

ARMY RESEARCH LABORATORY



# **Radio Frequency (RF) Measurements for Human Detection, Tracking, and Identification**

**by Thomas J. Pizzillo**

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**ARL-TR-4302**

**October 2007**

## **NOTICES**

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# **Army Research Laboratory**

Adelphi, MD 20783-1197

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**ARL-TR-4302**

**October 2007**

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## **Radio Frequency (RF) Measurements for Human Detection, Tracking, and Identification**

**Thomas J. Pizzillo**  
**Sensors and Electron Devices Directorate, ARL**

# REPORT DOCUMENTATION PAGE

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<b>13. SUPPLEMENTARY NOTES</b>					
<b>14. ABSTRACT</b> This report describes a protocol that is to be used during radio frequency measurements of humans. The purpose of the experiment is to measure the unique radar signature of walking humans so that methods of detecting and classifying dismounts can be developed. This information is needed for emerging UAV-based radar systems that must operate in complex urban environments. This report provides details of the experimental procedure, locations, safety considerations, and instrumentation. Also included is the volunteer agreement affidavit and the volunteer solicitation advertisement.					
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## 1. Locations of Study

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Building: Building 203  
Room: Anechoic chamber facility  
City: Adelphi

Building: Range 8  
Room:  
City: Aberdeen

Time Required to Complete Study: 1 year

Data Collection Dates: October 2007 – October 2008

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## 2. Project Introduction

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The changing nature of international security and urban warfare has compelled an Army need for assets that combine an all-weather ground moving target indicator (GMTI) and synthetic aperture radar (SAR) to provide an all-terrain (foliated and open) capability to detect and classify mounted and dismounted threats in a package form-fit-function compatible with future combat system Class IV unmanned aerial vehicle (UAV) system (*I*). To date, the practical detection of dismounts has not been achieved, largely because of their low velocities and low radar cross sections. Currently, there are no reliable techniques to detect targets below the minimum detectable velocity of a GMTI radar or those located in the low signal-to-clutter ratio (SCR) environment of a SAR image, but much effort is being dedicated to developing this capability (2,3,4).

Traditionally, the fast Fourier transform (FFT) has been the basis for SAR image analysis because it is best suited for extracting stationary signals within the image. When non-stationary signals are present, a SAR image may be degraded and artifacts introduced into the image because the Fourier basis is not localized and discards all time information when generating an image. Yet, a SAR image may contain important information about a wide range of time and frequency scales; thus, it is reasonable to assume that time-frequency transforms are useful for characterizing and classifying non-stationary signals. The short-time Fourier transform (STFT) is one such technique but is limited, depending on the window size since the time and frequency resolutions are fixed for a given window and may not possess the necessary resolution for extracting biometric features of interest. Additionally, the relative intensity of these features is expected to be very small, making time-frequency analysis a good candidate for extracting these

signals (5,6,7). “The inevitable presence of non-stationary processes in SAR data spanning any real scene compels some form of JTF (joint time-frequency) analysis”. Time-frequency techniques have been successfully demonstrated in the analysis of electrocardiograms (EKGs) (8).

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### **3. Research Objective**

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Scientific sensor development must be based on a sound understanding of the underlying phenomenology and of the relative strengths, weaknesses, and limitations of various sensing approaches. Additionally, the development of innovative models and algorithms requires validation that uses well-characterized ground truth data. Results of a systematic investigation of the underlying phenomenology and a benchmarking study establishing any new level of phenomena knowledge and understanding of the sensing challenges are necessary to significantly advance the state of the art in sensing that will enable the Government to effectively and efficiently manage and deliver future capabilities. Our objective is to populate a new human signatures database with data that characterize the radio frequency (RF) biometric signatures of humans in an anechoic chamber. These data then may be used to develop time-frequency analysis techniques to detect, track, and identify humans with the use of RF biometric discriminants (i.e., heart rate, breathing rate, voice, gait, and postural sway) and then to demonstrate and measure the performance of the developed time-frequency analysis techniques with data collected in a range environment simulating the look-down angles of a UAV-based SAR sensor system. However, it is expected that these measurements will be of such quality as to be generally applicable to any sensor system concept development, i.e., sense through the wall, persistent surveillance, search and rescue.

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### **4. Participants**

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Ten volunteers from within the U.S. Army Research Laboratory will be solicited. These volunteers maybe male or female age 18 and older with no physical or medical disabilities that would prevent them from being able to walk at a casual pace on a treadmill. Any volunteer who requires the use of any medical electronics (e.g., a pacemaker) will not be accepted.

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## 5. Instrumentation

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Two types of instrumentation radar will be used, with the major difference being the radar waveform generated. The first type will be a continuous wave radar that can transmit a single frequency anywhere from 0.3 to 38.6 GHz. We have chosen to operate on the following frequencies; 0.3, 0.4, 0.5, 1.2, 1.3, 1.4, 1.5, 15, 16, 17, 18, 33, 34, 35, 36, 37, and 38 GHz. The second type of radar transmits 100 nanosecond rf pulses at a rate of 1 MHz. Four carrier frequencies will be used, each with a 2-GHz band width. These frequency bands are 10 to 12, 16 to 18, 33 to 35, and 93 to 95 GHz. The radar parameters related to the electromagnetic radiation to which the participants will be exposed are shown in table 1.

Table 1. Radar parameters.

Frequency	Pulse width	Duty cycle (%)	Peak power	Antenna gain
	100 ns	10	20 dBm	20 dBi
	100 ns	10	20 dBm	20 dBi
33 to 35 GHz	100 ns	10	20 dBm	32 dBi
93 to 95 GHz	100 ns	10	20 dBm	32 dBi
	N/A	100	30 dBm	7 dBi
	N/A	100	30 dBm	20 dBi
	N/A	100	20 dBm	20 dBi
33 to 38 GHz	N/A	100	20 dBm	32 dBi

dBm = decibel (referenced to milliwatts)

dBi = forward gain of an antenna referenced to an isotropic radiator in decibels

A Life Fitness 9100HR treadmill will be used for the walking portion of the data collection. It provides a peak horsepower of 4.0 hp and a continuous horsepower of 2.0 hp. The maximum user weight capacity for walking is 350 lb. It has a flexible deck shock absorption system and a belt size of 18 by 58 inches. The frame has been removed, as shown in figure 1, to prevent interference and distortion of the RF measurements. During the treadmill portion of the measurement, an emergency stop button will be available, mounted on a tripod next to the treadmill. Volunteers may use this button to stop the treadmill at any time for any reason, particularly if they become disoriented or think they might fall. They are free to stop participation in any of the measurements at any time for any reason.



Figure 1. Treadmill.

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## 6. Procedure and Methodology

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Each volunteer will be assigned a participation number. The volunteer will be asked to wear three sensors: a Polar<sup>1</sup> T31 heart rate monitor that includes a transmitter belt worn about the chest and the associated wrist worn computer so the heart rate could be recorded; a hands-free mini-microphone worn on the head so that breathing rate and spoken words could be recorded; and a tri-axial accelerometer on the back of the pants waistband so body movements could be recorded. Each of these sensors will be connected to a Bioradio<sup>2</sup> Model 110 data logger worn on the side of the pants waistband where the recorded data will be transmitted wirelessly to a computer for storage and later analysis. The volunteer will be given instructions about how the sensors are to be worn (i.e., the heart rate monitor must be in contact with the skin) and then will be asked to place these sensors on his body himself. A private location will be provided for this activity. This information, along with a video recording of the measurement scene, will be recorded while RF measurements of the volunteer are completed in one of two scenarios: Scenario 1 is in an anechoic chamber; Scenario 2 is on an outdoor turntable at Range 8 at Aberdeen Proving Ground (APG). The volunteers may participate in one or both of these scenarios. There are no requirements as to which scenario the volunteer chooses or whether he participates in both. Within these scenarios, three different measurements will be recorded for the volunteer: he will be seated in a chair, he will be standing, and he will be walking casually on a treadmill. For Scenario 1, each measurement lasts 1 minute and will be repeated eight times with the volunteer facing a different 45-degree direction each time. At the 30-second mark of each measurement the volunteer will be directed to count from 1 to 10. For Scenario 2, each measurement will be repeated three times and will last 20 minutes. The volunteer will be asked

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<sup>1</sup>Polar is a registered trademark of Polar Electro, Inc.

<sup>2</sup>Bioradio is a registered trademark of Cleveland Medical Devices, Inc.

to count from 1 to 10 eight times during each measurement, once each for every 45-degree rotation of the turntable.

Scenario 1 requires 17 separate 0.5-hour commitments over a 2-week period.

Scenario 2 requires 16 separate one 1-hour commitments over a 4-week period.

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## **7. Participant Scenario**

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Upon arrival, the volunteer will be asked three questions:

Do you require the use of any medical electronics?

Are you able to maintain a casual walk for 1 minute on a tread mill?

or

Are you able to maintain a casual walk for 20 minutes on a tread mill?

If the volunteer answers yes, the measurements will begin with the volunteer reading and signing the consent form and the experimenter presenting a description of the measurements. The volunteer will be given the opportunity to ask questions and will be free to discontinue participation at any time. All data collected will be coded to protect the volunteer's identity. The volunteer's name will appear only on the consent form. A number will be assigned to all data records (rather than the volunteer's name) to protect the confidentiality of the data.

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## **8. Experimental Design**

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### **8.1 Anechoic Chamber Measurements**

#### **8.1.1 Test 1. Seated Measurement**

The volunteer will be asked to sit on a chair facing the radar while 1 minute of data is collected, and at the 30-second mark, the volunteer will be asked to count out loud from 1 to 10.

#### **8.1.2 Test 2. Standing Measurement**

The chair will be removed and the volunteer will be asked to stand while 1 minute of data is collected, and at the 30-second mark, the volunteer will be asked to count out loud from 1 to 10.

### **8.1.3 Test 3. Walking Measurement**

The volunteer will be asked to start the treadmill and maintain a comfortable walking pace for 1 minute; at the 30-second mark the volunteer will be asked to count out loud from 1 to 10 and at the end of 1 minute, the volunteer will be directed to stop.

The chair and treadmill will be repositioned by 45 degrees relative to the radar, and tests 1, 2, and 3 will be repeated and this process will be repeated so as to complete a 360-degree measurement set. A total of 24 measurements (3 tests times 8 positions) will be made for a total time of 24 minutes for each frequency within the bands of interest:

300 to 500 MHz – Three frequencies will be measured; 300, 400, and 500 MHz 24 minutes/frequency x 3 frequencies/volunteer = 72 minutes/volunteer

1.2 to 1.5 GHz – Four frequencies will be measured; 1.2, 1.3, 1.4, and 1.5 GHz 24 minutes/frequency x 4 frequencies/volunteer = 96 minutes/volunteer

15.2 to 18.2 GHz – Four frequencies will be measured; 15.2, 16.2, 17.2, and 18.2 GHz 24 minutes/frequency x 4 frequencies/volunteer = 96 minutes/volunteer

33.4 to 38.4 GHz – Six frequencies will be measured; 33.4, 34.4, 35.4, 36.4, 37.4, and 38.4 GHz 24 minutes/frequency x 6 frequencies/volunteer = 144 minutes/volunteer.

During each test, voice and video will be recorded as well as heart and breathing rates. The video recording will be used for data analysis, which may include sharing it with university collaborators. If the video is shared with outside collaborators, the participant's face will be digitally blocked. Body sway and shock transmitted through the body as a result of the impact of walking will be recorded with a tri-axial accelerometer. These data will be gathered by a data-logger worn by the volunteer and transmitted wirelessly to a computer outside the measurement area.

## **8.2 Outdoor Range Measurements**

### **8.2.1 Test 1. Seated Measurement**

The volunteer will sit in a chair on the turntable while it is rotated 360 degrees. At each multiple of 45 degrees, the volunteer will be asked to count out loud from 1 to 10.

### **8.2.2 Test 2. Standing Measurement**

The volunteer will stand on the turntable while it is rotated 360 degrees. At each multiple of 45 degrees, the volunteer will be asked to count out loud from 1 to 10.

### 8.2.3 Test 3. Walking Measurement

The volunteer will be asked to start and maintain a comfortable walking pace on the treadmill on the turntable while it is rotated 360 degrees. At each multiple of 45 degrees, the volunteer will be asked to count out loud from 1 to 10.

A total of 48 measurements, 3 tests x 4 frequency bands x 4 elevation angles (0, 15, 30, and 45 degree) will be made. The total time for each will be 240 minutes:

10 to 12 GHz – 20 minutes/test x 3 tests x 4 EL Angles = 240 minutes/volunteer

15 to 18 GHz – 20 minutes/test x 3 tests x 4 EL Angles = 240 minutes/volunteer

33 to 36 GHz – 20 minutes/test x 3 tests x 4 EL Angles = 240 minutes/volunteer

92 to 95 GHz – 20 minutes/test x 3 tests x 4 EL Angles = 240 minutes/volunteer

During each test, voice and video will be recorded as well as heart and breathing rates. Body sway and shock transmitted through the body as a result of the impact of walking will be recorded with a tri-axial accelerometer attached to the volunteer. These data will be gathered by a data-logger worn by the volunteer and transmitted wirelessly to a laptop outside the measurement area.

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## 9. Risks

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### 9.1 RF Radiation

RF radiation can be hazardous to personnel by the heating of the tissue of the eyes and body. The RF sources for these measurements are detailed in table 2 with only the center frequency of each band listed. A graphical representation of the data in table 2 is presented in figure 2 and shows the variation across each band.

#### 9.1.1 Tissue/Eye Exposure

The maximum permissible exposures (MPEs) for these frequencies as set forth in Institute of Electrical & Electronics Engineers C95.1, 2005 (9) are listed in table 2.

The distances (D) from the source within which these limits would be exceeded may be calculated via the following equation:

$$Pd \text{ (mW/cm}^2\text{)} = \frac{\text{power (mW)} * \text{numerical gain}}{4 * \pi * D(\text{cm})^2}$$

Where

- Pd = MPE
- Power = transmit power of the source
- Numerical gain = Antenna gain
- D = distance from the source

The hazard distances are listed in table 2.

It is readily apparent that these sources are not capable of exceeding the MPEs at distances greater than 0.36 meter. In every measurement scenario, the closest a volunteer will be to any source will be 15 meters and as far as 60 meters. In addition, a sign and tape will be placed around the access to the RF emitter to clearly identify “no-go” areas.

Table 2. Source characteristics and hazard distances.

Center Frequency (GHz)	$\lambda$ (m)	MPE (mW/cm <sup>2</sup> )	Transmit Power (mW)	Gain (dB)	Gain	Distance (cm)	Distance (m)
0.4	0.7500	1.33	1000	7	5.01	17.3	0.17
1.1	0.2727	10.00	1000	20	100.00	28.2	0.28
11	0.0273	10.00	100	20	100.00	8.93	0.09
16.5	0.0182	10.00	1000	20	100.00	28.2	0.28
34.5	0.0087	10.00	100	32	1584.89	35.51	0.36
93.5	0.0032	10.00	100	32	1584.89	35.51	0.36

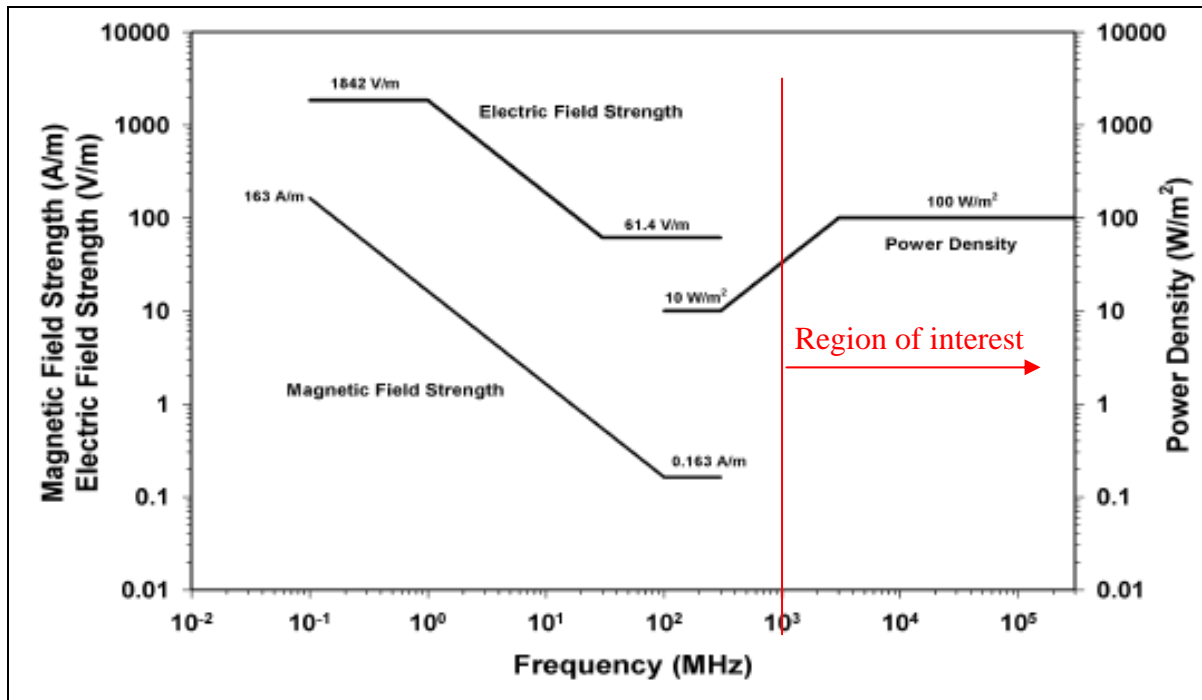


Figure 2. Graphic representation of the MPEs as excerpted from IEEE c95.1 2005.

### **9.1.2 Medical Electronics**

Electronics such as cardiac pacemakers can be sensitive to RF interference. However, volunteers who appear with any medical electronics will be rejected from participation.

### **9.1.3 Safety Measurements**

Measurements of radiation will be made by an ARL radiation safety professional before the start of any data collection to corroborate the measurements presented in the written protocol. The results of these measurements will be provided in a memorandum to the human use committee before the start of any data collection.

## **9.2 Environment**

The Range 8 facility is situated behind the security fence at APG and several natural hazards are associated with the area. In addition, this portion of the measurements will be made during the summer months so heat and humidity are potential risks.

- a. Heat stress and dehydration are considered the leading risks during the outdoor portions of these measurements and all activities will be in accordance with the wet bulb warning system, derived from TBMED-507, posted on the APG web site.
- b. There is the risk of sunburn. Sun screen will be available at the test site.
- c. There are wild animals, snakes, and poisonous insects in the vicinity of the range 8 test site. All volunteers will be asked to take appropriate precautions.
- d. There is risk of tick bites and the potential for Lyme disease. Insect repellent will be available at the test site and we will ask volunteers to inspect themselves frequently for ticks.

Other risks include physical fatigue, muscle strains, sprains, cuts, abrasions, skin irritations, broken bones and injuries which may result from falls from the treadmill. The absorber material used in the anechoic chamber and at the range 8 facility will provide some padding if a fall does occur. In case of any incidents, the criteria defined in AR 385-40, Accident Reporting and Records, and AR 190-40, Serious Incident Report, will be followed.

## **9.3 Mitigation**

An independent safety professional from ARL will inspect all experimental equipment and conditions for human use in the configuration to be employed during the measurements. The safety inspection will specifically consider any risks associated with a human participant walking on the treadmill on the moving turntable. The emergency stop button will be evaluated for its effectiveness and safety during use by human participants performing the walking task on the turntable. All identified safety issues will be resolved to the satisfaction of the safety inspector who will then provide a safety review assuring that the experimental setups in Adelphi and APG

are safe for all participants. The results of this review will be provided in a memorandum to the human use committee before the start of any data collection.

A memorandum will be sent to local emergency services with the dates and times of the measurements to alert them of the data collection effort as a means of minimizing delay in providing aid to any participant who may suffer a physical injury.

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## References

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8. Pon, Lin-Sen; Gephart, K.; Mingui Sun; Sclabassi, R. J. Analysis of heart rate changes associated with ictal activity. *Proceedings of the 22nd Annual International Conference of the IEEE*, 1, 68-70, July 2000.
9. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

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**Appendix A. Volunteer Agreement Affidavit**

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**VOLUNTEER AGREEMENT AFFIDAVIT:**

ARL-HRED Local Adaptation of DA Form 5303-R. For use of this form, see AR 70-25 or AR 40-38

The proponent for this research is:	<b>U.S. Army Research Laboratory Sensors and Electronic Devices Directorate Adelphi, MD 20783-1197</b>
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Authority:	Privacy Act of 1974, 10 U.S.C. 3013, [Subject to the authority, direction, and control of the Secretary of Defense and subject to the provisions of chapter 6 of this title, the Secretary of the Army is responsible for, and has the authority necessary to conduct, all affairs of the Department of the Army, including the following functions: (4) Equipping (including research and development), 44 USC 3101 [The head of each Federal agency shall make and preserve records containing adequate and proper documentation of the organization, functions, policies, decisions, procedures, and essential transactions of the agency and designed to furnish the information necessary to protect the legal and financial rights of the Government and of persons directly affected by the agency's activities]
Principal purpose:	To document voluntary participation in the Research program.
Routine Uses:	The SSN and home address will be used for identification and locating purposes. Information derived from the project will be used for documentation, adjudication of claims, and mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies.
Disclosure:	The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this data collection.

**Part A • Volunteer agreement affidavit for subjects in approved Department of Army research projects**

*Note: Volunteers are authorized medical care for any injury or disease that is the direct result of participating in this project (under the provisions of AR 40-38 and AR 70-25).*

Title of Research Project:	Radio Frequency (RF) Measurements for Human Detection, Tracking, and Identification	
Human Use Protocol Log #	ARL-20193-07001	
Principal Investigator:	Thomas J. Pizzillo Robert Tan	Phone: 301-394-3143 E-Mail: Pizzillo@arl.army.mil Phone: 410-278-4387 E-Mail: Rtan@arl.army.mil
Associate Investigator(s)	Jerry Silvious Robert Bender	Phone: 301-394-0881 E-Mail: Silvious@arl.army.mil Phone: 410-278-4319 E-Mail: Rbender@arl.army.mil
Location of Research:	Adelphi Laboratory Center (ALC)	
Dates of Participation:		

Date of Human Use Review: 30 August 2007  
Expiration Date: 29 August 2008

Volunteer's Initials \_\_\_\_\_

Administrator's Initials \_\_\_\_\_

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**Part B • To be completed by the Principal Investigator**

Note: Instruction for elements of the informed consent provided as detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.

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**Purpose of the Research**

You are invited to participate in a study designed to investigate human radio frequency (RF) Doppler signatures at a variety of radio frequencies. The primary purpose of this investigation is to understand the underlying phenomenology associated with these signatures for the purpose of developing waveforms and algorithms to exploit the uniquely identifying aspects of the human RF signature for intelligence, surveillance, and reconnaissance applications.

This study is being conducted by the Army Research Laboratory (ARL) – Sensors and Electronic Devices Directorate (SEDD) in support of Advanced Technology Objective (ATO) with the Intelligence and Information Warfare Directorate, Communications-Electronics Research Development and Engineering Center.

**Procedures**

You will be assigned a participation number. Then you will be asked to wear three sensors: A heart rate monitor that includes a transmitter belt worn about the chest and a wrist worn computer so your heart rate may be recorded; a hands free mini-microphone worn on your head so your breathing rate and spoken words may be recorded; and a tri-axial accelerometer on the back of your pants waistband so your body movements may be recorded. Each of these sensors will be connected to a data logger worn on the side of your pants waistband where the recorded data will be transmitted wirelessly to a computer for storage and later analysis. You will be given instructions on how the sensors are to be worn, i.e. the heart rate monitor must be in contact with the skin, and then you will be asked to place these sensors on your body. A private location will be provided for this activity. This information along with a video recording of the measurement scene will be collected while RF measurements of you are completed in an anechoic chamber located at the Adelphi, Laboratory Center. A member of the measurement team will be located at the door of the anechoic chamber for you to communicate with or to notify if you want to stop your participation at any time. The video recording will be used for data analysis which may include sharing it with university collaborators. If the video is shared with outside collaborators your face will be digitally blocked. The anechoic chamber is a large, room size facility in which the scattering of RF energy is precisely controlled. Three different measurements will be recorded: You will be seated in a chair; You will be standing on a treadmill and; You will be walking on a treadmill at whatever pace you are comfortable. Each measurement lasts 1-minute and will be repeated eight (8) times with you facing a different 45° direction each time. At the thirty (30) second mark of each measurement you will be directed to count from one (1) to ten (10). During the treadmill portion of the measurement an emergency stop button will be available to you mounted on a tripod next to the treadmill. You may use this button to stop the treadmill at any time for any reason; particularly if you become disoriented or think you may fall. You are free to stop your participation in any of the measurements at any time for any reason.

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Volunteer's Initials\_\_\_\_\_

Administrator's Initials\_\_\_\_\_

The scheduling of your participation is flexible but requires that you be available for seventeen (17) separate one (1) hour sessions over a four (4) week period. There would be either one or two sessions scheduled on any given day but every effort will be made to accommodate your availability. The specific schedule will not be known until after all volunteers have been identified. The minimum amount of time you would be required on any given day for any measurement will be a single session of 1 hour and a maximum amount of time of 2 hours for 2 sessions on a single day.

Your participation is strictly limited to the activities described above. There will be short breaks between each position measurement as the experimenters reconfigure the test set-up but there are no other breaks scheduled. You are responsible for feeding yourself as no meals will be provided. You are responsible for your own transportation to the measurement location. There is no monetary compensation for your participation to include local travel but you are free to make other arrangements with your supervisor. Wear clothing appropriate for this activity such as gym clothing. Beyond the instructions you will receive for placing the sensors on your body there are no special instructions or training required for participation. There are no questionnaires to complete, no tests or examinations beyond what has been described previously. If you have questions or doubts about what is expected of you please voice these concerns to the experimenter present that day and they will be able to help you.

### **Benefits**

You will receive no benefits from participating in the project, other than the personal satisfaction of supporting the collection of the knowledge necessary to develop future RF sensors to meet the Army's needs.

### **Risks**

Risks associated with this evaluation are minimal and include physical fatigue, muscle strains, sprains, cuts, abrasions, skin irritations, broken bones and injuries which may result from falls while on the treadmill. All injuries will be handled by the ARL/ALC Safety Team who are on call via (301) 394-6302, 6304, 6310 or 2377 and located within ten minutes of the measurement location.

There are no uncontrolled risks. All sensors will be cleaned with sanitary wipes before each use.

Members of the measurement team will be available to you throughout all measurements to assist you should a problem arise. At any time you may ask to terminate your participation and the measurements will be stopped. Care will be taken to minimize risks.

You will be exposed to RF radiation comparable to your daily environment. The IEEE standard that regulates the consumer electronic industry specifies that little or no risk is associated with radiation at the frequencies and power levels to be used in these measurements. The frequencies to be used are similar to many products such as cell phones and police radars with power levels

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similar to or less than these same products. Research to date indicates there is no evidence of a cumulative effect from exposures to these RF sources.

### **Confidentiality**

All data and information obtained about you will be considered privileged and held in confidence. Photographic or video images of you taken during this data collection will not be identified with any of your personal information (name, rank, or status). Complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or command authorities. In addition, applicable regulations note the possibility that the U.S. Army Human Research Protections Office may inspect the records.

### **Disposition of Volunteer Agreement Affidavit**

The Principal Investigator will retain the original signed Volunteer Agreement Affidavit and forward a photocopy of it to the Chair of the Human Use Committee after the data collection. The Principal Investigator will provide a copy of the signed and initialed Affidavit to you.

### **Contacts for Additional Assistance**

If you have questions concerning your rights on research-related injury, or if you have any complaints about your treatment while participating in this research, you can contact:

**Chair, Human Use Committee**  
U.S. Army Research Laboratory  
Human Research and Engineering Directorate  
Aberdeen Proving Ground, MD 21005  
(410) 278-6237 or (DSN) 298-6237

**OR Office of the Chief Counsel**  
U.S. Army Research Laboratory  
2800 Powder Mill Road  
Adelphi, MD 20783-1197  
(301) 394-1070 or (DSN) 290-1070

I do hereby volunteer to participate in the research project described in this document. I have full capacity to consent and have attained my 18th birthday. The implications of my voluntary participation, duration, and purpose of the research project, the methods and means by which it is to be conducted, and the inconveniences and hazards that may reasonably be expected have been explained to me. I have been given an opportunity to ask questions concerning this research project. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights or project related injury, I may contact the **ARL-HRED Human Use Committee Chairperson at Aberdeen Proving Ground, Maryland, USA by telephone at 410-278-6237 or DSN 298-6237**. I understand that any published data will not reveal my identity. If I choose not to participate, or later wish to withdraw from any portion of it, I may do so without penalty. I understand that military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human volunteers and that no administrative sanctions can be given me for choosing not to participate. I may at any time during the course of the project revoke my consent and withdraw without penalty or loss of benefits. However, I may be required (military volunteer) or requested (civilian volunteer) to undergo certain examinations if, in the opinion of an attending physician, such examinations are necessary for my health and well being.

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Expiration Date: 29 August 2008

Volunteer's Initials \_\_\_\_\_

Administrator's Initials \_\_\_\_\_

<i>Printed Name Of Volunteer (First, MI., Last)</i>	
<i>Social Security Number (SSN)</i>	<i>Permanent Address Of Volunteer</i>
<i>Date Of Birth (Month, Day, Year)</i>	
<i>Today's Date (Month, Day, Year)</i>	<i>Signature Of Volunteer</i>
<i>Signature Of Administrator</i>	

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**VOLUNTEER AGREEMENT AFFIDAVIT:**

ARL-HRED Local Adaptation of DA Form 5303-R. For use of this form, see AR 70-25 or AR 40-38

The proponent for this research is:	<b>U.S. Army Research Laboratory Sensors and Electronic Devices Directorate Adelphi, MD 20783-1197</b>
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Authority:	Privacy Act of 1974, 10 U.S.C. 3013, [Subject to the authority, direction, and control of the Secretary of Defense and subject to the provisions of chapter 6 of this title, the Secretary of the Army is responsible for, and has the authority necessary to conduct, all affairs of the Department of the Army, including the following functions: (4) Equipping (including research and development), 44 USC 3101 [The head of each Federal agency shall make and preserve records containing adequate and proper documentation of the organization, functions, policies, decisions, procedures, and essential transactions of the agency and designed to furnish the information necessary to protect the legal and financial rights of the Government and of persons directly affected by the agency's activities]
Principal purpose:	To document voluntary participation in the Research program.
Routine Uses:	The SSN and home address will be used for identification and locating purposes. Information derived from the project will be used for documentation, adjudication of claims, and mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies.
Disclosure:	The furnishing of your SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this data collection.

**Part A • Volunteer agreement affidavit for subjects in approved Department of Army research projects**

*Note: Volunteers are authorized medical care for any injury or disease that is the direct result of participating in this project (under the provisions of AR 40-38 and AR 70-25).*

Title of Research Project:	Radio Frequency (RF) Measurements for Human Detection, Tracking, and Identification	
Human Use Protocol Log #	ARL-20193-07001	
Principal Investigator:	Thomas J. Pizzillo Robert Tan	Phone: 301-394-3143 E-Mail: Pizzillo@arl.army.mil Phone: 410-278-4387 E-Mail: Rtan@arl.army.mil
Associate Investigator(s)	Jerry Silvious Robert Bender	Phone: 301-394-0881 E-Mail: Silvious@arl.army.mil Phone: 410-278-4319 E-Mail: Rbender@arl.army.mil
Location of Research:	Aberdeen Proving Ground (APG)	
Dates of Participation:		

Date of Human Use Review: 30 August 2007  
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Volunteer's Initials \_\_\_\_\_

Administrator's Initials \_\_\_\_\_

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**Part B • To be completed by the Principal Investigator**

Note: Instruction for elements of the informed consent provided as detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.

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**Purpose of the Research**

You are invited to participate in a study designed to investigate human radio frequency (RF) Doppler signatures at a variety of radio frequencies. The primary purpose of this investigation is to understand the underlying phenomenology associated with these signatures for the purpose of developing waveforms and algorithms to exploit the uniquely identifying aspects of the human RF signature for intelligence, surveillance, and reconnaissance applications.

This study is being conducted by the Army Research Laboratory (ARL) – Sensors and Electronic Devices Directorate (SEDD) in support of Advanced Technology Objective (ATO) with the Intelligence and Information Warfare Directorate, Communications-Electronics Research Development and Engineering Center.

**Procedures**

You will be assigned a participation number. Then you will be asked to wear three sensors: A heart rate monitor that includes a transmitter belt worn about the chest and a wrist worn computer so your heart rate may be recorded; a hands free mini-microphone worn on your head so your breathing rate and spoken words may be recorded; and a tri-axial accelerometer on the back of your pants waistband so your body movements may be recorded. Each of these sensors will be connected to a data logger worn on the side of your pants waistband where the recorded data will be transmitted wirelessly to a computer for storage and later analysis. You will be given instructions on how the sensors are to be worn, i.e. the heart rate monitor must be in contact with the skin, and then you will be asked to place these sensors on you body. A private location will be provided for this activity. If you are not able to place the sensors on your body, you will be dismissed from the study. This information along with a video recording of the measurement scene will be recorded while RF measurements of you are completed while you are rotated through 360° at a very slow rate of 1 rotation in twenty (20) Minutes on an outdoor turntable located at the Range 8 measurement facility on Aberdeen Proving Ground. A member of the measurement team will be located in the immediate vicinity of the turntable for you to communicate with or to notify if you want to stop your participation at any time. This member will be in radio contact with the turntable operator located in the measurement trailer approximately one hundred feet away.

The video recording will be used for data analysis which may include sharing it with university collaborators. If the video is shared with outside collaborators your face will be digitally blocked. Three different measurements will be recorded: You will be seated in a chair; You will be standing and; You will be walking on a treadmill at whatever pace you are comfortable. Each measurement will be repeated three (3) times and will last twenty (20) minutes. You will be asked to count from one (1) to ten (10) eight (8) times during each measurement, once each for every 45° rotation of the turntable. During the treadmill portion of the measurement an emergency stop button will be available to you mounted on a tripod next to the treadmill. You

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may use this button to stop the treadmill at any time for any reason; particularly if you become disoriented or think you may fall. You are free to stop your participation in any of the measurements at any time for any reason.

The scheduling of your participation is flexible but requires that you be available for sixteen (16) separate one and one-half (1.5) hour sessions over a four (4) week period. There would be either one or two sessions scheduled on any given day but every effort will be made to accommodate your availability. The specific schedule will not be known until after all volunteers have been identified. The minimum amount of time you would be required on any given day for any measurement will be a single session of 1.5 hours and a maximum amount of time of 3 hours for 2 sessions on a single day.

Your participation is strictly limited to the activities described above. There will be short breaks between each position measurement as the experimenters reconfigure the test set-up but there are no other breaks scheduled. You are responsible for feeding yourself as no meals will be provided. You are responsible for your own transportation to the measurement location. There is no monetary compensation for your participation to include local travel but you are free to make other arrangements with your supervisor. Wear clothing appropriate for this activity such as gym clothing. Beyond the instructions you will receive for placing the sensors on your body there are no special instructions or training required for participation. There are no questionnaires to complete, no tests or examinations beyond what has been described previously. If you have questions or doubts about what is expected of you please voice these concerns to the experimenter present that day and they will be able to help you.

### **Benefits**

You will receive no benefits from participating in the project, other than the personal satisfaction of supporting the collection of the knowledge necessary to develop future RF sensors to meet the Army's needs.

### **Risks**

Risks associated with this evaluation are minimal. Weather related injuries are considered the leading risks and will depend on the time of year you are scheduled to participate. During the summer months heat stress, dehydration and sunburn are the potential risks. You will be encouraged to use sunscreen, which will be available at the measurement site. During the winter months measurements will not be scheduled if the outside temperature is below 50° F to minimize the use of heavy jackets or other cold weather protection clothing. Other risks include physical fatigue, muscle strains, sprains, cuts, abrasions, skin irritations, broken bones and injuries which may result from falls while on the treadmill. All injuries will be handled by emergency medical service personnel who will be on call approximately fifteen minutes away. You are advised that there are wild animals, snakes, and poisonous insects in the vicinity of the measurement site and to take appropriate precautions. There is risk of tick bites and the potential for Lyme disease at Aberdeen Proving Ground. Literature in the form of a handout will be provided to you with information about Lyme's disease. You will be encouraged to use insect

repellent, which will be available at the measurement site, and we will ask you to inspect yourself frequently for ticks.

There are no uncontrolled risks. All sensors will be cleaned with sanitary wipes before each use.

You will be exposed to RF radiation comparable to your daily environment. The IEEE standard that regulates the consumer electronic industry specifies that little or no risk is associated with radiation at the frequencies and power levels to be used in these measurements. The frequencies to be used are similar to many products such as cell phones and police radars with power levels similar to or less than these same products. Research to date indicates there is no evidence of a cumulative effect from exposures to these RF sources.

Members of the measurement team will be available to you throughout all measurements to assist you should a problem arise. At any time you may ask to terminate your participation and the measurements will be stopped. Care will be taken to minimize risks. During the summer, activities will be in accordance with the wet bulb global temperature (WBGT) warning system, derived from TBMED-507, posted on the APG website. Water will be available at all times. In addition, activities will be suspended during any weather conditions that are inherently dangerous. If it is raining or if there is an accumulation of water on the ground, measurements will be suspended if conditions are thought to be unsafe.

### **Confidentiality**

All data and information obtained about you will be considered privileged and held in confidence. Photographic or video images of you taken during this data collection will not be identified with any of your personal information (name, rank, or status). Complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or command authorities. In addition, applicable regulations note the possibility that the U.S. Army Human Research Protections Office may inspect the records.

### **Disposition of Volunteer Agreement Affidavit**

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Volunteer's Initials\_\_\_\_\_

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## Contacts for Additional Assistance

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**Chair, Human Use Committee**  
**U.S. Army Research Laboratory**  
**Human Research and Engineering Directorate**  
**Aberdeen Proving Ground, MD 21005**  
**(410) 278-6237 or (DSN) 298-6237**

**OR Office of the Chief Counsel**  
**U.S. Army Research Laboratory**  
**2800 Powder Mill Road**  
**Adelphi, MD 20783-1197**  
**(301) 394-1070 or (DSN) 290-1070**

I do hereby volunteer to participate in the research project described in this document. I have full capacity to consent and have attained my 18th birthday. The implications of my voluntary participation, duration, and purpose of the research project, the methods and means by which it is to be conducted, and the inconveniences and hazards that may reasonably be expected have been explained to me. I have been given an opportunity to ask questions concerning this research project. Any such questions were answered to my full and complete satisfaction. Should any further questions arise concerning my rights or project related injury, I may contact the **ARL-HRED Human Use Committee Chairperson at Aberdeen Proving Ground, Maryland, USA by telephone at 410-278-6237 or DSN 298-6237**. I understand that any published data will not reveal my identity. If I choose not to participate, or later wish to withdraw from any portion of it, I may do so without penalty. I understand that military personnel are not subject to punishment under the Uniform Code of Military Justice for choosing not to take part as human volunteers and that no administrative sanctions can be given me for choosing not to participate. I may at any time during the course of the project revoke my consent and withdraw without penalty or loss of benefits. However, I may be required (military volunteer) or requested (civilian volunteer) to undergo certain examinations if, in the opinion of an attending physician, such examinations are necessary for my health and well being.

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Expiration Date: 29 August 2008

Volunteer's Initials\_\_\_\_\_

Administrator's Initials\_\_\_\_\_

<i>Printed Name Of Volunteer (First, MI., Last)</i>	
<i>Social Security Number (SSN)</i>	<i>Permanent Address Of Volunteer</i>
<i>Date Of Birth (Month, Day, Year)</i>	
<i>Today's Date (Month, Day, Year)</i>	<i>Signature Of Volunteer</i>
<i>Signature Of Administrator</i>	

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## **Appendix B. Volunteer Solicitation Advertisement**

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**Volunteers are needed from within the Army Research Laboratory.** Male or female volunteers over the age of eighteen (18) with no physical or medical disabilities that prevent walking at a casual pace on a treadmill that has a weight limit of 350 pounds and who do not require the use of any medical electronics e.g. a pacemaker are being sought for participation in a study being conducted by the Sensors and Electronic Devices Directorate. You are invited to participate in a study designed to study the interaction of radio frequency (RF) energy with humans. The RF fields are the same as those present in our daily environment every day and at levels less than most consumer electronics such as cell phones, cordless phones, and other wireless transmitters. This investigation is being conducted under the supervision of the Human Research and Engineering Division (HRED) Human use Committee. The primary purpose of this investigation is to develop technology for intelligence, surveillance, and reconnaissance applications. Participants from both ALC and APG sites are needed. You must have the approval of your supervisor to participate. You will receive no benefits from participating in this project, other than the personal satisfaction of supporting the development of the knowledge necessary to develop future RF sensors to meet the Army's needs. To volunteer or to get more detailed information please contact Mr. Thomas Pizzillo, [pizzillo@arl.army.mil](mailto:pizzillo@arl.army.mil), 301-394-3143 or Mr. Bob Tan, [rtan@arl.army.mil](mailto:rtan@arl.army.mil), 410-278-4387.

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