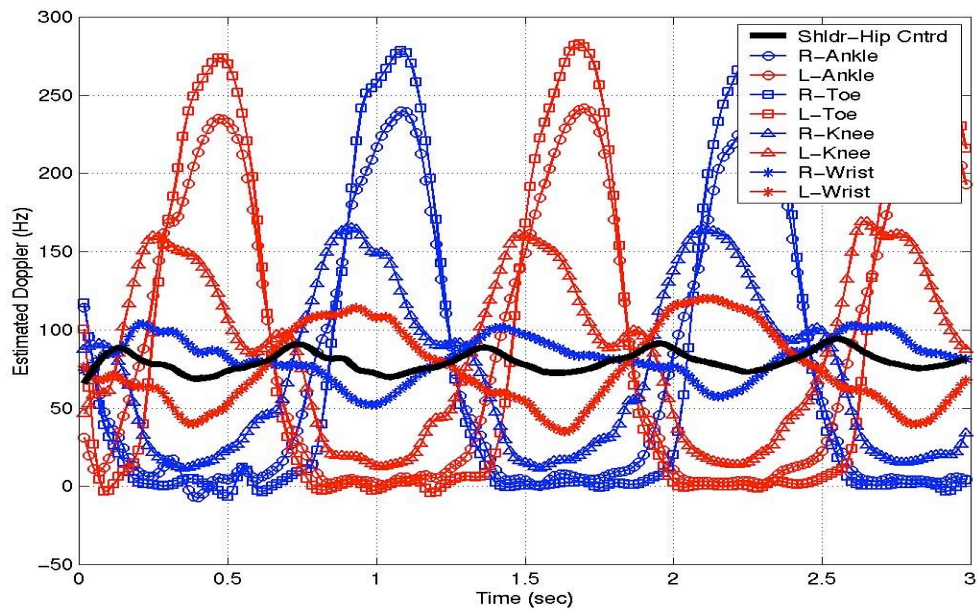
- Radar Measured Gait Analysis
 - Investigation of radar sensed gait to identify subjects after they have been enrolled in a 'gait' data base



- Gait research program performed for DARPA
 - Registered almost 100 subjects by having them walk toward radar
 - Took gait data 6 months later on same subjects used to build data base
 - Developed recognition algorithm to compare 'probe' to 'gallery'
 - Had 80% and higher recognition rate with low false alarm rate

GTRI Human Gait Program Processed Human Gait Signal

- Doppler signature produced by body members (walking subject)



**Radar Flashlight, LLC Clip-on Monitor
Heart and Respiration Rate Sensed Through Clothes**

- RADAR Flashlight, LLC is commercializing radar vital signs instrumentation
 - Clip-on radar heart and respiration rate monitor is first product
 - Stand-off long range non-contact radar vital signs monitoring system also planned as product

**Radar Flashlight, LLC Clip-on Monitor
Clip-on Sensor Specifications**

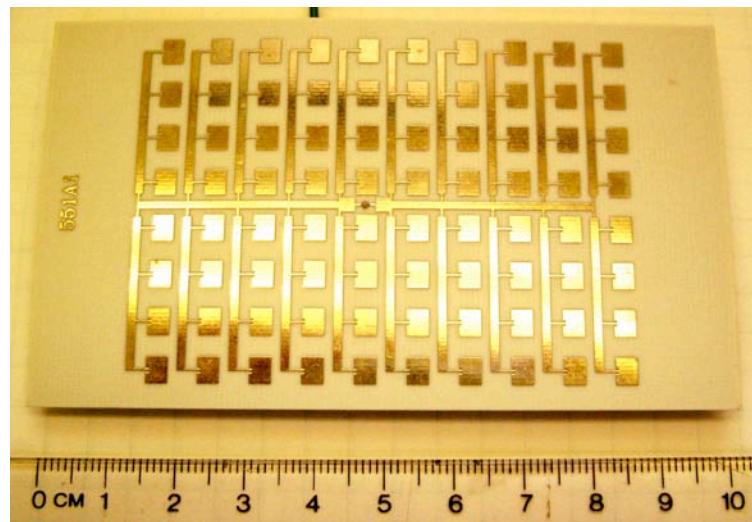
- Sensor unit is clipped on uniform over thorax area
- Battery operation
- Up to 10 patients monitored simultaneously
- Patient monitoring performed on hand held unit
- Sensors data sent to hand held unit via radio link
- Distance Between clip-on sensor and hand held monitor = 50 feet
- Loss of signal alarm
 - Radio link
 - Patient vital signs

**Radar Flashlight, LLC Clip-on Monitor
Heart and Respiration Rate Sensed Through Clothes**

- Applications for RADAR Flashlight, LLC Clip-on System
 - Small military units behind operating behind lines with wounded
 - Wounded stays in body armor and battle dress while system monitors
 - Victim can be moved on short notice without usual wired system mobility problems
 - Civilian heart and respiration rate monitoring applications
 - No removal of clothes required to monitor
 - Next generation system may be very inexpensive (disposable)

**Radar Flashlight, LLC Clip-on Monitor
Radar System**

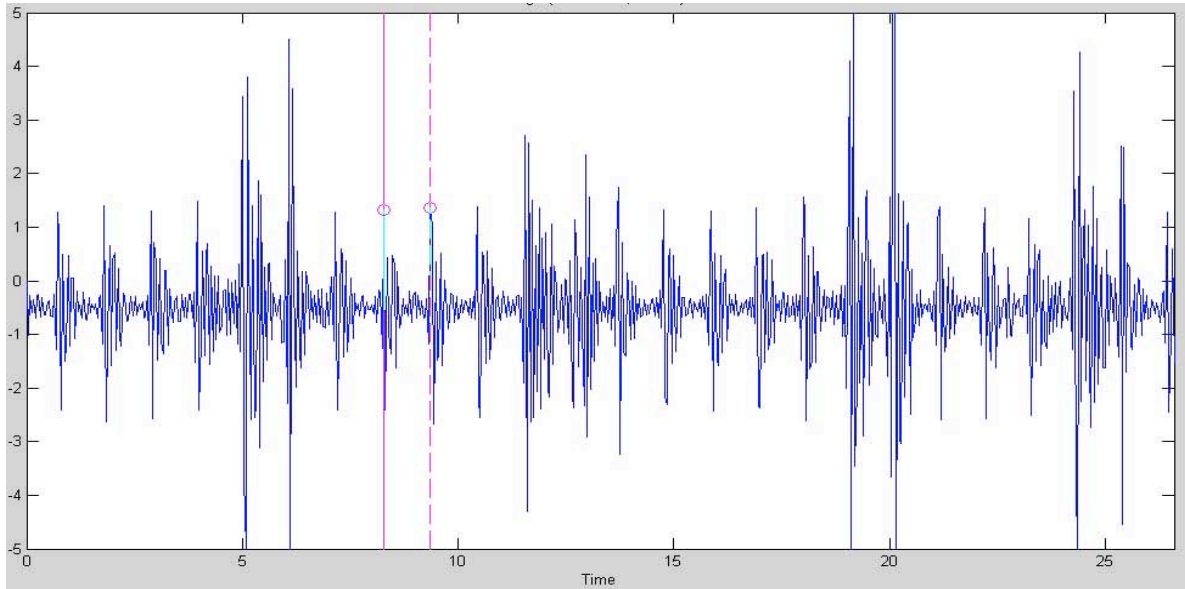
Radar System Used in Clip-on Sensor Package



Sensor weight is 2 ounces

**Radar Flashlight, LLC Clip-on Monitor
Heart Signature Taken Through Clothes**

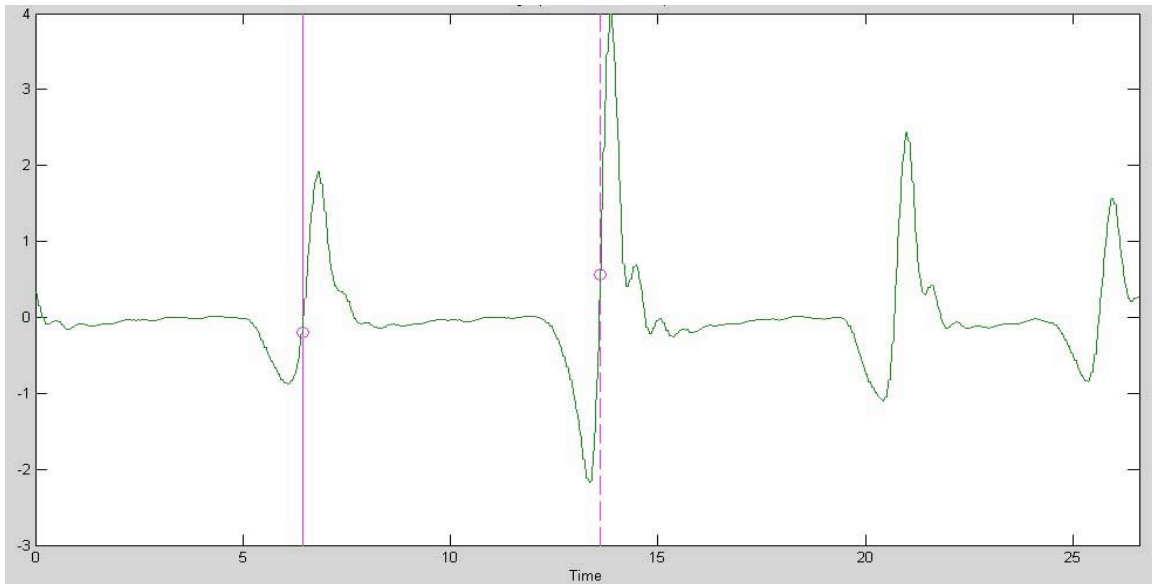
Clip-on Sensor's Heart Signal Channel Output



Time in seconds

**RADAR Flashlight, LLC Clip-on Sensor
Respiration Signature Taken Through Clothes**

Clip-on Sensor's Respiration Signal Channel Output



Time in seconds

Radar Technology For Acquiring Biological Signals What Radar Can't Do (Yet)

- Monitor low level biological electrical signals in body
 - EKG
 - EEG
- Recover heart and respiration signals from all parts of the body
 - Thorax - front aspect best to monitor
 - Heart and respiration signal can be picked up from back area
 - If vessel or artery comes close to surface heart signal detectable

Radar Technology For Acquiring Biological Signals Current Radar Vital Signs Challenges

- Any subject motion currently causes artifacts in signal from stand-off radar system
 - Moving body motion induces signal larger than small heart and respiration signal
 - Techniques to isolate heart and respiration signature from small body motion signature needs to be developed
 - Covert deception analysis on basis of heart and respiration rate at checkpoint possible if subject body motion artifact problem can be solved
- Motion artifact not same magnitude problem in clip-on system
- Recovery of radar developed heart and respiration signal from walking subject topic for future research
 - Data is in the Doppler sidebands but only as “micro-Doppler” components
 - Micro-Doppler recovery techniques should be subject of future research efforts

Radar Technology For Acquiring Biological Signals Future Research Topics in the Area of Radar Based Deception Detection

- Heart and respiration signal recovery while subject is being questioned at Customs or Immigration counter
 - Motion artifact suppression research
 - Method to determine deception from only 2 channels of information
- Detection and recovery of heart and respiration signal when subject of interest is walking
- Techniques to isolate heart and respiration rates of subject moving in crowd

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