U.S. Department of Homeland Security
Washington, DC 20528

Homeland Security

August 15, 2011

Ginger McCall
EPIC
1718 Connecticut Avenue N.W.
Washington, D.C. 20009

Re: **DHS/OS/PRIV 11-0214, S&T 10-0003.55**

Dear Ms. McCall:

This is an amended final response to your Freedom of Information Act (FOIA) request to the Department of Homeland Security (DHS), dated November 24, 2010, and received by this office on December 14, 2010. You were seeking documents concerning the development and deployment of body scanner (or Whole Body Imaging, Advanced Imaging Technology, Millimeter Wave or Backscatter) technology by law enforcement agencies in surface transit and in street roaming vans. You specifically requested all contracts, proposals, and communications with the manufacturers of the "Z Backscatter Vans" or similar technology. We sent you a response letter dated February 12, 2011, however after further reviews we have determined that some documents that were originally withheld will be released to you. These documents include deliverables related to the contract and communications with the manufacturers of the "Z Backscatter Vans" or similar technology.

After further reviews of the DHS Science and Technology Directorate (S&T) Explosives Division's responsive records, I have determined that 151 pages of the records are releasable in their entirety, and 21 pages are partially releasable, pursuant to Title 5 U.S.C. § 552 FOIA Exemption (b)(6). Please note that enclosure three was previously mailed to you with financial information withheld, however, the enclosed document now includes that financial information.

Enclosed are 172 pages with certain information withheld as described below.

FOIA Exemption 6 exempts from disclosure personnel or medical files and similar files the release of which would cause a clearly unwarranted invasion of personal privacy. This requires a balancing of the public's right to disclosure against the individual's right privacy. The types of documents and/or information that we have withheld consist of telephone numbers, signatures, and email addresses. The privacy interests of the individuals in the records you have requested outweigh any minimal public interest in disclosure of the information. Any private interest you may have in that information does not factor into the aforementioned balancing test.

Provisions of the FOIA allow us to recover part of the cost of complying with your request. 6 CFR § 5.11. In this instance you will not be charged. If you need to contact our office again about this matter, please refer to **DHS/OS/PRIV 11-0214, S&T 10-0003.55**.

Sincerely,

Marshall Caggiano
Attorney/Advisor
Science and Technology Directorate

Enclosures:
1) BomDetec, Phase IA Report, October 31, 2008
2) Northeastern UniversityBomDetec Technical Concept Paper
3) Notice to Proceed, Contract and Statement of Work
4) Kickoff Meeting Slides for BomDetec, August 16, 2006

Experimental Results for Limited Wide Aperture Multi-Monostatic Millimeter-Wave Radar for Standoff Concealed Explosives Detection.

BomDetec, Phase IA Report

Carey M. Rappaport, José Ángel Martinez-Lorenzo, Justin Fernandes
Gordon-CenSSIS
Northeastern University
Boston, MA 02115
[redacted]

October 31, 2008

1 State of the art in standoff suicide bomber detection

In the increasingly important problem of identifying suicide bombers wearing explosives concealed under clothing, it is essential to detect suspicious individuals at a distance. Systems are being developed which employ multiple sensors to determine the presence of explosives on people, including observing and following individuals, identifying explosive residues or heat signatures on the outer surface of their clothing, or by characterizing explosives using penetrating X-rays or terahertz wave radar. At present, radar is the only modality that can penetrate and sense beneath clothing at a distance of 10 to 50 meters without causing physical harm. Unfortunately, current radar systems require impractically large synthetic apertures to effectively distinguish people wearing concealed body-worn improvised explosive devices from innocent individuals.

Initial millimeter-wave studies at 50 m have shown that with sufficient bandwidth and view angles, it is possible to create highly-resolved images of body shape with concealed weapons and other recognizable items clearly visible. However, when the view is restricted to that available with a single stationary antenna that could readily fit on top of a truck or van, 10 m standoff detection is much more difficult. Experiments with 77 GHz Frequency Modulated Continuous Wave (FMCW) radar, developed for commercial applications including automobile collision avoidance systems, indicate that simple threshold detection fails to distinguish metal pipes on skin from skin alone. Analysis has indicated that this is due to the extremely complex nature of scattering and interference from the electrically large contours of a human body at mm-wave

frequencies when the precise shape of the body is unknown. While lowering the frequency would reduce the scattering complexity, a larger antenna would be required, and the system would be less able to resolve small-scale differences in body contours due to foreign objects.

The objective of this research project was the development and evaluation of an inexpensive, high resolution, radar that can distinguish foreign objects hidden on individuals at a distance, and still fits in or on a van, as shown in Fig. 1. The radar would be developed by using new cutting-edge technology to provide a revolutionary improvement in the field of standoff detection. A successful radar design will be facilitated by our previous field experience as well as by new basic research to be performed in the field of numerical modeling and novel signal processing algorithms. Northeastern University partnered with Forschungsgesellschaft für Angewandte Naturwissenschaften (FGAN-FHR) in Wachtberg, Germany to model, design, develop, experimentally test and validate such a radar system. We combined the extensive detection and identification experience of Northeastern University's Gordon Center for Subsurface Sensing and Imaging Systems (CenSSIS) and our expertise in suicide bomber detection gained from working on the DHS-funded Awareness and Localization of Explosive Related Threats (ALERT) Center of Excellence and BomDetec programs, with the hardware and experimentation expertise of FGAN-FHR to create a powerful collaboration that will enhance security in both countries.

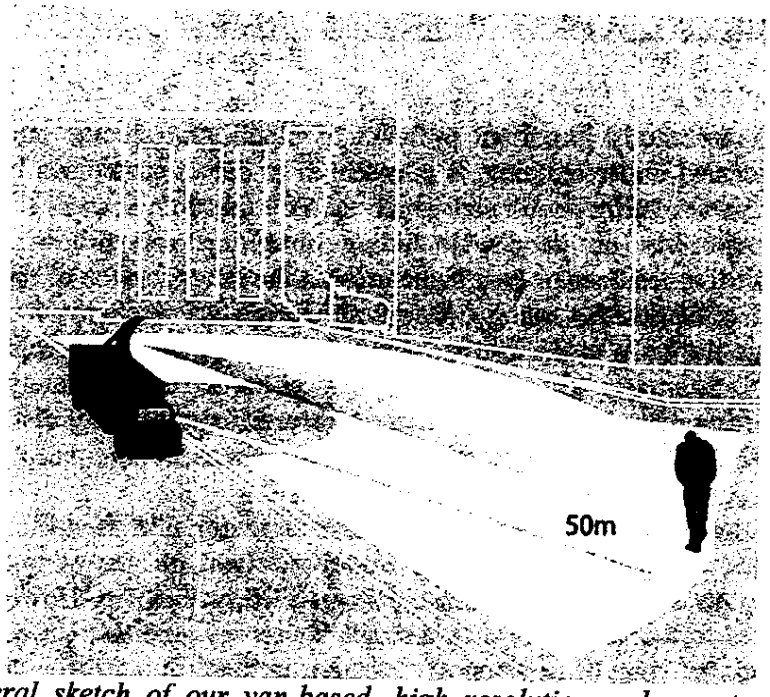


Fig 1 – General sketch of our van-based, high resolution radar system for standoff detection of potential suicide bombers.

2 General Detection Approach

The main objective of the radar system is to detect *irregular contours* on the surface of a human body [1]. If these irregularities can be identified on individuals with no externally visible objects – such as bags, books, or straps – the individual has an increased likelihood of being a suicide bomber. For narrowband radar, detection of metal objects or irregularity is not possible at standoff distances. This is due to the uncertainty inherent in summing up all scattered field contributions from every reflective element illuminated by the antenna beam [2]. Since the field scattered by metal is of the same order of magnitude as that of skin above 60 GHz, it is not possible to distinguish an innocent person from a terrorist using reflected intensity alone.

Instead, we propose a new concept to detect hidden threat objects -- such as metal pipes -- under clothing. In this new method, we attempt to detect abrupt changes in the shape of a person's skin surface, instead of analyzing the changes of a reflectivity function as proposed in [3]. The idea of detecting irregular contours requires scanning a small illuminating spot across the body surface. This spot must be tight enough to focus on object edges one at a time, and thus should be comparable to the size of the target irregularities. The beamwidth required for such an illuminating spot is inversely proportional to the electrical size of the radar antenna. For this particular application, an antenna producing a 5 cm wide spot at fifty meters would require a 1000 wavelength aperture. The only cost effective antenna of this size is created by using an array of reflectors [4]. Fig. 2 presents the farfield pattern produced by an array of thirteen elements each comprising a 75 wavelength wide reflector, with a beamwidth of about BW=0.05 deg. The vertical dashed lines show the angular projection of an averaged human chest at 50m superimposed over the antenna pattern. This antenna illuminates only a small portion of the human chest, and as a result, the electromagnetic scattering of this area can be processed separately from other illuminated areas. The farfield pattern of the reflector array is the combination of the array pattern and the reflector pattern. Grating lobes, with intensity -14 dB below peak at ±0.75 deg, result from constructive interference of the finite number of discrete array elements. These grating lobes are of reduced intensity due to each element having a 75 λ reflector pattern taper to nulls at about 1.5 deg. It is critical to design a system where these grating lobes fall outside of the angular projection of the human body at the selected range.

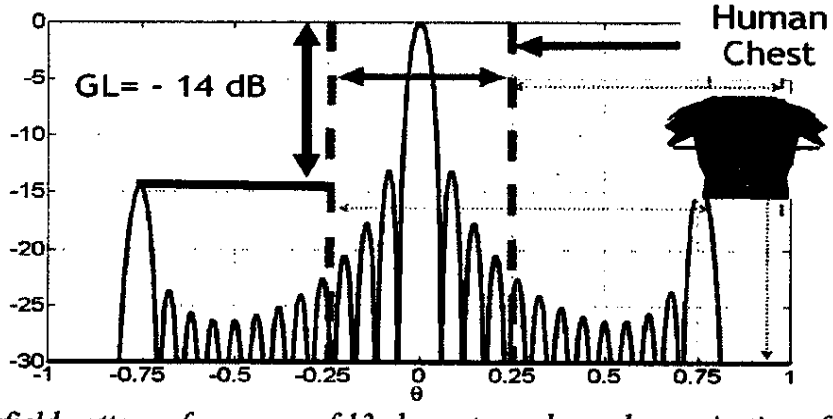


Fig 2 – Farfield pattern of an array of 13 elements, and angular projection of a human body at 50 meters (between vertical dashed lines).

A big aperture creating a narrow static beam which illuminates a reduced area of the angular projection of the human chest is not sufficient to determine irregular shape variations of the chest. To achieve this goal, the radar must be able to steer the beam across an individual's torso. In addition, beam zooming over multiple ranges of target distance would provide great general purpose flexibility [5, 6]. Using beam steering, different areas of an individual's torso can be illuminated and independently examined by the radar. This concept has been studied using a two-dimensional Finite Difference Frequency Domain (2D-FDFD) numerical code, where a cross section of a human body has been used as a reference model (Fig. 3a) to simulate the electromagnetic response of a person with and without metal pipes attached to his chest (Fig. 3b, 3c). Figs. 4 and 5 present the 77 GHz scattered field when the array forms a beam at two different chest positions. It is possible to see how the illuminated area is different for each scanning case, and that the farfield produced by a body with metal pipes is substantially different from that of a body without those pipes. The electromagnetic scattering of regular body shape produces a continuous response – in terms of phase variations – for adjacent and continuous illuminated areas, while it has an abrupt response for irregular body shapes.

Fig. 6 compares received signals from bodies with and without pipes as a function of the scanning position across each subject. The received signal is found by matching the antenna beam – for the receiving mode - to the area of the body under test. For the body without pipes, the magnitude of the received signal has a maximum when the transmitting and receiving beams scan to a point producing a specular reflection. The maximum received signal decays slowly compared to the body with pipes. The received phase variation is another important characteristic, varying more rapidly with position across the torso with pipes than without. The phase appears to change slope, often dramatically at every pipe position.

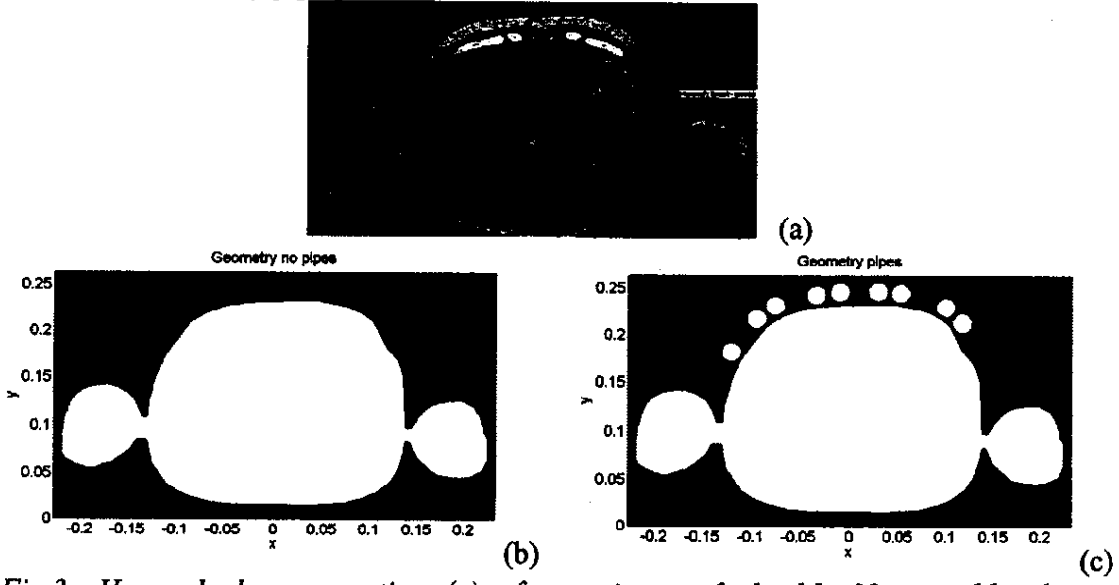


Fig 3 – Human body cross section: (a) reference image of a healthy 39-year-old male which was frozen and sliced every 1mm for the Visible Human Project [7]; (b) simulated geometry with no pipes; and (c) simulated geometry with pipes. The colors indicate material index for each pixel, either air (red), skin (black), and, since waves penetrates only 1 mm in skin, metal (white) for the interior of the body.

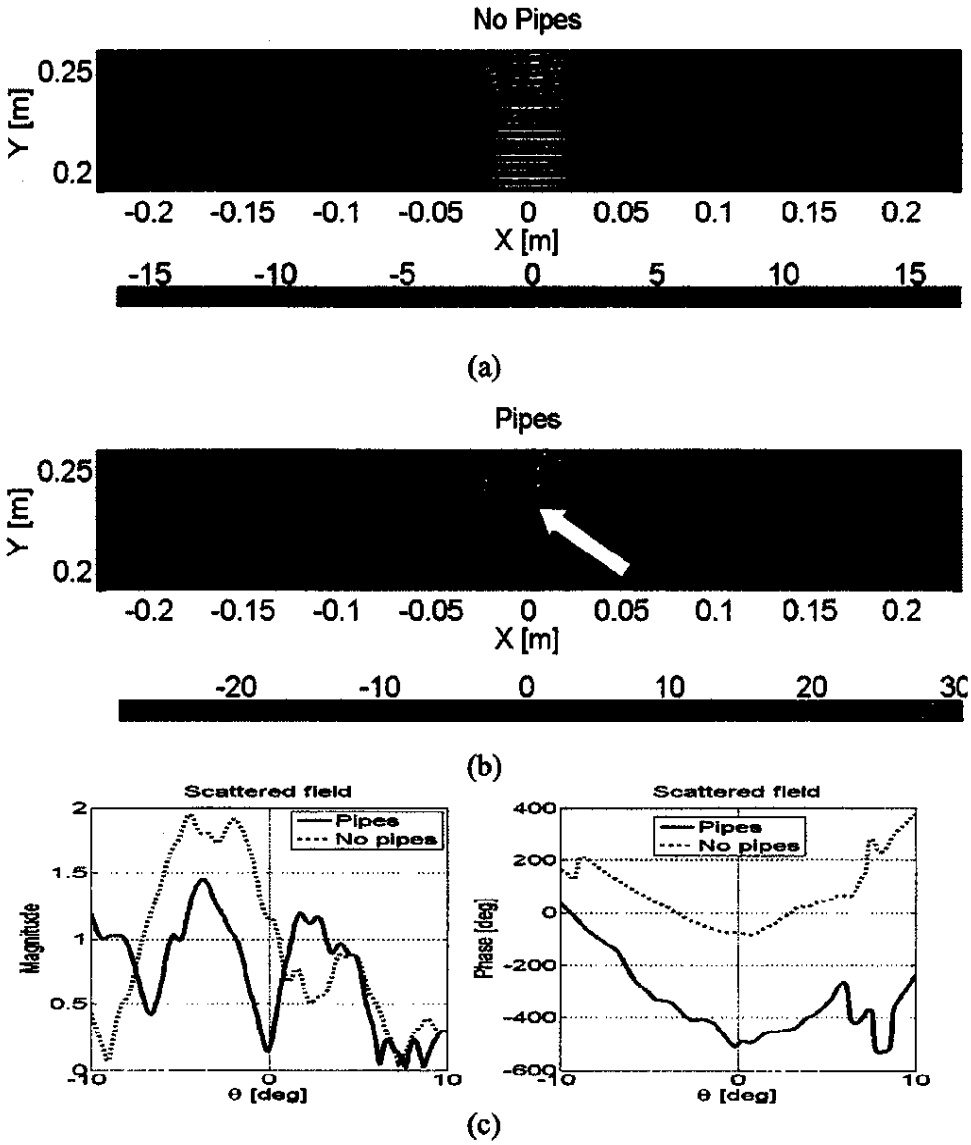
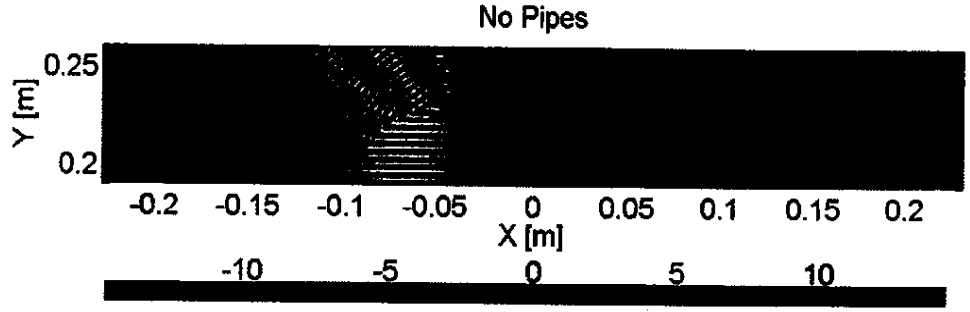
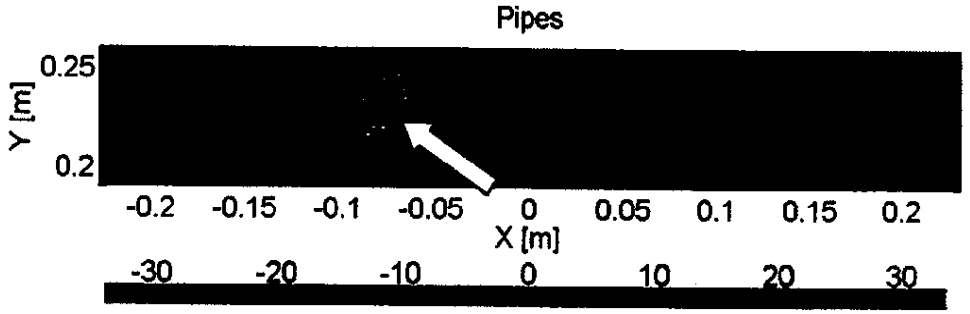


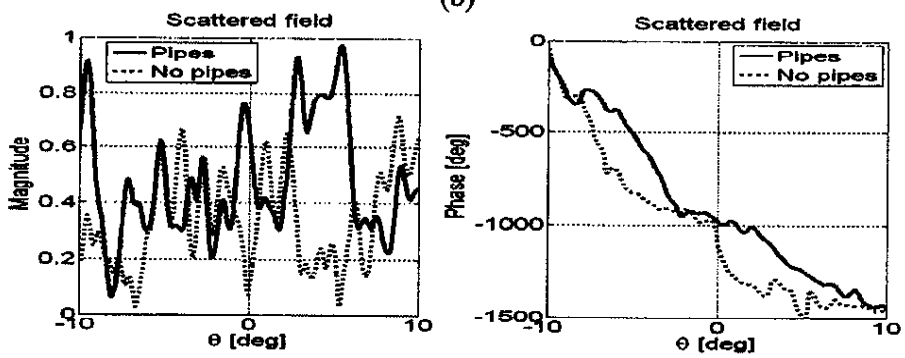
Fig 4 – Scattered 77 GHz field for a beam formed at x = 0 m on the body target geometry of Fig.3: (a) near-field real part for the no pipe case of Fig. 3b; (b) near-field real part for the pipes case of Fig. 3c showing the illumination of just a single pipe (indicated by arrow); (c) far-field comparison between pipes and no pipes cases for a tight single beam.



(a)



(b)



(c)

Fig 5 – Scattered 77 GHz field for a beam formed at $x = -0.07$ m: (a) near-field real part for the no pipe case of Fig. 3b; (b) near-field real part for the pipes case of Fig. 3c showing the illumination of just a single pipe (indicated by arrow); (c) far-field comparison between pipes and no pipes cases for a tight single beam.

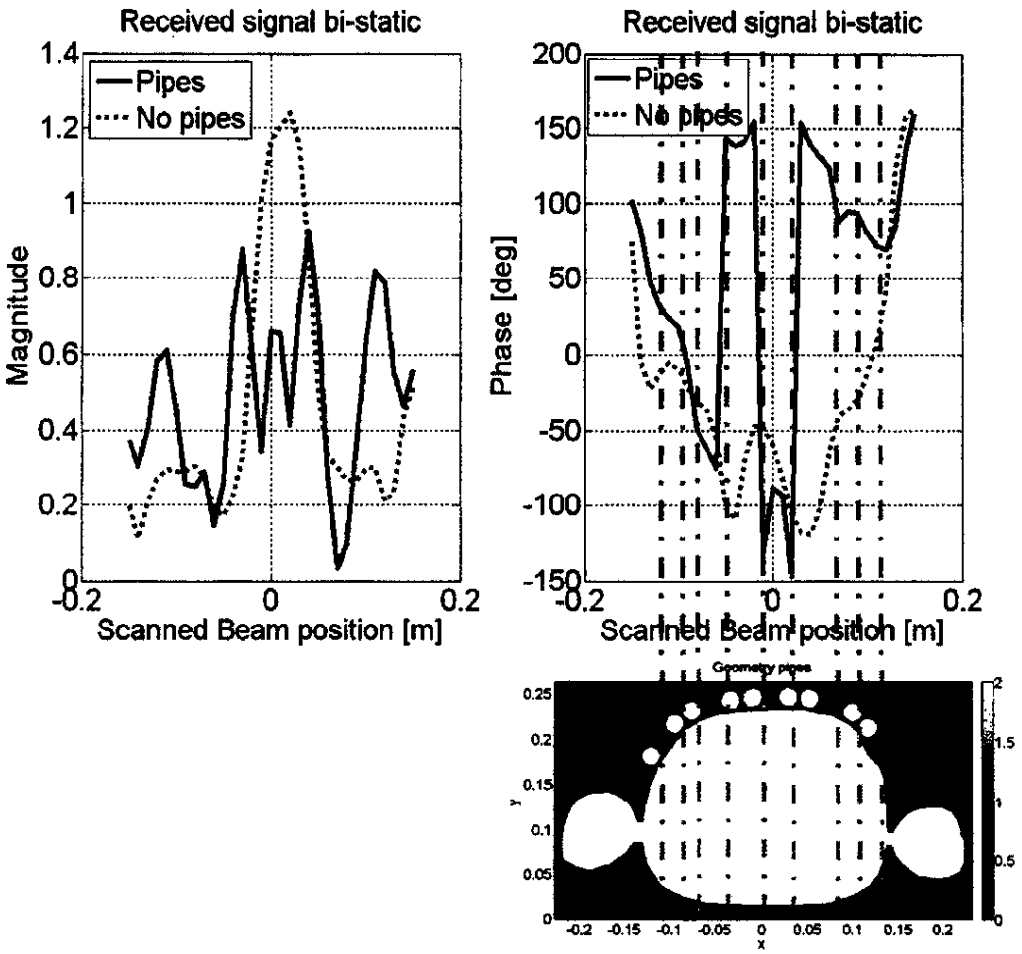


Fig 6 – Received signal magnitude and phase for beams formed at 31 different equally-spaced positions (as a function of position) starting at x= −0.15 m and ending at x = 0.15 m for pipe and no pipe cases. All positions are beam-matched in reception.

After the failure to detect potential suicide bombers using the 77GHz millimeter wave radar system (designed in 1997 by Raytheon for a vehicle collision avoidance system) using feature estimation algorithms created by Personnel Protection Technologies (PPT), researchers at Northeastern University developed a new set of signal processing algorithms – able to detect "lumpiness" or unusual or manmade features on the surface of the skin – and pursued radar systems better suited to distinguish abrupt changes in body surface morphology. The new signal processing techniques require a Multi-Transmitter-Multi-Receiver (MTMR) radar configuration, but no such technology is currently available off the shelf.

The monostatic FMCW radar system developed by FhG-IAF [8], and successfully used for imaging applications by FGAN-FHR, is the best existing technology which balances performance and cost for the eventual MTMR application. A set of measurements were performed jointly by NEU and FGAN-FHR researcher at the FGAN-

FHR experimental facility in Wachburg, Germany during the last two weeks of August 2008 and the information provided by this FMCW radar was processed using traditional Inverse Synthetic Aperture Radar (ISAR) signal processing techniques to create 2D images of persons with and without metal pipes strapped to their chests. Successful discrimination between the two types of targets was achieved at a range of 10 meters using the simple monostatic configuration. In order to increase the range and operate under limited field of view available with a van-mounted configuration, an improved radar system operating in a MTMR configuration would be required for the next phase in this research effort.

3 Frequency Domain Modeling Techniques

3.1 Introduction

The development of new models and further optimization of existing numerical codes is an essential component of this research project. Fast computational routines are effective design tools and will be able to predict the viability of the new MTMR system, by fully characterizing the electromagnetic behavior of the radiating system, as well as by simulating the potential suicide bomber response.

Gordon-CenSSIS has extensive experience in modeling complex electromagnetic problems. For this particular case, high frequency techniques – like Physical Optics (PO), Physical Theory of Diffraction (PTD) [9, 10], Geometrical Optics (GO) or Uniform Theory of Diffraction (UTD) [11] - are not ideal tools since none take into account the mutual coupling and existing interactions between the potential suicide bomber and the explosives structures he might be wearing. Full-wave analysis techniques must be used to be able to precisely characterize the interaction between electromagnetic waves and complex geometries. Surface Integral-Equations (IE) solved by the Method of Moments (MoM) [12] technique are also not suitable for this application, since each object in the geometry must be modeled as a surface integral equation coupled in matrix form to all the other objects of the geometry. A realistic suicide bomber with multiple pipe scatterers is thus too complicated a target for IE-MoM. Moreover, surface integral-equations do not take into account the inhomogeneities associated with the human body and it is therefore almost impossible to determine the associated Green's functions which are required to compute the moment of each element in the geometry. We have chosen instead to use the full-wave Finite Difference Frequency Domain (FDFD) method [13], which overcomes all the problems presented by IE-MoM method. FDFD discretizes Maxwell's equations in the frequency domain across the entire computational space, and then solves the resulting simultaneous equations for every pixel in the space. The farfield response is then determined by applying the Kirchhoff diffraction formula to the electric and magnetic currents on the surfaces of the box surrounding the computational space.

3.2 Developed modeling techniques for security applications

Research efforts developed by Gordon-CenSSIS under the HSARPA contract 'Prototypes and Technologies for Improvised Explosive Device Detection' used a 2D-FDFD code and digital signal processing techniques for modeling realistic geometries [13]. The 2D-FDFD numerical code was successfully applied to demonstrate that it is possible to detect concealed explosives when using a transmitting antenna with an electrically large aperture with strong focusing capabilities [2]. Refining these simulations with 3D-FDFD numerical algorithms should lead to clear improvements in the modeling of realistic antennas and targets. Gordon-CenSSIS researchers have developed a 3D-FDFD numerical code running on a 64-node computational cluster, but to be able to fully analyze a 3D geometry of on the order of 300x200x100 wavelengths (which would require solving 6 billion simultaneous equations)- is still beyond reach of current computer technology. As a result, 2.5D simulations seem to be a suitable compromise between accuracy and computational cost. Although the 2D-FDFD code produced suitable preliminary results for 2D configurations, refinement of antenna and target shapes will require development of enhanced 2.5D codes to accurately simulate the scattering of realistic 3D bodies.

4 Signal processing techniques

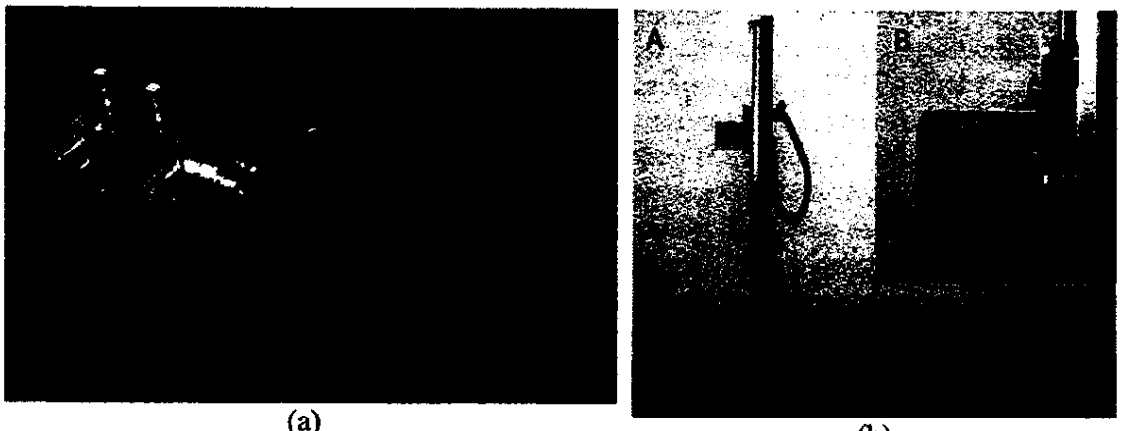
4.1 Introduction

Gordon-CenSSIS and FGAN-FHR are two of the best recognized institutions for applying signal processing techniques to sensing and imaging problems. The processing algorithms applied in each physical problem depend on the type of information that needs to be extracted from physical measurements or synthetic data generation. For imaging problems - where the main objective is the reconstruction of the spatial distribution of chosen physical properties - the number of required measurements is large. However, for sensing problems – where the main objective is estimating the presence or absence of an object – or feature estimation problems – where the main objective is describing certain features of the objects or the media – the amount of information required is reduced drastically.

It is of vital importance to find the minimum amount of information which is required for the practical case of detecting a potential suicide bomber; this minimum amount of information would depend on a specific concept of operation (CONOPS)

FGAN-FHR has successfully developed many radar-based experimental systems, able to perform imaging by using traditional Synthetic Aperture Radar (SAR) techniques [15-17] for security applications for different kinds of CONOPS. One of those systems was developed for detecting and imaging concealed weapons and other objects underneath human clothes. Another system was developed for luggage scanning and imaging. Both systems used the FMCW radar, which was mounted upon a linear drive to realize the required synthetic aperture length. For human inspection, the drive was

mounted in a portal illuminating the person standing motionless for about one second in this archway. Fig. 7a is a photograph of the 94 GHz wideband mm-wave integrated circuit (MMIC) radar module, and Fig. 7b presents the radar attached to an x-y positioning system used for luggage and human scanning. Figure 8 shows excellent concealed object imaging results achieved with this portal system.



(a) (b)

Fig 7 – 94 GHz FMCW radar module developed at the Franhofer Institute, and analyzed, characterized, and built into security applications by FGAN-FHR, and (b) Translation positioner for synthetic aperture radar, showing detail monostatic module in inset

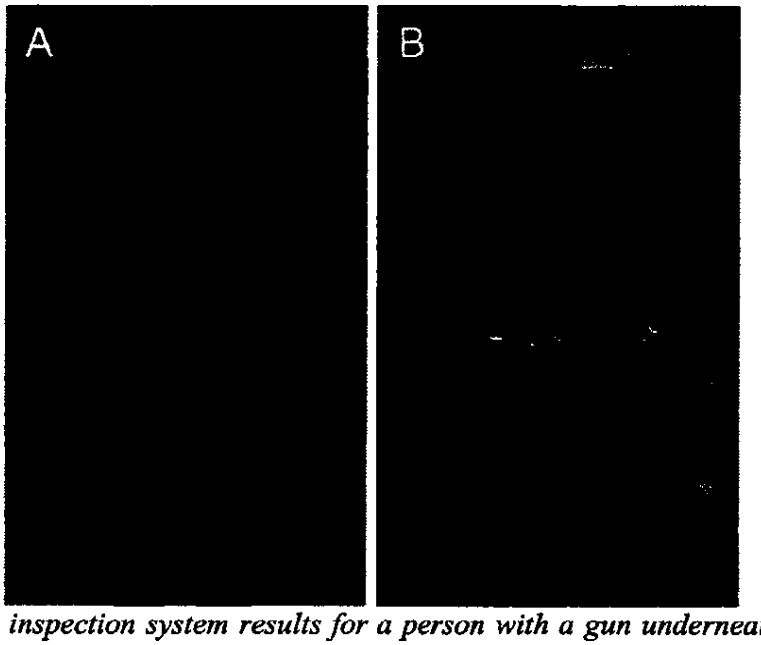
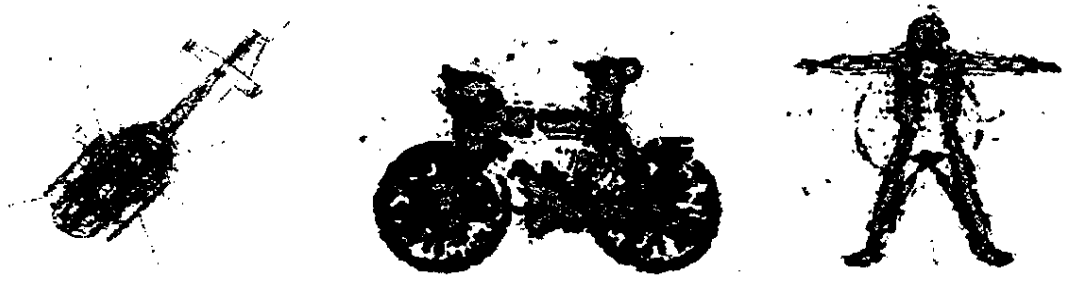


Fig 8 –Human inspection system results for a person with a gun underneath his clothes (left) and for a person wearing an explosive belt (right).

The previous systems both used SAR configurations, where the target was static and the radar moving so as to capture multiple views of the target. ISAR (Inverse-SAR) is another possible configuration, where the radar is static and the target in motion. Fig. 9

shows some examples of high resolution ISAR images measured at 94 GHz with the FhG-IAF FMCW radar system. These images provide good insight into the capabilities of radar-based sensor systems. In all images in Fig 9, the system was pointing to a target located on a rotating turntable, and measurements were collected over 360°.



(a) (b) (c)

Fig. 9 – 220 GHz, 50 m, 360 deg. ISAR measurements in tower/turntable configuration for (a) helicopter, (b) bicycle, (c) person.

4.2 Previously developed ISAR signal processing for standoff detection at 15 meters

In our particular case, the CONOPS requires millimeter wave radar for standoff detection of potential suicide bombers with a limited field of view. Experiments was performed in FGAN-FHR at range of 13 meters (Fig. 10), to determine the feasibility of detecting explosive simulants with a limited effective aperture, using only a small subset of possible ISAR view angles are used to generate the image. We chose a 2.7 deg. total field of view, corresponding to a 60 cm wide synthetic aperture at 13 m, or 2.35 m aperture at 50 m range.

(a) (b) (c)

Fig. 10 – ISAR imaging configuration: radar module with offset reflector (a) front view and (b) side view; and (c) measurements performed on a turntable on a manikin model.

Vertical/vertical (VV) polarization measurements were taken across a 4.8 GHz bandwidth, centered at 99 GHz, using a 150 Hz PRF, while a target person was rotated on the FGAN-FHR turntable at 3 degrees per second. Several initial body orientations were chosen. The data was processed using standard ISAR backprojection techniques described as follows.

FMCW radar is different from normal chirp radar, in that it is constantly producing a sawtooth type frequency ramp. For the purpose of explaining how one obtains range information from a FMCW radar we will focus on one frequency ramp, shown below.

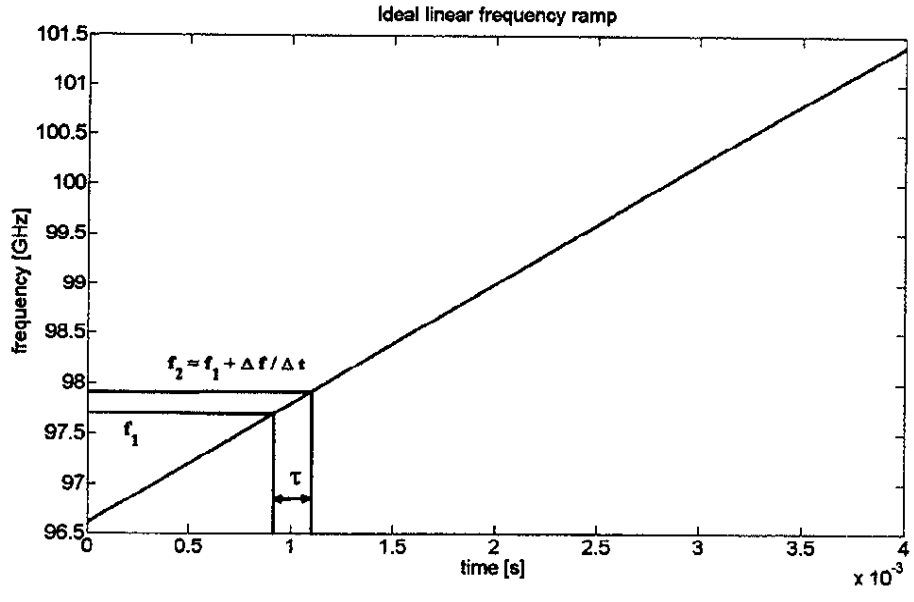


Fig. 11 – Ideal linear frequency ramp of FMCW radar local oscillator.

The radar transmits a continuous signal of frequencies from 96.6 GHz to 101.4 GHz during a modulation period of 4 ms. We will refer to the first instantaneous transmitted frequency as f_{t1}.

$$s_{f_1} = Ae^{j(2\pi f_{t_1} t + \varphi_{a_1})}$$

The signal is reflected from scatterers within the beam of the transmitting antenna. The reflected signal is received τ seconds later after completing a round trip, and can be written as:

$$s_r = \Gamma Ae^{j(2\pi f_{t_1}(t+\tau) + \varphi_{a_1})}$$

where Γ is the target reflection coefficient, defined as:

$$\Gamma = |\Gamma| e^{\varphi_\Gamma}$$

and,

$$s_r = |\Gamma| Ae^{j(2\pi f_{t_1}(t+\tau) + \varphi_{a_1} + \varphi_\Gamma)}$$

Meanwhile, τ seconds later, the local oscillator is generating a new signal defined as:

$$s_{t_2} = Ae^{j(2\pi(t+\tau)(f_{t_1}+\alpha\tau)+\varphi_{\varepsilon_2})}$$

where s_{t_2}, $\alpha = \frac{df}{dt}$ = frequency sweep rate, and ϕ_{ε_2} is the phase error generated by the voltage controlled oscillator (VCO).

The instantaneous transmitting and received signals are mixed internally within the radar via a coupler. The result is a intermediate frequency (IF), which can also be referred to as a beat frequency.

$$IF = s_r s_{t_2}$$

After mixing the instantaneous transmitting signal with the received signal, the IF is passed through a low pass anti-aliasing filter with cutoff frequency corresponding to the maximum sample rate of the data acquisition system. Below is the signal that is sampled by the data acquisition system:

$$IF = \frac{A^2}{2}|\Gamma| e^{j\left[2\pi(t+\tau)(f_{t_0}+\alpha\tau-f_{t_0})+\varphi_{\varepsilon 2}-(\varphi_{t_1}+\varphi_T)\right]}$$

$$IF = \frac{A^2}{2}|\Gamma| e^{j[2\pi t\alpha\tau+\varphi_{\Gamma}+\Delta\varphi]}$$

where $\Delta\varphi$ is the the accumulated phase error of the radar.

The data acquisition used for this experiment was sampling at 500 KHz. The Nyquist sampling rate limits frequencies to less than 250 KHz. The range limit of the system can then be defined as follows,

$$max(IF) = 250\text{kHz}$$

The experimental frequency sweep rate of the FMCW VCO is:

$$\alpha = \frac{4.8\text{GHz}}{4\text{ms}}$$

based upon the frequency sweep rate α and the maximum sample rate, the maximum measureable distance can be defined as:

$$max(d) = \frac{max(IF)}{\alpha}c = 62.5[\text{m}]$$

where d = distance to target [m] and c is the speed of light in free space. In practice the radar phase errors lead to incoherence, which limits the effective range to 13m. Figure 12 show the full sampled IF signal.

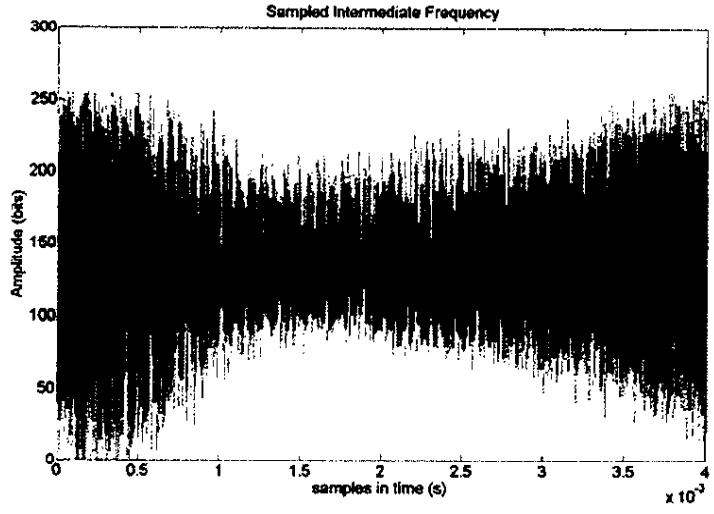


Fig. 12 – Example of a sampled IF signal produced by mixing and filtering the instantaneous transmitting and receiving signals.

Once the data is acquired, an image can be created via a limited view inverse synthetic aperture (ISAR) technique. The first step in the ISAR processing is to take a Fourier transform over each of the sampled IF response.

$$R = \int_{-\infty}^{\infty} IFe^{-j\omega t}dt$$

Each frequency represented in R maps to a specific τ, according to Figure 11, which in turn corresponds to a specific distance to the target. Therefore, Fourier transformation of the sampled time domain IF signal results in a spatial frequency domain signal. Figure 13 plots one range profile.

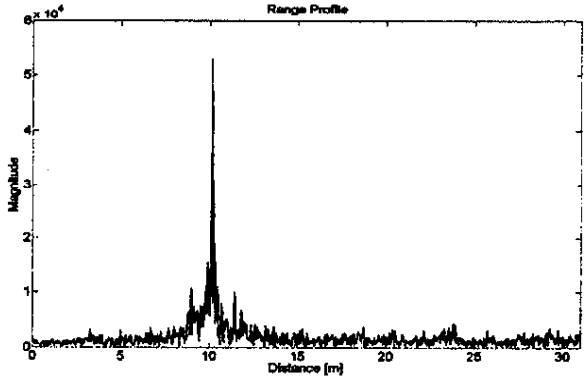


Fig. 13 – Example of a range profile produced via taking the Fourier transform of the IF signal of Figure 12.

After performing the Fourier transform on the sampled IF signals, a matrix containing 18000 range profiles one for each azimuth angle is obtained, as shown in Figure 14.

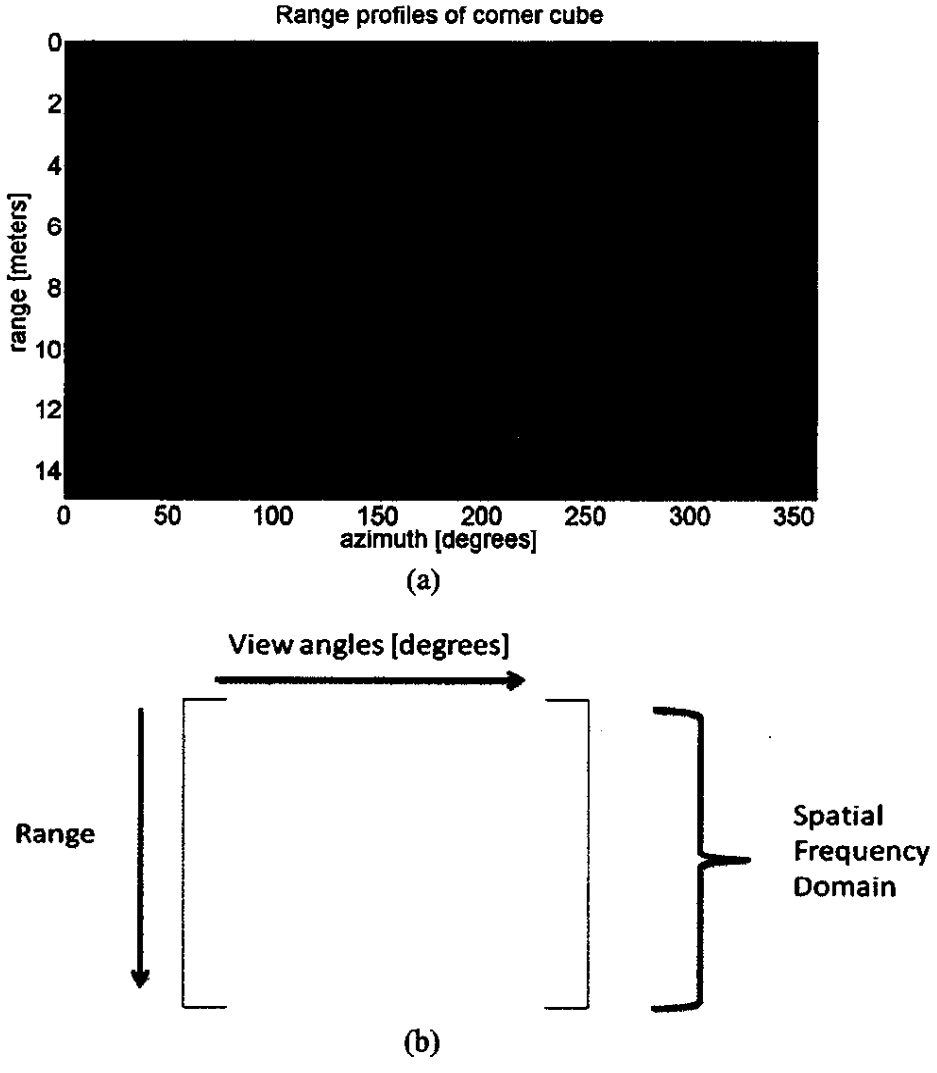


Fig. 14 – (a) sample matrix of 18000 range profiles obtained from a corner cube rotating on the target platform.; (b) Graphical representation of spatial frequency domain matrix

Once all of the range profiles are obtained, the data is transformed from the view angle space to image space by performing a Fourier transform in the second azimuth dimension over a finite set of range profiles. However, care must be taken in how this FFT is performed. To obtain an accurate image of the target scatterers, the range and cross-range resolutions must be comparable. The maximum resolution is limited by the system's processed bandwidth and the center frequency of the system.

$$BW = 4.8 \text{ GHz}$$

The range and cross-range resolutions are defined as:

$$\Delta Y = \frac{c}{2BW} = 3.13\,\text{cm}.$$

$$\Delta X = \frac{\lambda}{2\Delta\Theta}$$

where

$$\lambda = \frac{c}{f_c} = \frac{c}{99e9} = 3.03\,\text{mm}$$

and since the $\Delta X = \Delta Y$:

$$\Delta\Theta = \frac{\lambda}{2\Delta X} = 2.7^\circ$$

Therefore, to transform angular space to Cartesian space we must perform the second Fourier transfrom over 2.7° blocks of the angular range profiles.

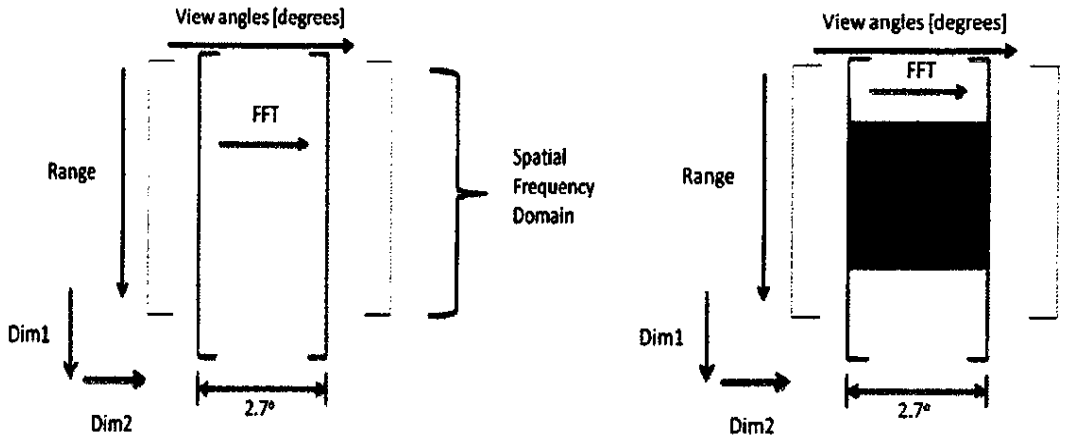


Fig. 15 – (a) Red brackets indicates the finite azimuthal segment over which the second Fourier transform is performed, (b) Final region of interest extracted from range profile matrix.

A new image matrix is then extracted from the spatial matrix such that range data outside our region of interest (ROI) is eliminated, leaving a square matrix contiaining the ROI, as shown in Figure 16. Each pixel within the image matrix represents a scattering intensity on a Cartesian coordinate grid.

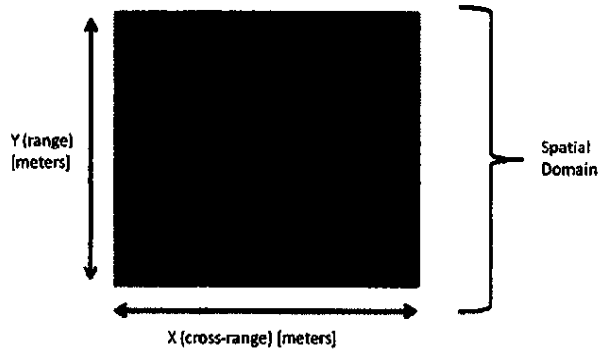


Fig. 16 – Final transformation of image into Cartesian range/cross-range space **I'**

We will refer to the concatenated result of the second Fourier transform as an image matrix **I'**. After the range profile information has been transformed to a spatial domain, target classification and threat detection is performed.

From the SAR images created, we conclude that there are multiple unique backscattering patterns resulting from humans wearing conductive materials on their bodies. The most obvious distinguishing trait associated with a human wearing scatterers on his chest is the increase in amount of forward scattering. Due to "ringing" of waves between the pipes and the skin and each other, the reconstructed images appear to persist in time (and correspondingly, range). The images for individuals wearing pipes tend to be taller than the images for no pipes. To quantify this, a test function is applied to the image created by the SAR processing.

First, the image is first normalized to its maximum value.

$$\mathbf{I} = \frac{\mathbf{I}'}{\max(\mathbf{I}')}$$

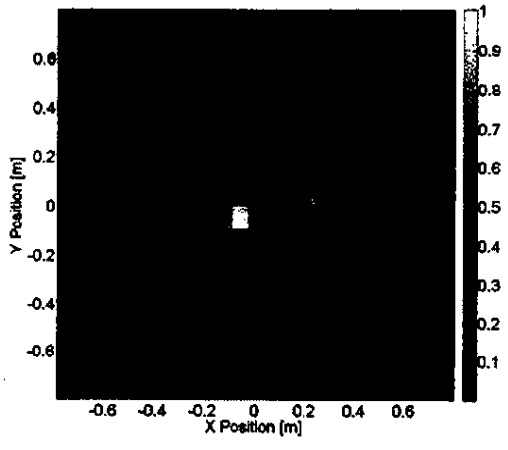


Fig. 17 – Example of normalized image matrix, with color level indicating intensity

An experimental noise level threshold is also chosen such that all pixels within the image whose value is greater than 5% of the maximum value are increased in power in the following manner.

$$\forall i \in \mathbf{I} \geq 0.05, i = i + 0.25$$

values below noise threshold are set to zero,

$$\forall i \in \mathbf{I} < 0.05, i = 0$$

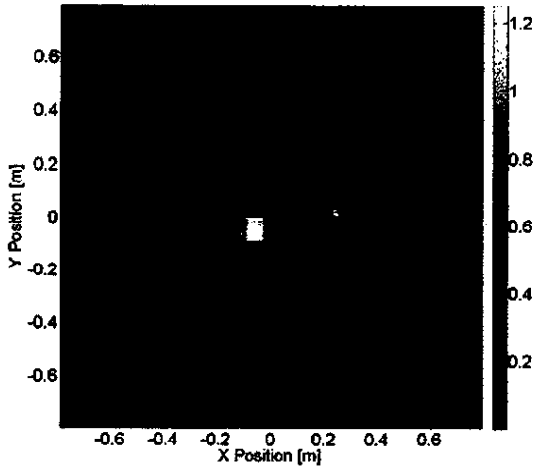


Fig. 18 – Example of normalized image matrix after noise threshold modifications

Next, a test function is chosen which finds the best fitting elliptise for the shape of the reconstructured image. An elliptical test function is defined as:

$$\mathbf{T}_{n,m} = \frac{A}{\left[1 + (\frac{x}{a_n})^2 + (\frac{y}{b_m})^2\right]^4}$$

where a_n and b_m, the semi-major and semi-minor axes lengths, are determined for the best fitting function.

Initially, we noticed extreme valued pixels within the image matrix caused the test function to concentrate there and neglect the scattering intensity of fringing pixels whose values were much lower. To prevent this from happening, all values in the image matrix which were set to zero are set equal to the test function.

$$\forall \mathbf{I}_{n,m} = 0, \mathbf{I}_{n,m} = \mathbf{T}_{n,m}$$

This allows the algorithm to neglect the error contribution of noise within the image.

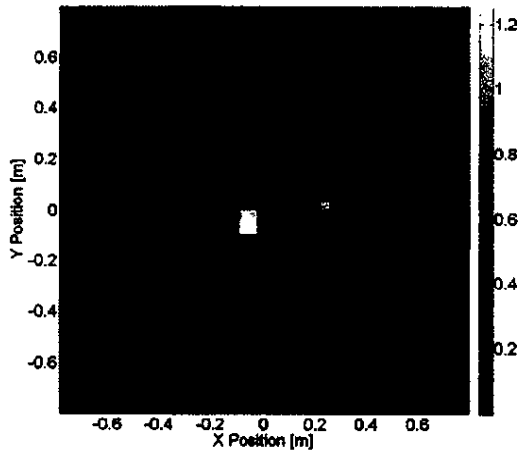


Fig. 19– Example of image matrix after below noise threshold pixels are set equal to elliptical test function

Once the modified image matrix is created the squared absolute value of the difference between the elliptical test matrix $\mathbf{T}_{n,m}$ and the modified image matrix $\mathbf{I}_{n,m}$ is taken,

$$\mathbf{D}_{n,m} = |\mathbf{I}_{n,m} - \mathbf{T}_{n,m}|$$

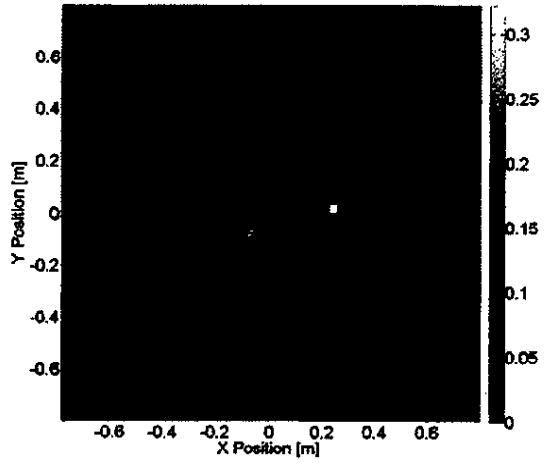


Fig. 20– Example of the squared absolute value difference matrix resulting from subtracting the modified image matrix from the elliptical test function matrix.

all elements in $\mathbf{D}_{n,m}$ are summed. The result is the total squared error of the image approximation.

$$Dtotal_{n,m} = \sum_{x=1}^{x=N} \sum_{y=1}^{y=M} \mathbf{D}_{n,m}(x,y)^2$$

Once the algorithm takes the squared difference for all combinations of (n, m) the index of the smallest difference is retrieved. The a_n and b_m corresponding to that index are chosen to define the best fitting elliptical approximation of the image matrix I. The ratio of the semi-major and semi-minor axes defining the best fitting elliptical approximation is recorded and used as the metric to determine presence of large scatterers on the targets chest. We have concluded that the presence of irregular scatterers on a target chest causes the axial ratio to become greater than one for an innocent target, and less than one for threat targets.

5 Numerical Results

Fig. 21 shows typical reconstructed intensity as a function of target position. The limited view angle makes detailed imaging impossible, but other discriminating features are clear.

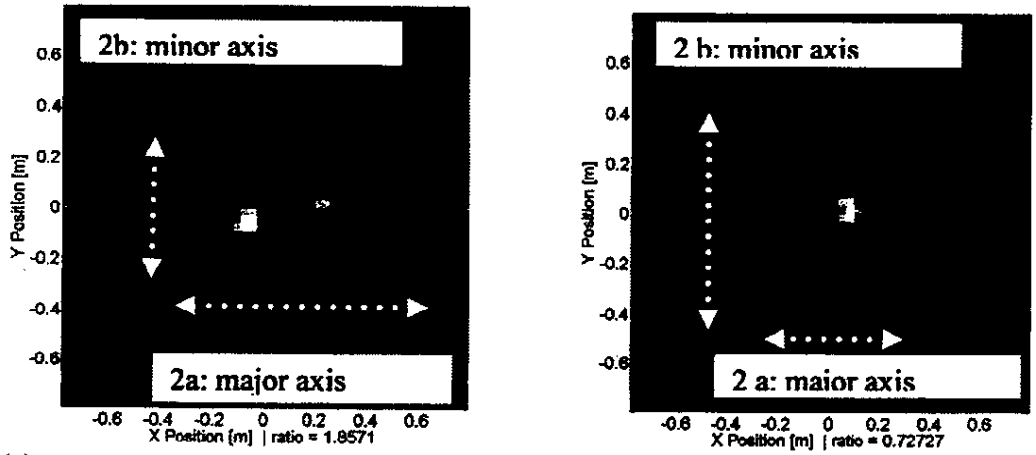


Fig. 21 – 2D-ISAR images and best fit ellipses for Subject A when wearing (a) no pipes (b) one pipe. The image is elongated in range, Y, when pipes are worn.

The best fit ellipse feature algorithm was applied to human subjects with varying physical characteristics: male, female, short, tall, thin and corpulent persons were all tested by the radar system. Table 1 presents the axial ratio determined for each of the subjects of Fig. 22 for different pipe configurations and aspect angles. It is clear that each subject not wearing pipes has a larger axial ratio than when he/she is wearing the metal pipes. The probabilities of detection (P_d) and false alarm (P_f) for the system can be established by setting a threshold and computing threat declarations. For example, two thresholds were established for each aspect angle, denoted as T_1 and T_2. For the aspect angle of 3 degrees and T_1 threshold: P_d = 83.3% and P_f = 0%, and for T_2 threshold: P_d = 91.6% and P_f = 33.3%. For the aspect angle 61 degrees and T_1 threshold: P_d = 58.3% and P_f = 0%, and for T_2 threshold: P_d = 100% and P_f = 33.3%. These results represent the first time radar with a limited aperture has been successfully used to detect concealed objects at standoff distances. While these results are very good, the system must be

improved for general-purpose implementation. We believe the multistatic configuration will produce significantly better results that could lead to an improved detection system.

(a) (b) (c)

Fig. 22 – Photographs of tested persons: (a) Subject A wearing vest with eight explosive simulant pipes, (b) Subject B wearing 4 pipes, and (c) Subject C, without simulants.

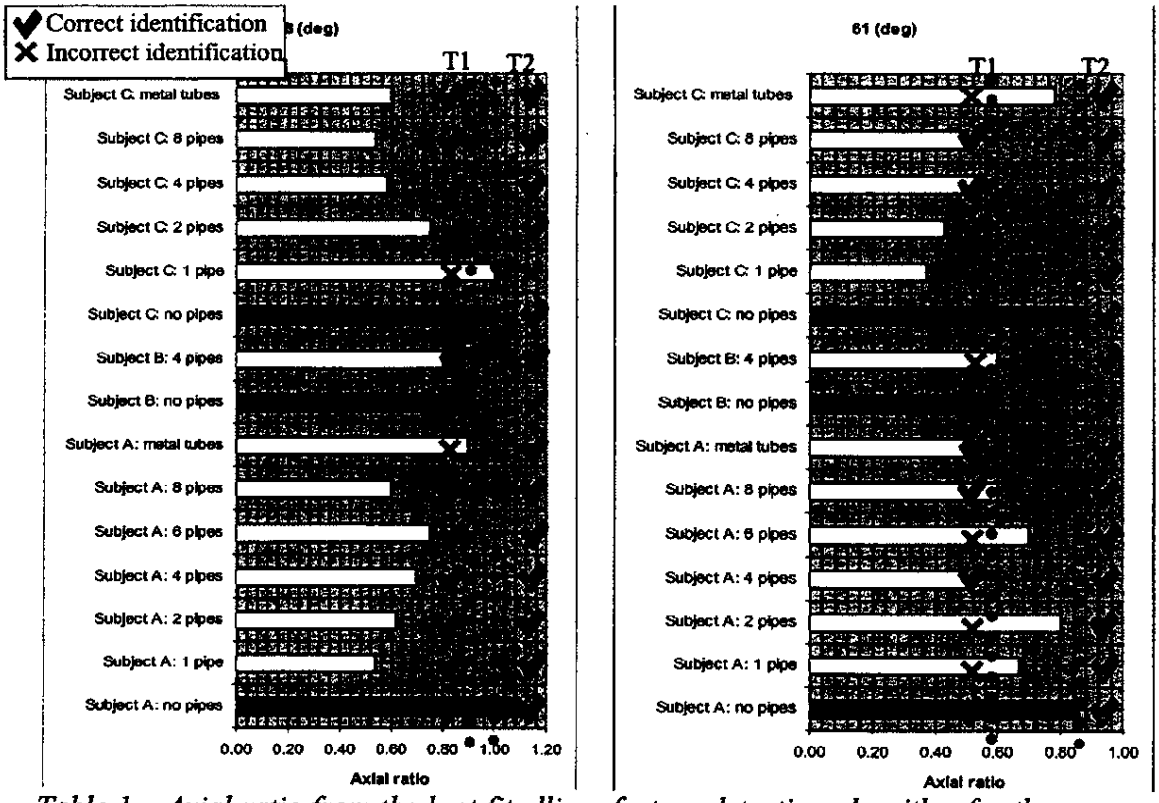


Table 1 – Axial ratio from the best fit ellipse feature detection algorithm for the persons in Fig. 22. The black bars are non-threats which are always longer for a given subject than when he/she is wearing pipes. Several possible thresholds are indicated.

Appendix A gives results for all tested innocent and threat cases for the three subjects for three distinct view poses: 0, 45, and 60 degrees. Although the poses are for the same individuals, since the measured data from one pose does not overlap that of another, the measurements and processing can be considered independent. Thus the Appendix presents 36 threat cases and 9 innocent cases. While many additional cases could be considered, this measurement set is complete, and indicates a consistent hypothesis testing detection result. In each individual's case, the no-pipe ellipse axial ratio is greater (although occasionally only marginally so) than the ratio for pipes. For the case of Subject C, who is portly, and for which the pipes lie only on the extreme sides of his chest, the discrimination is the least accurate. For the other two cases, the declarations are excellent.

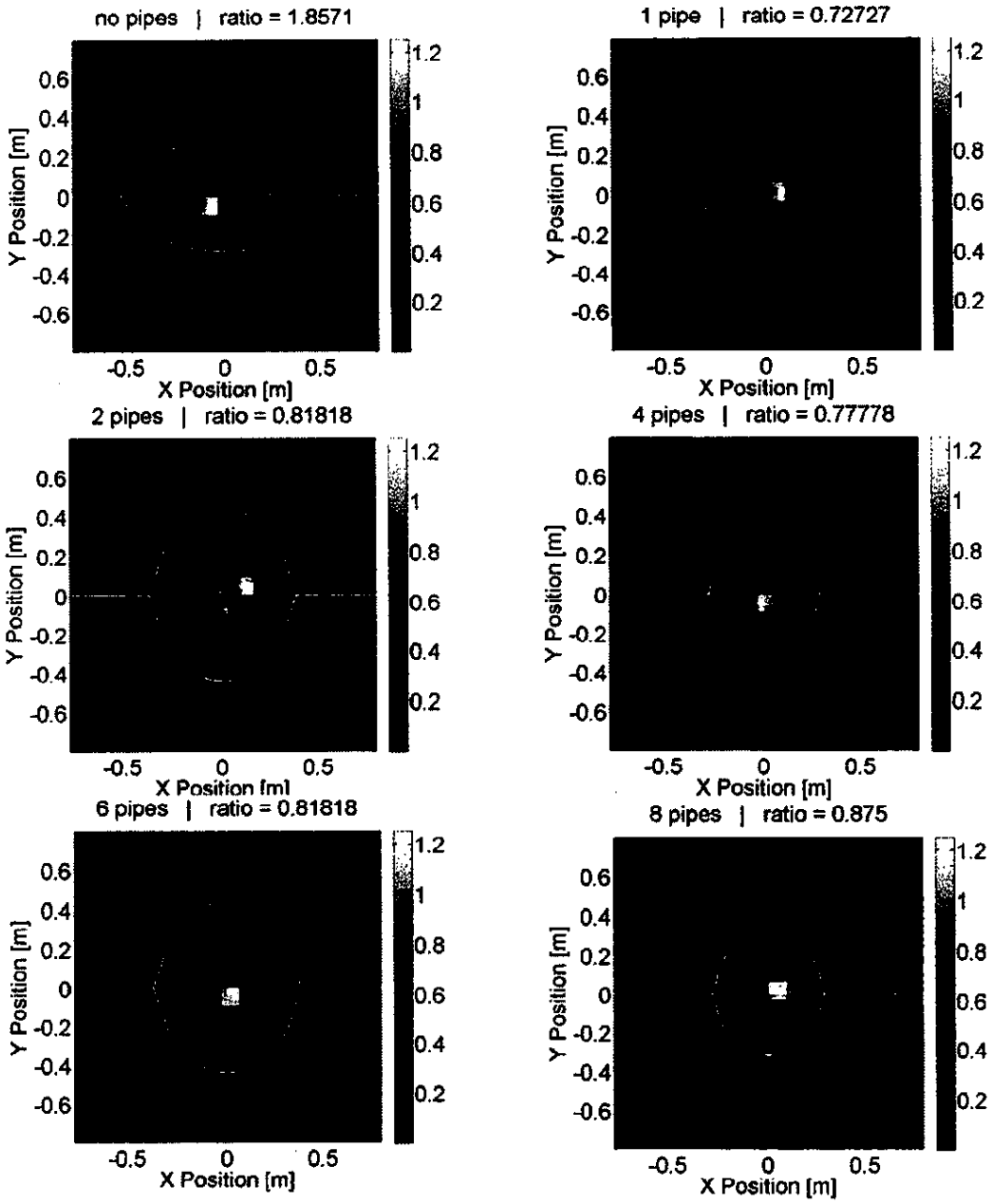
The results presented in this report indicate that even with a severely limited (2.7 degree) portion of the full ISAR observation circle, features can be identified to discriminate individuals wearing one or more pipes from those not wearing concealed threat objects. With this limited aperture, detailed imaging is not possible. However, we have identified the elongation feature of the reconstructed scatterer, which correlates well with threats for several quite different body types. While 2.7 degrees is only $1/130^{th}$ of a typical ISAR scan, it still represents 60 cm at 13 m and 2.35 m at 50 m range, which constitute a wide apertures.

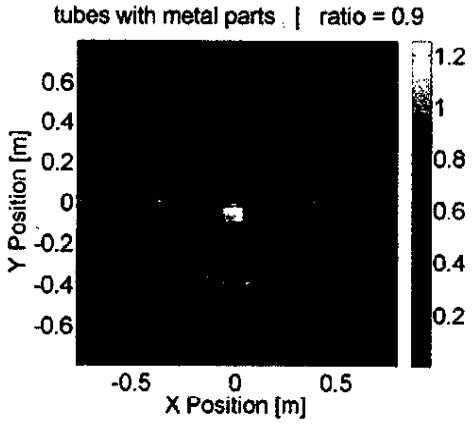
The next step is to consider a radar with a stationary array aperture, with thinned irregularly spaced antenna elements. This radar could produce similar discrimination results without relying on either target or radar motion. A 2.5 m array would fit in or on a vehicle, and with appropriate focusing could provide finely adjustable scanning across an individual's torso. Although more expensive than a single module ISAR radar, it would represent a practical means of safely and securely screening for concealed threats at standoff distances.

Appendix A - Limited view ISAR images

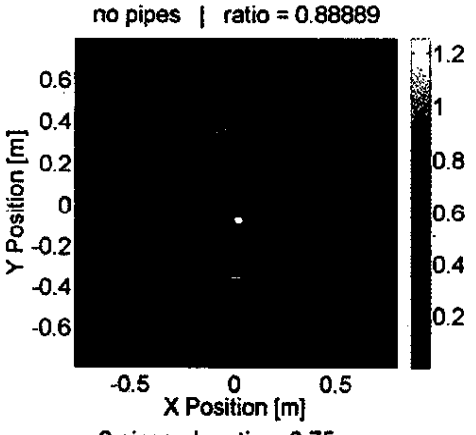
Incident angle = 0° (normal to target chest)

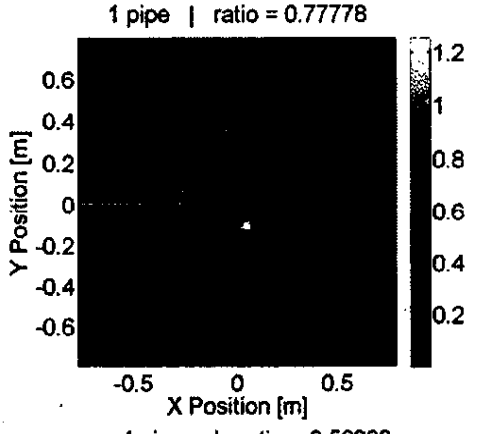
Target: Subject A

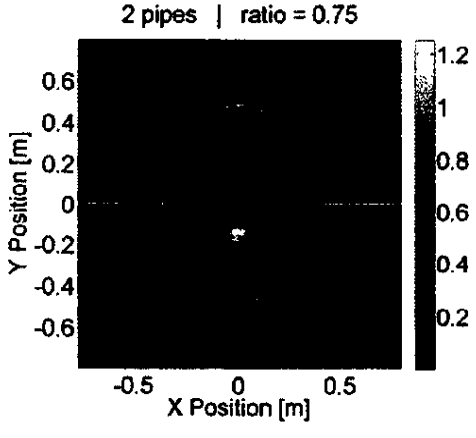


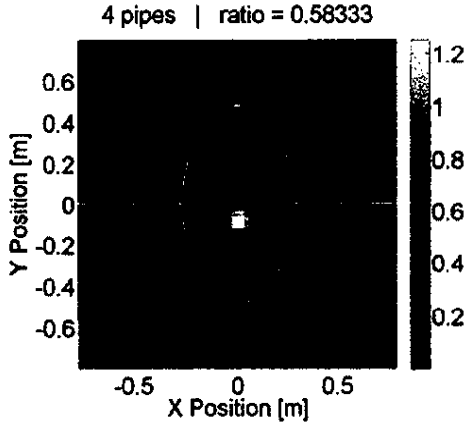


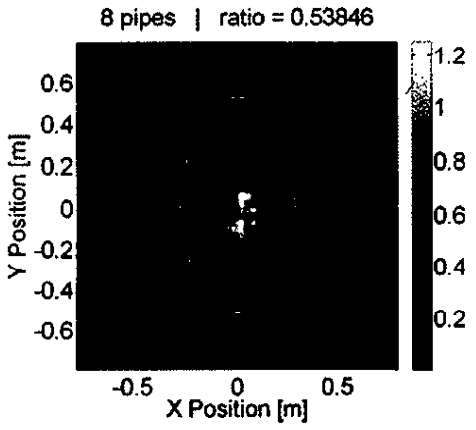
Target: Subject B

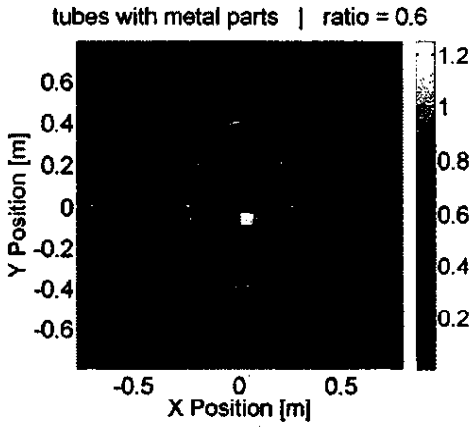




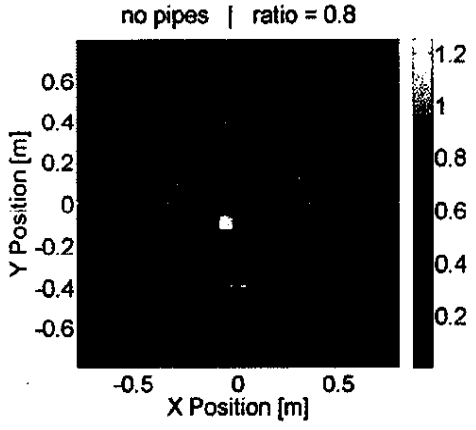


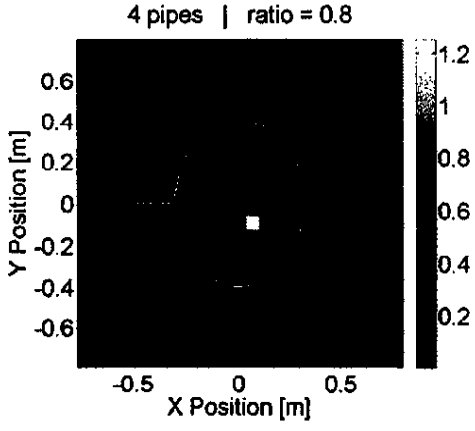






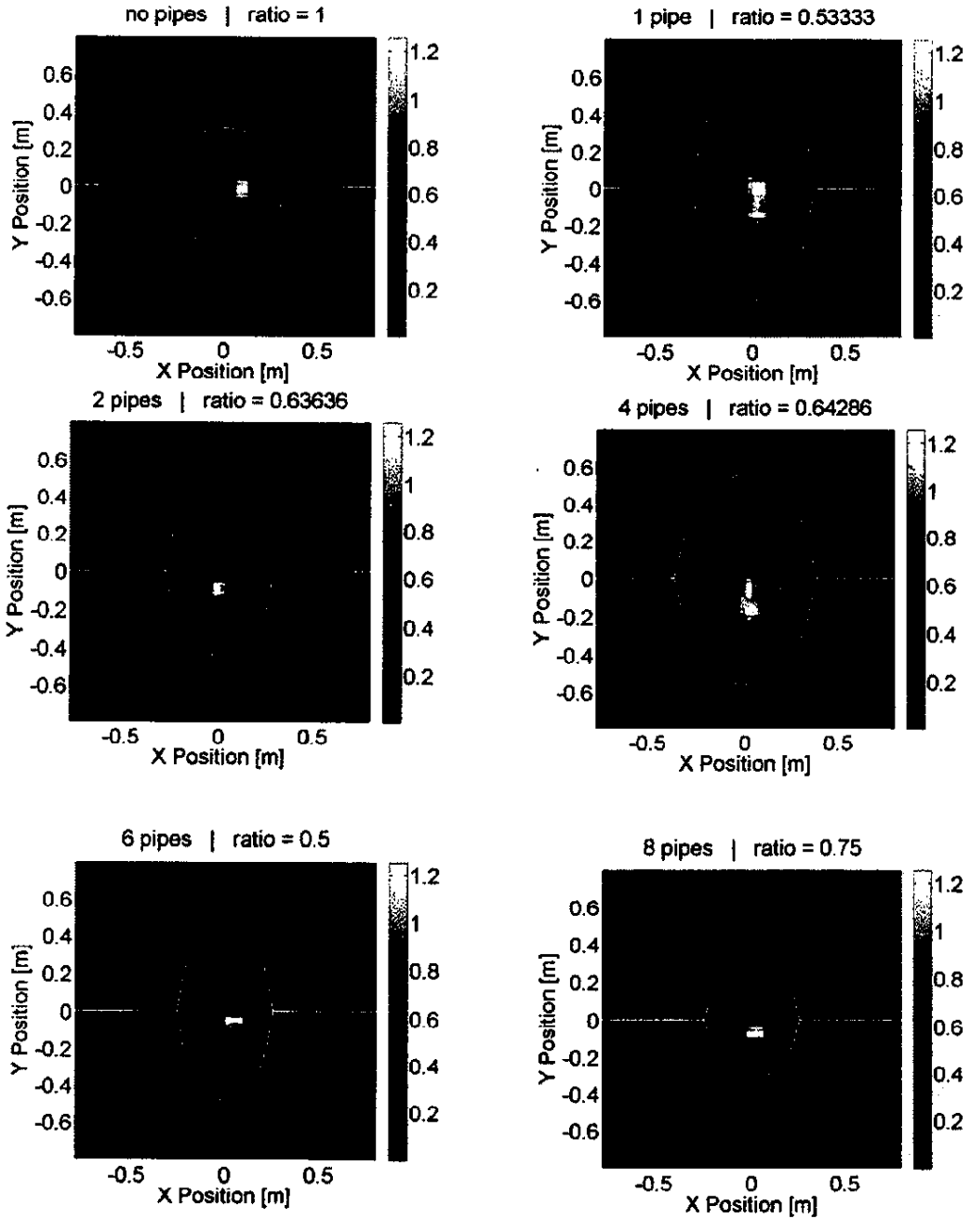
Target: Subject C

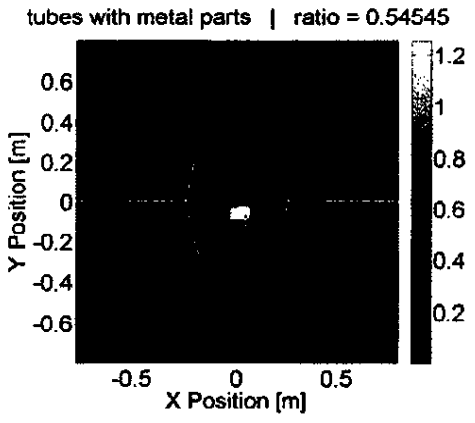




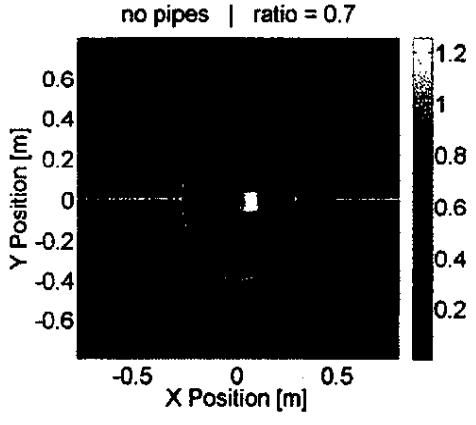
Incident angle = 45°

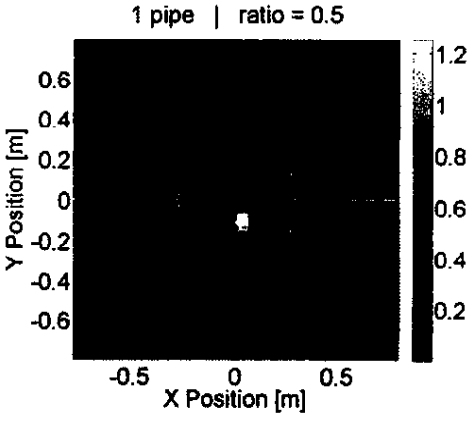
Target: Subject A

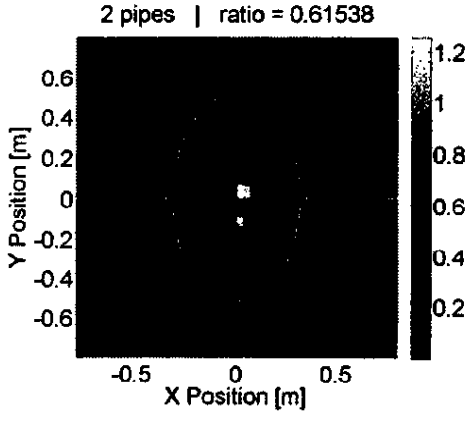


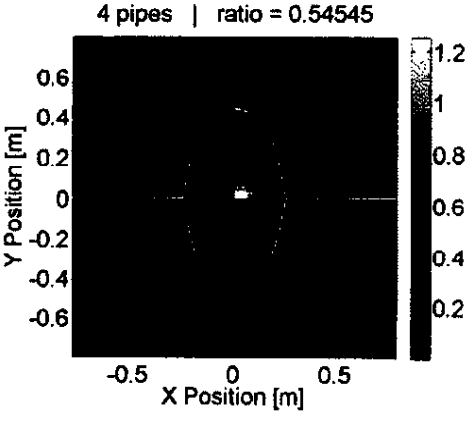


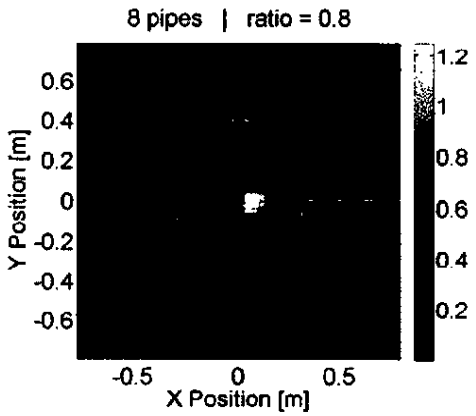
Target: Subject B

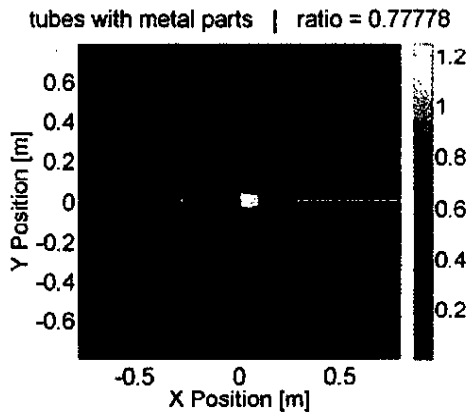




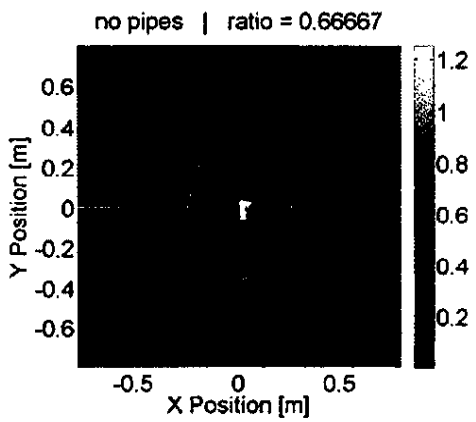


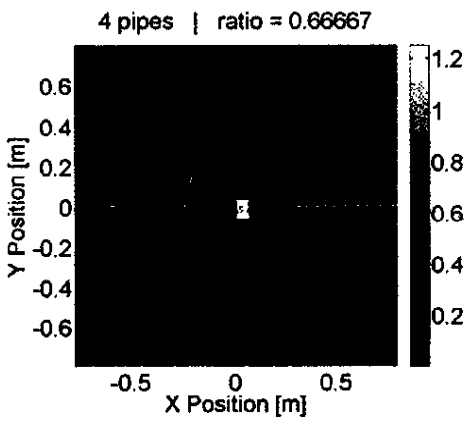






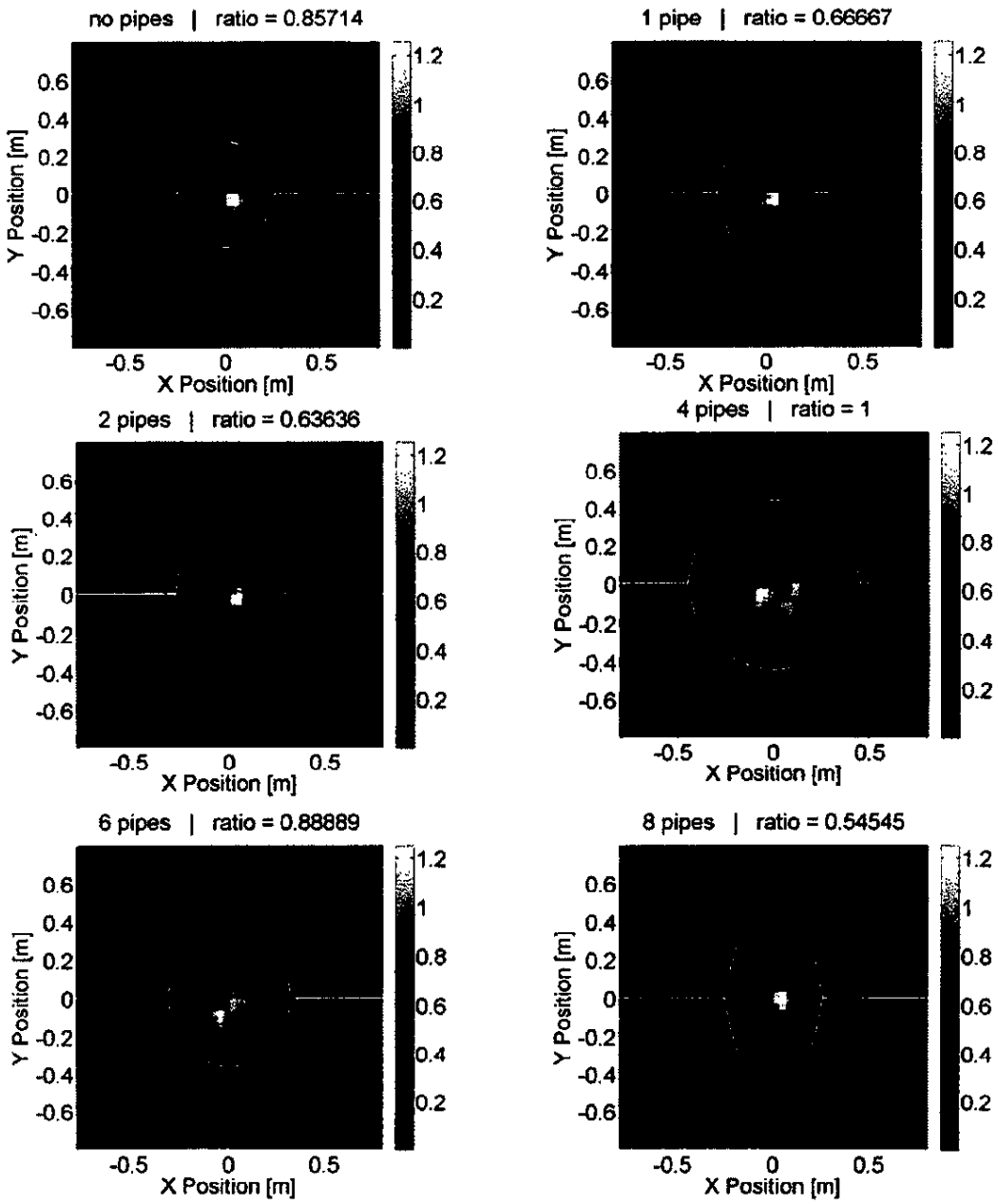
Target: Subject C

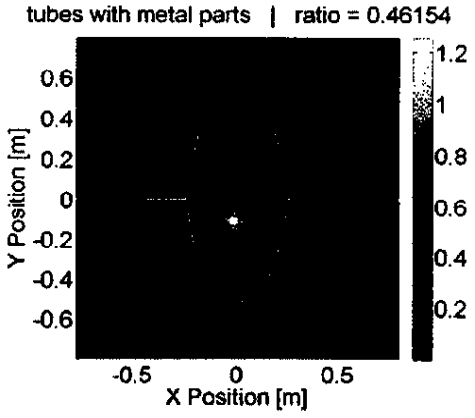




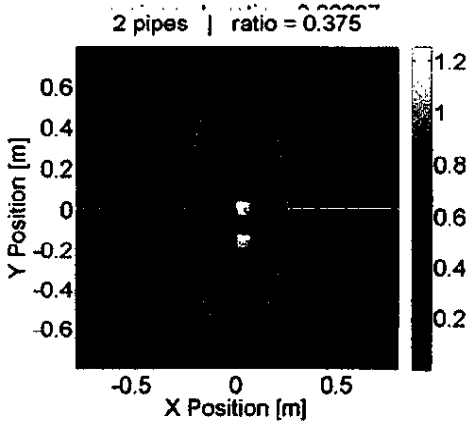
Incident angle = 60°

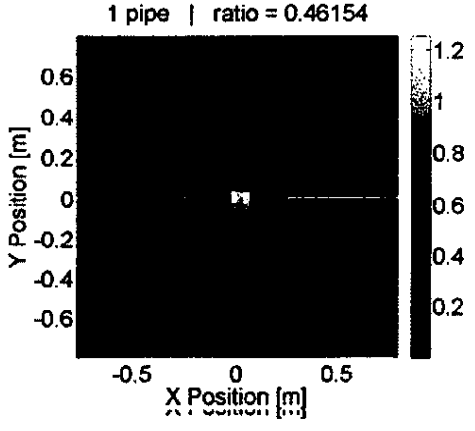
Target: Subject C

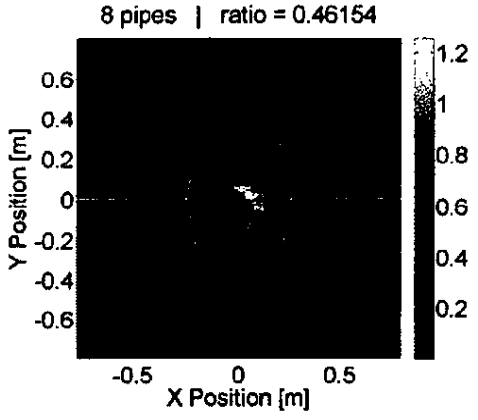


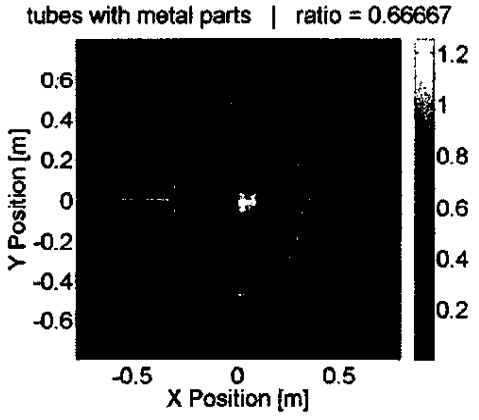


Target: Subject B

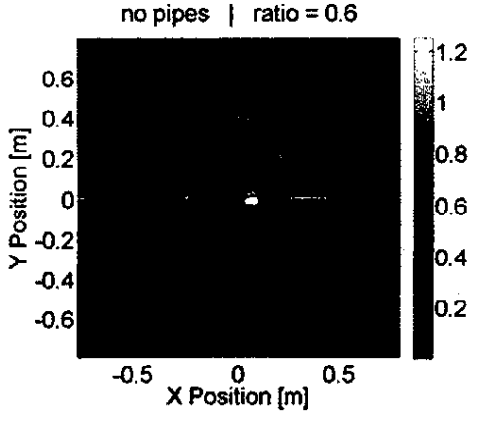


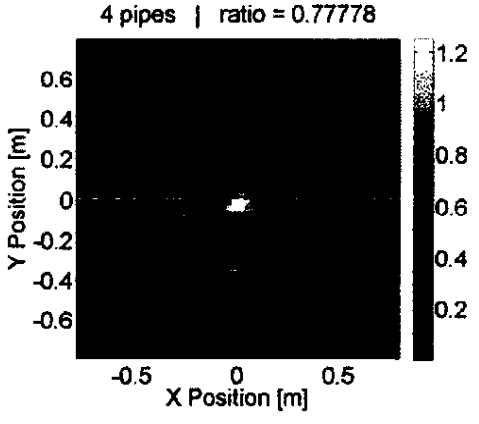






Target: Subject C





5. References

[1] Martinez-Lorenzo, J. A., Rappaport, C. M., et all. "Standoff Concealed Explosives Detection Using Millimeter-Wave Radar to Sense Surface Shape Anomalies". , *AP-S 2008, IEEE AP-S International Symposium*, San Diego, CA, USA, Jun. 2008.

[2] Martinez-Lorenzo, J. A., Rappaport, C. M., Sullivan, R. and Pino, A. G. "A Bi-static Gregorian Confocal Dual Reflector Antenna for a Bomb Detection Radar System". , *AP-S 2007, IEEE AP-S International Symposium*, Honolulu, Hawai'i, USA, Jun. 2007.

[3] Sheen, D., McMakin, D., Hall, T., "Three-Dimensional Millimeter Wave Imaging for Concealed Weapon Detection," *IEEE T-MTT*, Sept., 2001.

[4] Rappaport, C., "High Resolution Thinned Array Synthesis Based on an Optimized Mapping Function," *1986 Antennas and Propagation Soc. / URSI Symp. Digest*, pp. 375-378, June, 1986.

[5] Martínez-Lorenzo, J. A. et. al. "Zooming and Scanning Gregorian Confocal Dual Reflector Antennas", *IEEE Transactions on Antennas and Propagation*, N-56, vol-9, pp. 2910--2919, Sept 2008.

[6] Gonzalez-Valdes, B., Martínez-Lorenzo, J. A., Pino, A. G. and Rappaport, C. M "Zooming and scanning a beam by hybrid mechanical-electronic pointing systems". *ESA Antenna Workshop on Space Antenna Systems and Technologies*, Noordwijk, Netherlands, Jun. 2007.

[7] www.nlm.nih.gov/research/visible/visible_human.html

[8] Tessmann, et. al., "Compact single-chip W-band FMCW Radar Modules for commercial high-resolution sensor applications," *IEEE T. MTT*, vol. 50. no12, Dec., 2002.

[9] Ufimtsev, P., *Method of edge waves in the physical theory of diffraction*, , pp. 1-243, 1962, translation prepared by the U.S. Air Force Foreign Technology Division, Wright-Patterson AFB, Ohio, 1971.

[10]Martinez, J. A., Pino, A. G., Vega, I., Arias, M., & Rubiños, O. "ICARA: Induced Current analysis of Reflector Antennas," *IEEE Antennas and Propagation Magazine*, vol. 47, no. 2, 2005, pp. 92-100.

[11] Keller, J. B., Geometrical theory of diffraction, *J. Optics Soc. Amer.*, vol.52, pp. 116-130, 1962.

[12] El-Shenawee, M., Rappaport, C., Miller, E., and Silevitch, M., "3-D Subsurface Analysis of Electromagnetic Scattering from Penetrable/PEC Objects Buried under Rough Surfaces: Application of the Steepest Descent Fast Multipole Multilevel (SDFMM)," *IEEE T Geosci. Rem. Sens*, 6/2001, pp. 1174-118.

[13] Rappaport, C., Dong, Q., Bishop, E., Morgenthaler, A., and Kilmer, M., "Finite Difference Frequency Domain (FDFD) Modeling of Two Dimensional TE Wave Propagation and Scattering," *URSI Symp. Digest* Pisa, Italy, May 16-18, 2004, pp. 1134-1136.

[14] John C. Curlander, Robert N. McDonough, *Synthetic Aperture Radar: Systems & Signal Processing*, John Wiley & Sons, Inc., USA, 1991.

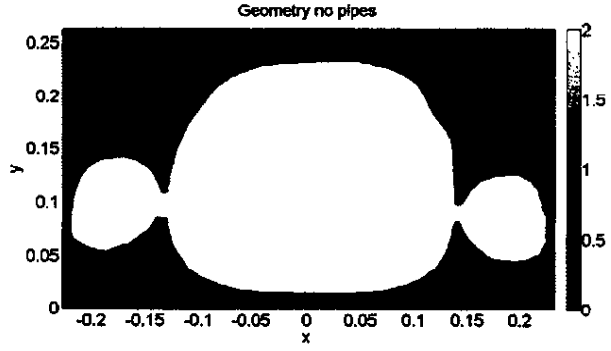
[15] Walter G. Carrara, Ron S. Goodman, Ronald M. Majewski, *Spotlight Synthetic Aperture Radar: Signal Processing Algorithms*, Artech House, Inc., USA, 1995.

[16] Victor C. Chen, Hao Ling, *Time-Frequency Transforms for Radar Imaging and System Analysis*, Artech House, Inc., USA, 2002.

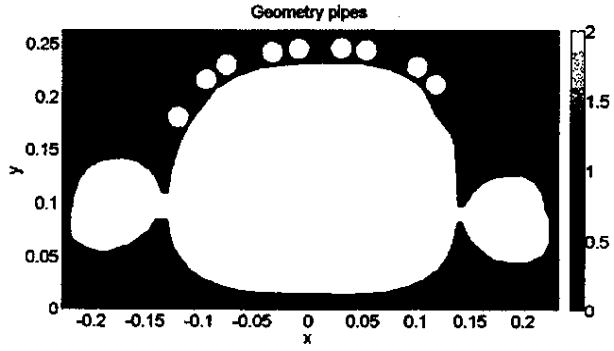
[17] Chris Oliver, Shaun Quegan, *Understanding Synthetic Aperture Radar Images*, SciTech Publishing, Inc., USA, 2004

1 - Introduction

An essential component of the multi-sensor system BomDetec system is the early detection of suspicious individuals at distance. While several sensing modalities can observe and follow people and may identify explosive residues or heat signatures on the outer surface of clothing, at present radar is the only modality that can penetrate and sense through clothing without causing physical harm to people at 50m. The initial BomDetec study showed that a simple threshold detection approach using a single polarization radar with relatively wide illuminating spot fails to unambiguously detect foreign objects worn under clothing. Analysis has indicated that this is due to the extremely complex nature of scattering and interference from the electrically large non-deterministic contours of the human body at the chosen frequency of 77GHz. Fig. 1 presents the cross section of a human body with and without a set of pipes, and the complex nature of the scattered field produced for both cases – when the incident field illuminates the whole cross section- can be observed in Fig.2. Lowering the frequency will reduce the interference complexity, but would require a larger antenna, and be even less specific in sensing small-scale differences in body contours due to foreign objects.

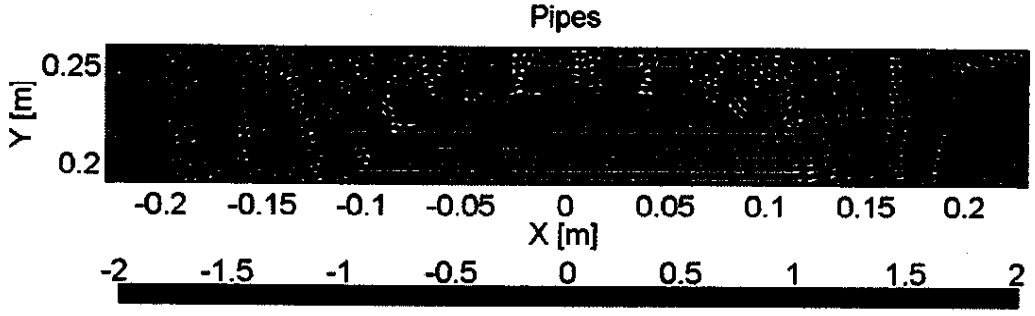


(a)



(b)

Fig 1 – Simulated geometry (a) human body 'no-pipes' and (b) human body with 'pipes'. The index '2' in the figure indicates metal and the index '1' indicates air.



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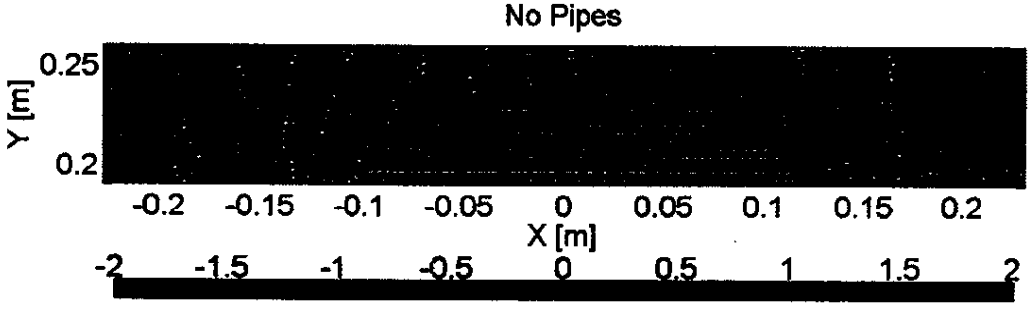

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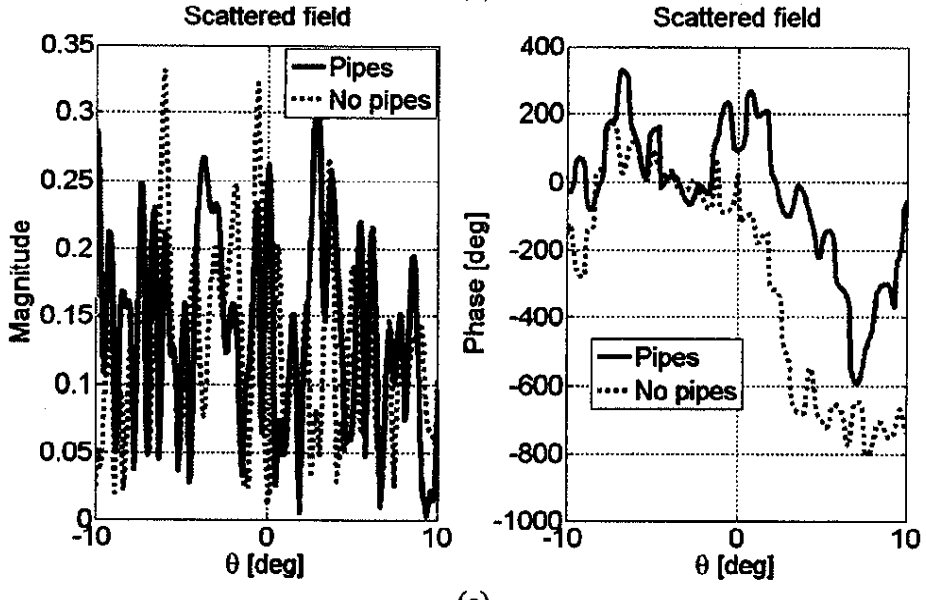


(c)

Fig 2 – Scattered field for an incident plane wave coming from 0°: (a) near-field real part for the 'one-pipe' case, (b) near-field real part for the 'no-pipe' case. (c) far-field comparison between 'one-pipe' and 'no-pipes' cases,

2 - Technical Concept: Suicide Bomber Detection Using Millimeter-Wave-Radar

Radar has the potential to discriminate concealed body-worn objects at distance, but only with careful radar antenna design and processing. Since nearfield millimeter wave sensing has been shown to be effective in discriminating and imaging both metal and plastic objects, it is clear that the physics do not disallow this sensing modality. What is needed is to identify the aspects of standoff millimeter wave sensing which are problematic. The main difficulty is the limited view of the target from a distant source. By increasing the aperture of the radar antenna to an unprecedented (but not unreasonable) size, it may be possible to overcome the standoff target discrimination limitation.

2.1 Narrow-beamwidth requirement

The main objective of the radar system is to be able to detect irregular contours on the surface of a human body. If these irregularities can be identified on individuals with no externally visible objects – such as bags, books, or straps – the individual has an increased likelihood of being a suicide bomber. As it is shown in the PDR report of Phase I, it is impossible to distinguish between a terrorist and an innocent person when the antenna beamwidth is comparable to the size of a human chest (see Fig. 2). This is due to the uncertainty of radar signal summing up all the scattered field contributions from every reflective element illuminate by the antenna beam [1]. Since the field scattered by a metal object is of the same order of magnitude as that of skin at 77 GHz, it is impossible to distinguish the electromagnetic signature of an innocent and terrorist.

A new concept to detect hidden pipes under clothes is proposed. It consists in detecting abrupt changes at the shape of the person under test instead of analyzing the changes of a reflectivity function as proposed in [2]. The idea of detecting irregular contours requires scanning a small antenna illuminating spot, which is of the same order of magnitude as the target irregularities, across the body surface. The beamwidth required for such an illuminating spot is inversely proportional to the electrical size of the antenna. For this particular application, an antenna producing a five centimeters wide spot at fifty meters would require a 1000 wavelength aperture. The only feasible antenna solution of this extent is an array of reflectors. Fig. 3 presents the farfield pattern produced by an array of thirteen elements each 75 wavelengths wide, with a beamwidth of about BW=0.05 deg. The vertical dashed lines show the angular projection of an averaged human chest at 50m superimposed over the antenna pattern. It is also important to realize that this antenna illuminates a small portion of the human chest, and as a result, the electromagnetic signature of this area could be processed separately from other illuminated areas. The farfield pattern of the reflector array is the combination of the array pattern and the reflector pattern. Grating lobes, at ± 0.75 deg, result from constructive interference of the finite number of discrete array elements. The grating lobes are lower intensity than the main beam because the 75 wavelength element pattern tapers to nulls at about 1.5 deg (as

shown in Fig. 2). It is important to design a system where these grating lobes fall aside of the angular projection of the human body at the selected range.

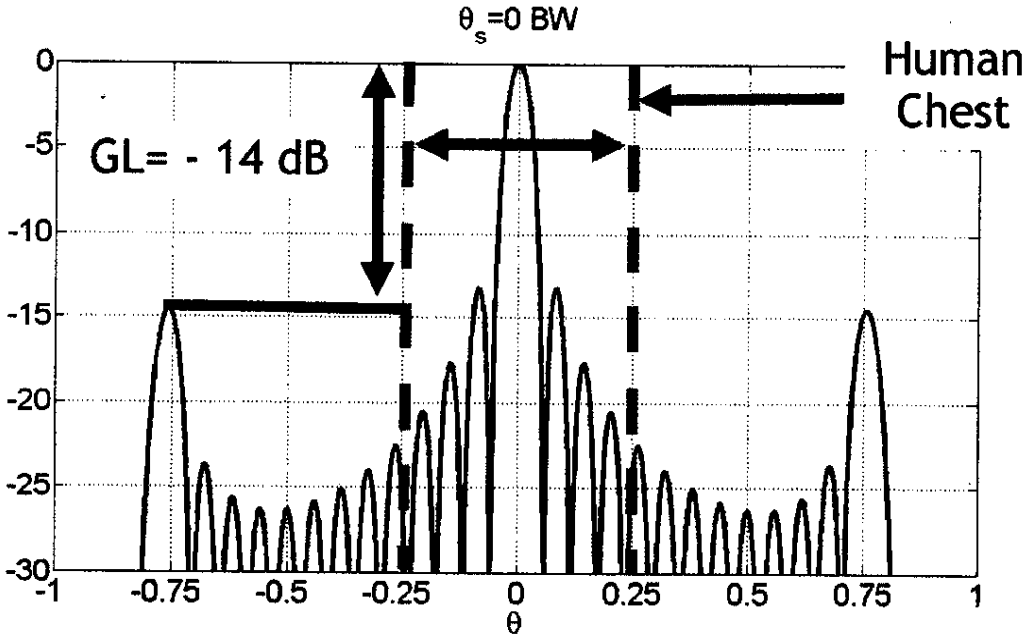
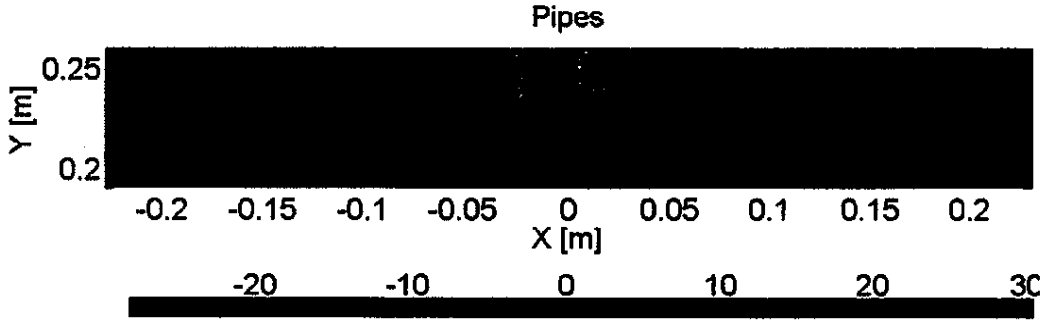


Fig 3. Farfield pattern of an array of 13 elements, and angular projection of a human body at fifty meters (between vertical dashed lines)

2.2 Steering-beam requirement

A big aperture creating a static and narrow beam which illuminates a reduced area of the angular projection of the human chest is not enough to determine irregular shape variations. To achieve this goal, a system able to steer the beam is required. With steering, different areas of the subject under test can be illuminated and analyzed independently by the antenna receiver. Figs. 4, 5 and 6 present the scattered field when the array forms a beam at three different chest positions. It is possible to see how the illuminated area is different for each scanning case, and the farfield produced by a body with pipes is substantially different from that of a body without pipes.

The electromagnetic signature of non-irregular body shape would produce a continuous response – in terms of phase variations – for adjacent and continuous illuminated areas, while it would have an abrupt response for irregular body shapes.



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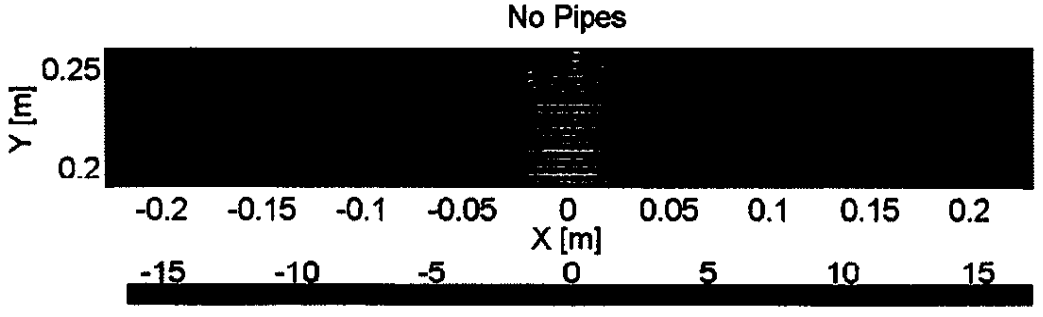

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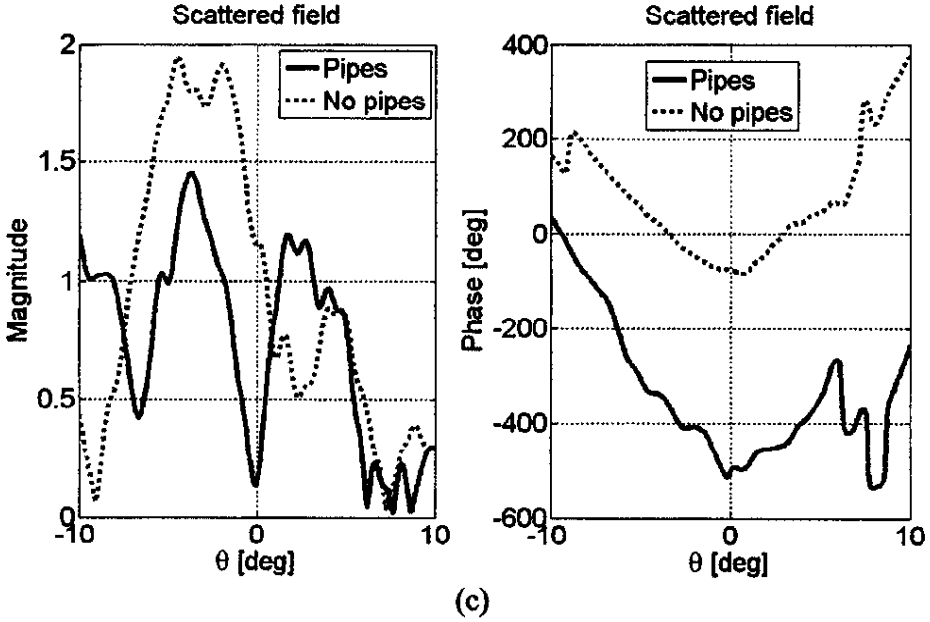
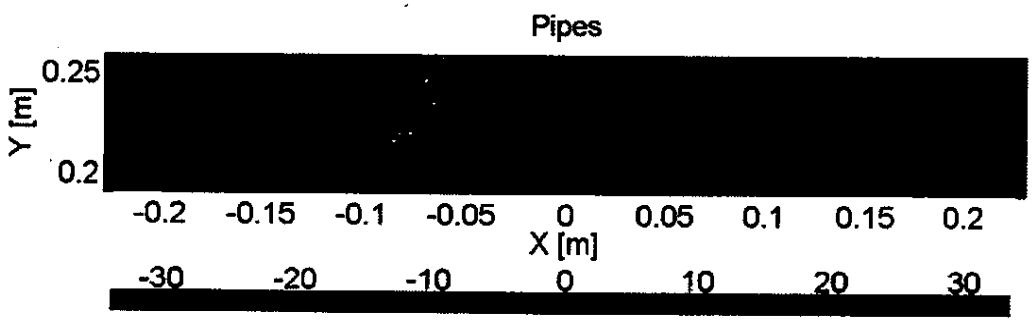


(c)

Fig 4 – Scattered field for a beam formed at x = 0 m: (a) near-field real part for the 'one-pipe' case, (b) near-field real part for the 'no-pipe' case (c) far-field comparison between 'one-pipe' and 'no-pipes' cases



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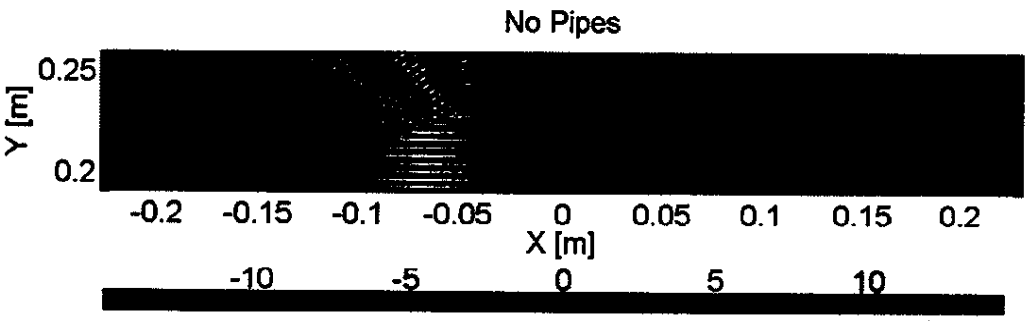

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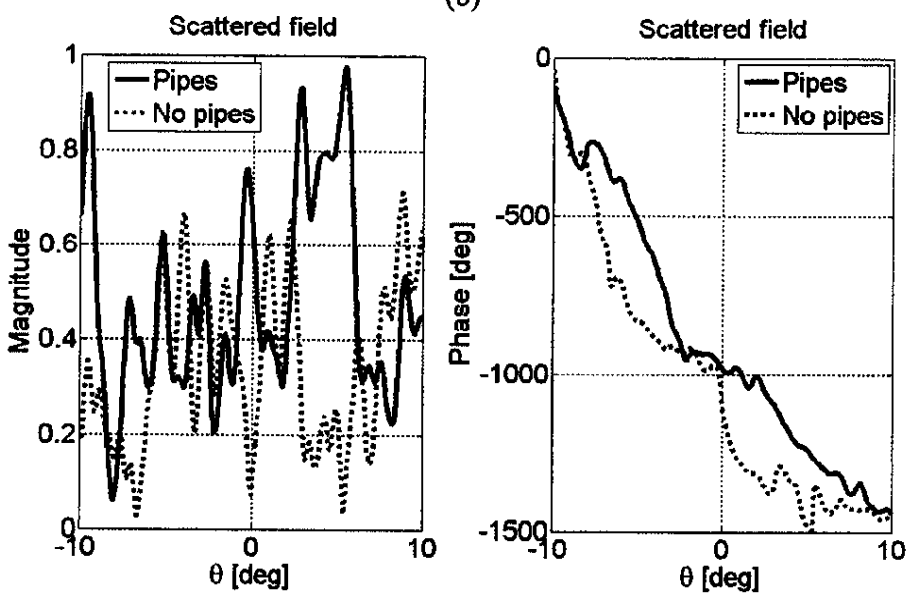
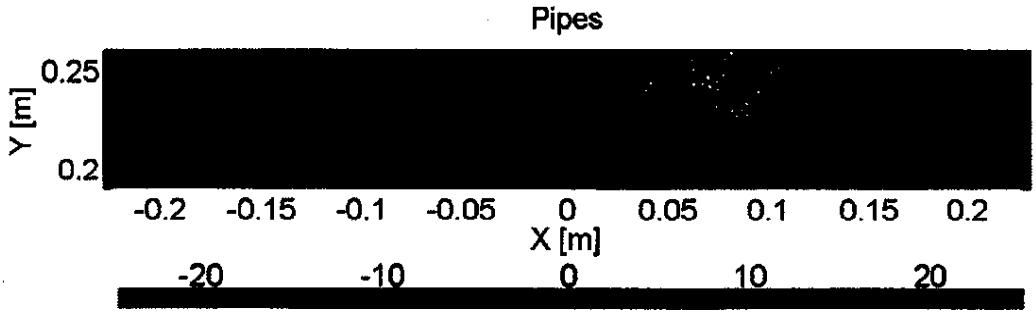


(c)

Fig 5 – Scattered field for a beam formed at x = -0.07 m: (a) near-field real part for the 'one-pipe' case, (b) near-field real part for the 'no-pipe' case, (c) far-field comparison between 'one-pipe' and 'no-pipes' cases,



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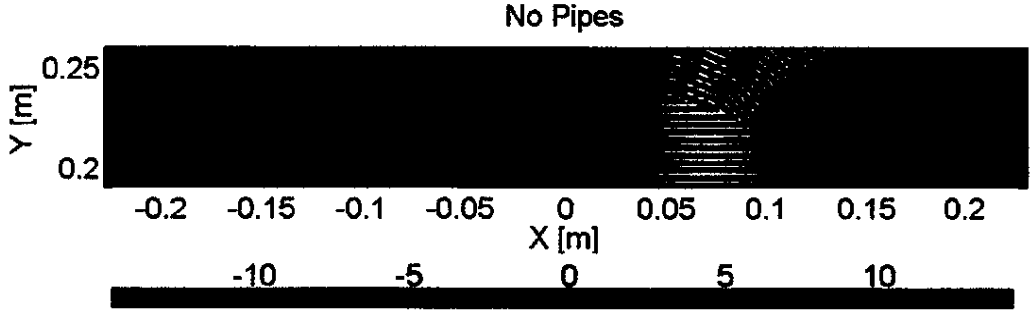

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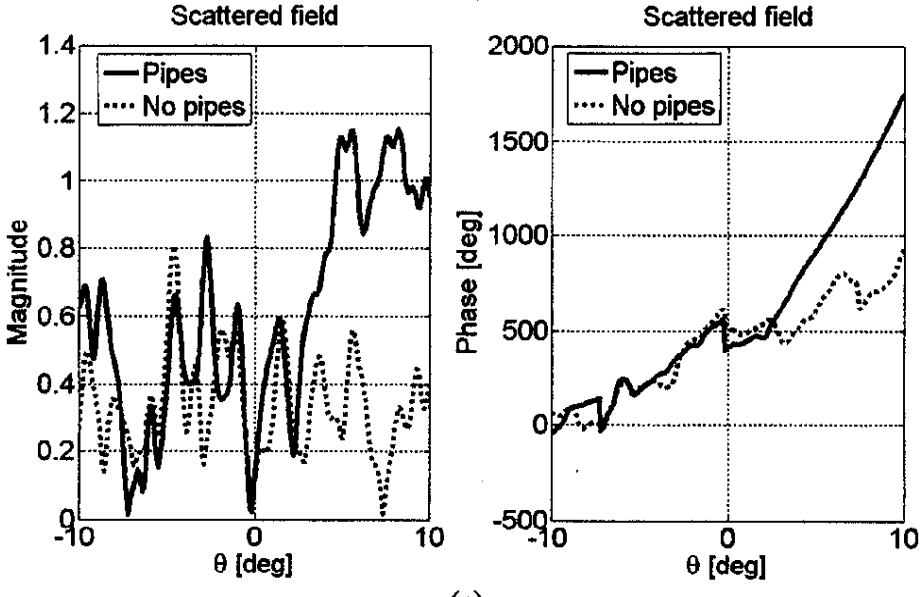


(c)

Fig 6 – Scattered field for a beam formed at x = 0.07 m: (a) near-field real part for the 'one-pipe' case, (b) near-field real part for the 'no-pipe' case, (c) far-field comparison between 'one-pipe' and 'no-pipes' cases,

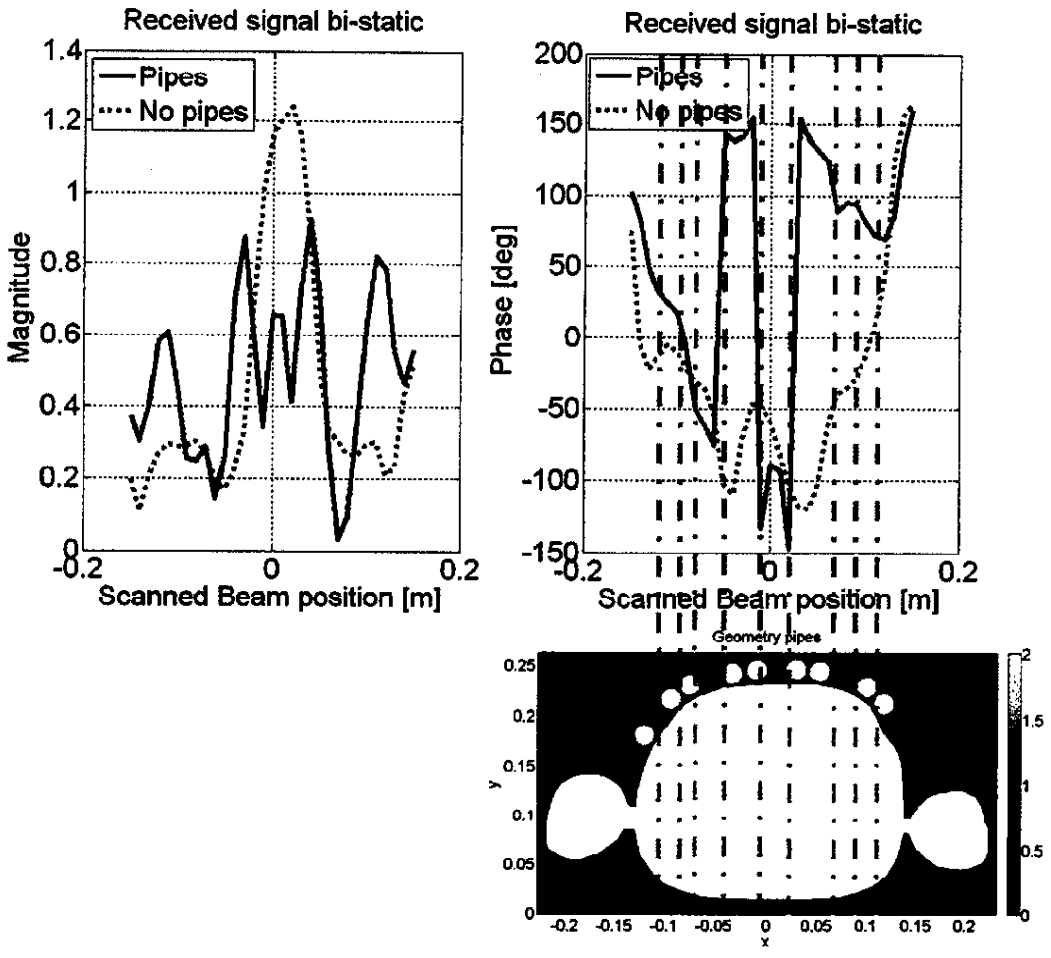


Fig 7 – Received signal for a beam formed at 31 different equally spaced positions starting at x= -0.15 m and ending at x = 0.15 m and beam-matched in reception.

Fig. 7 presents a comparison between the received signal from a body with and without pipes as a function of the scanning position across the human body. The received signal is achieved by matching the antenna beam – for the receiving mode - to the area under test. The magnitude of the received signal, for the body without pipes, has a maximum when the transmitting and receiving beams scan to a position coincident with the point producing the specular reflection. The maximum received signal decays slowly if compared with the case of the body with pipes. Other important characteristic is observed in the phase of the received signals, while the body with pipes produces a slow phase variation, the body without pipes produces important phase shift when the array scans to a position coincident with the location of the pipes.

2.3 Steering a narrow beam: Physical implementation

For the selected range and beamwidth, the antenna must be able to scan ±5BW in order to cover the forty centimeter extent of a human chest. The system configuration, formed by an array of reflectors, is suitable for steering and zooming the antenna beam [3, 4]. The procedure of steering the beam is accomplished by introducing a linear phase shift at each reflector. Increasing the relative phase shift between antenna array elements increases the scan angle. Fig. 8 shows the farfield pattern achieved when the antenna is scanned +1BW. For this beam scanning, the lateral grating lobe is also shifted the 1 BW, and its power increases relative to the main beam. Fig. 10 shows the patterns for 1, 3 and 5 BW relative to the boresight pattern. While the grating lobe approaches the boresight direction and increases in intensity, it is still 7 dB down for transmission, or -14 dB below the main beam for two-way operation.

In order to reduce the complexity of the system, the beam forming – for the transmitting and receiving mode - is done by software instead of hardware. The processing procedure consists of treating each element's transmission/reception of the incident/scattered field independently. The combination of the received signals must be done coherently by a DSP or local computer, which introduces the required linear phase shift for beam scanning. Both amplitude and phase are required for each element for coherent summation. Given its specific position, the amplitude and phase of each element of the array can be controlled by a digital beam former to steer the beam. It is important to ensure that the farfield pattern of each element of the array to completely illuminate the torso of the individual under observation. Fig. 8 shows that this situation is achieved for 75 wavelength elements.

Another capability of software beam forming the fact that the angular scanning resolution can be increased as much as desired, limited only by the tradeoff between angular resolution and processing time. Thus, questionable observations can be examined with grater detail. It is important to note that this finer scanning resolution only requires additional processing, not additional radar sensing: the information from a single set of element observations provides all the necessary detail.

Another important capability for the system would be its ability for zooming, which means that it would be able reconfigure the beamwidth to work not only at 50m range but also at 20m range. The zooming capability could be done by reducing the radiating aperture of the antenna. This is equivalent to turning off some elements of the array in order to produces a broader beam [3, 4]. This capability could also be developed by software instead of hardware, which reduces drastically the complexity of the system.

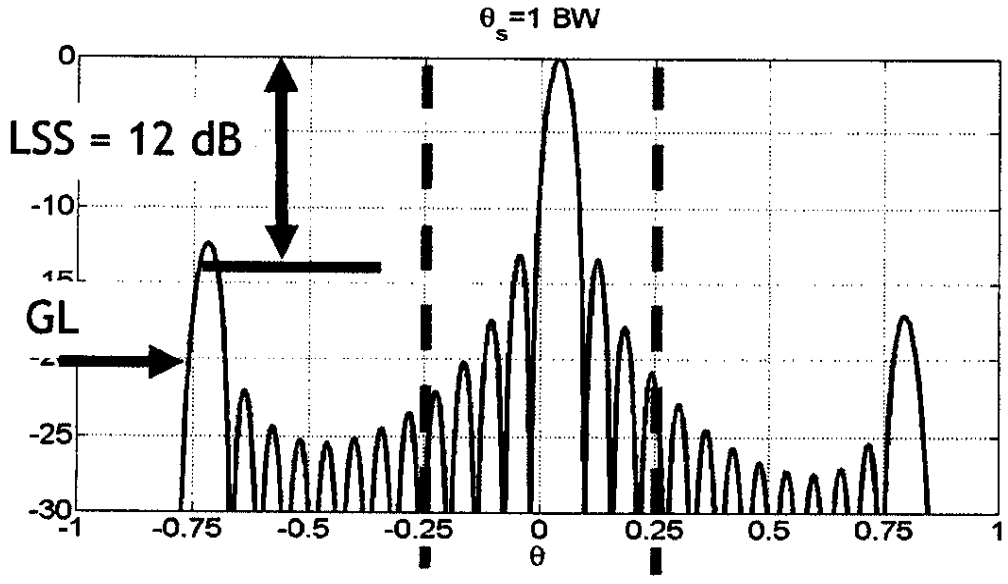


Fig 8. Antenna farfield pattern for 1BW scanning condition

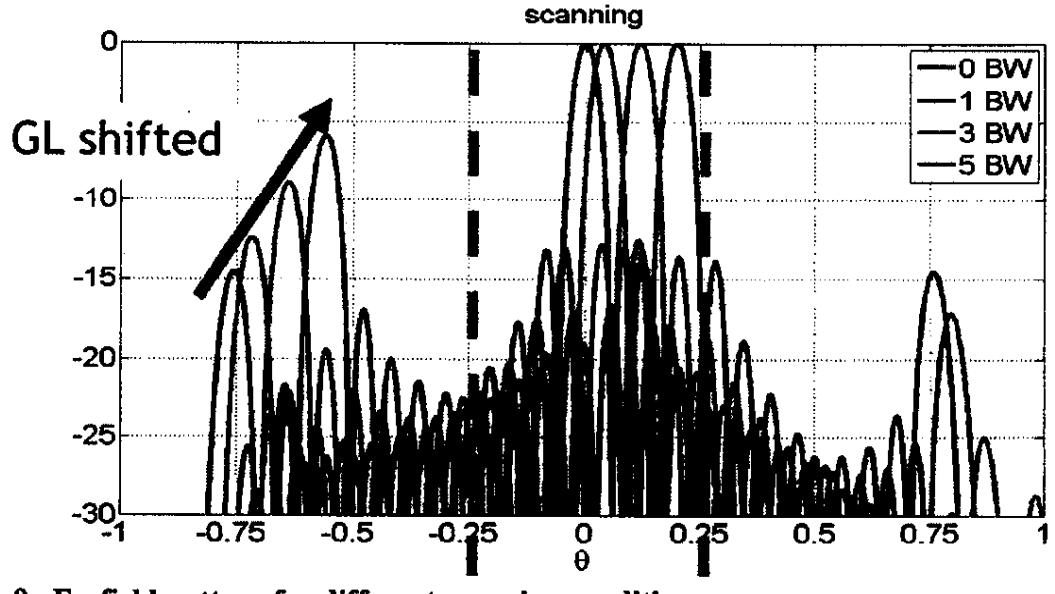


Fig 9. Farfield pattern for different scanning conditions

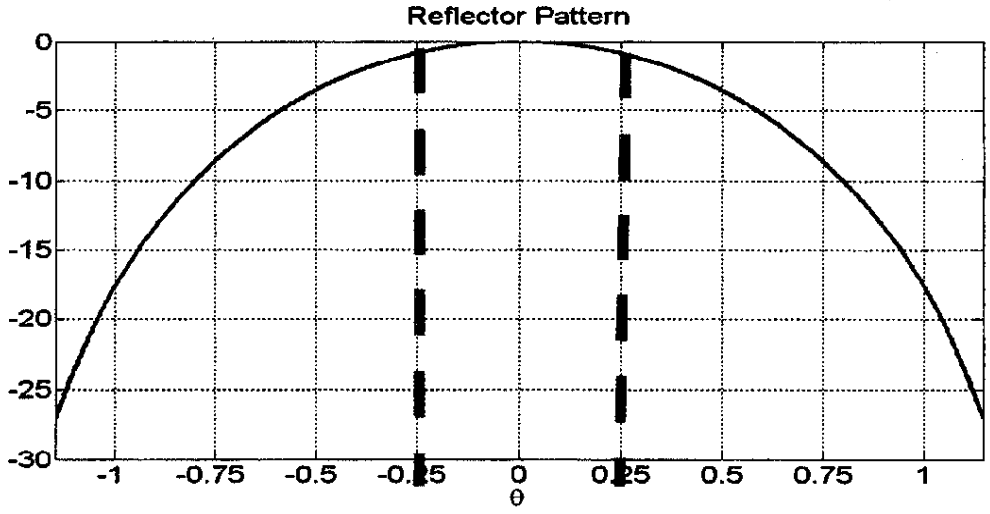


Fig 10. Farfield pattern of a single array element

2.4 'Cost reduction' vs 'system capabilities degradation': thinned array optimization

Fig. 11 shows a feasible array of 39 reflectors which would generate an illuminating spot 5 x 20cm at 50m range. The total price of the system is related with the number of reflectors of the array: the higher number of reflectors the higher price of the system. It is possible to save cost by thinning the array and removing reflector elements without overly compromising the beam pattern. The grating lobes increase somewhat, but with careful design [5], the pattern will remain effective across the area of the torso.

Fig. 12 shows the resulting pattern when the number of reflectors per row is reduced from thirteen to eight. The number and the position of reflectors must be optimized to allow the antenna scanning the beam without pattern degradation.

Fig. 13 presents the antenna farfield pattern for a configuration with eight reflectors per row and different scanning angles. The lateral grating lobe levels remain below -5 dB, (-10 dB for two-way). As a result of optimizing the number of elements of the array in both horizontal and vertical dimensions, the final array configuration could appear as in Fig. 14.

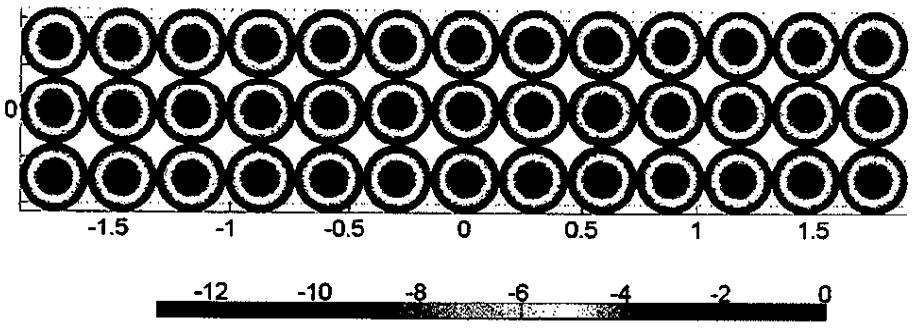


Fig 11. Array of reflectors producing a projected beam of 5 cm by 20 cm at fifty meters

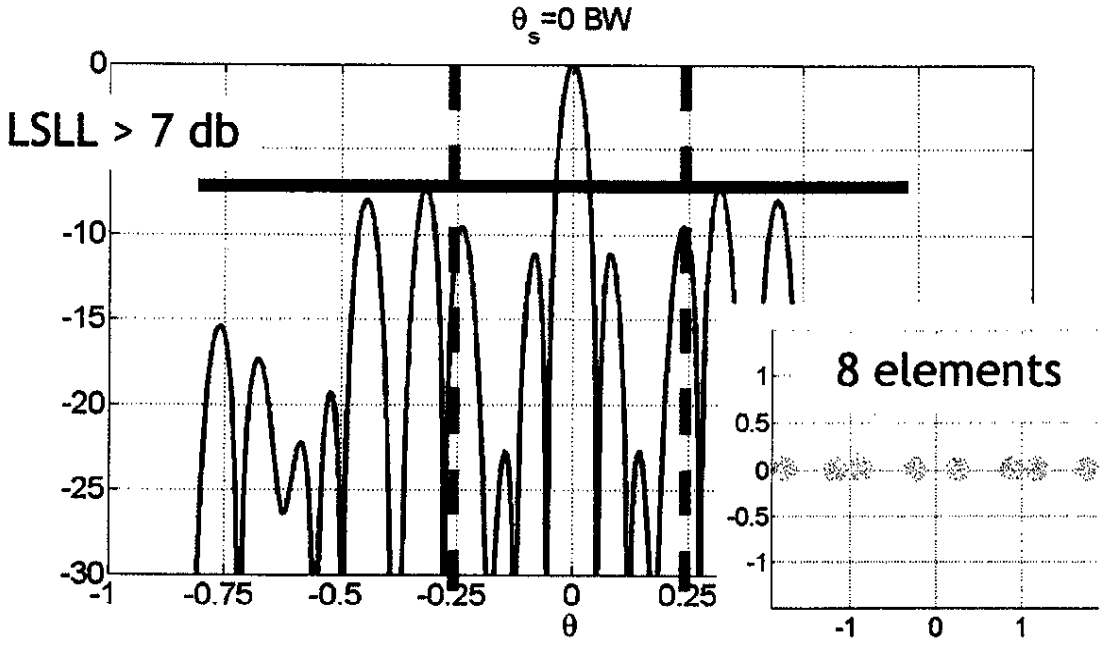


Fig 12. Array farfield pattern for a configuration with eight reflectors per row

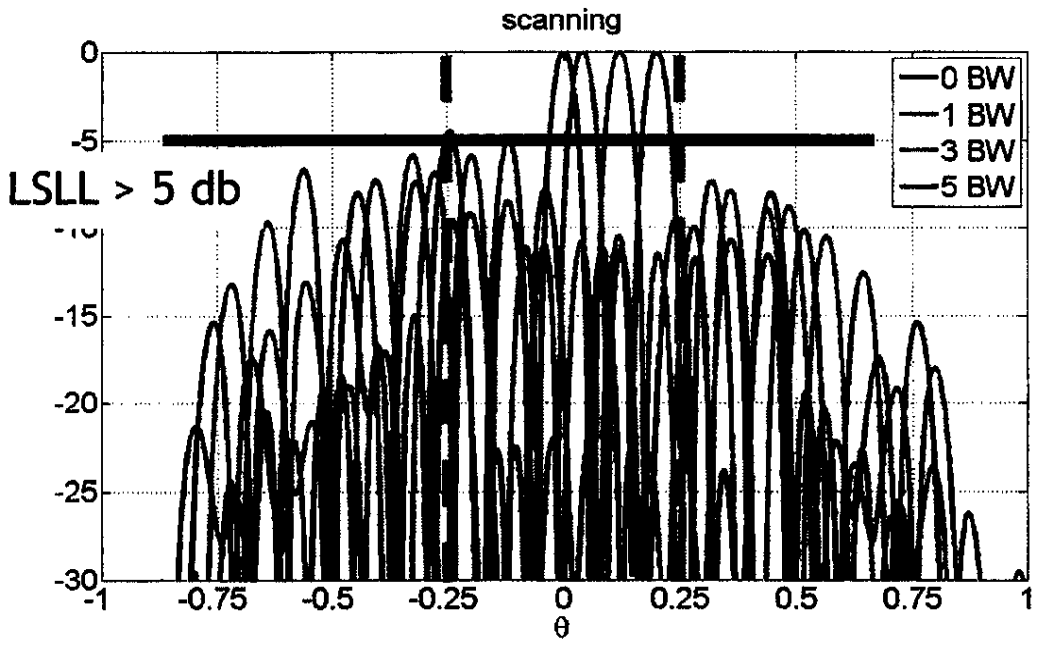


Fig 13. Array farfield pattern for different scanning conditions and eight reflectors per row configuration

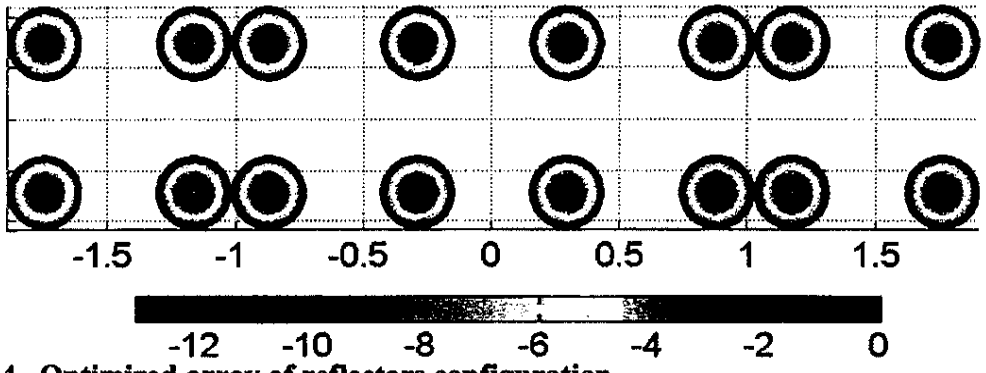


Fig 14. Optimized array of reflectors configuration

3 System Description: Hardware schematics

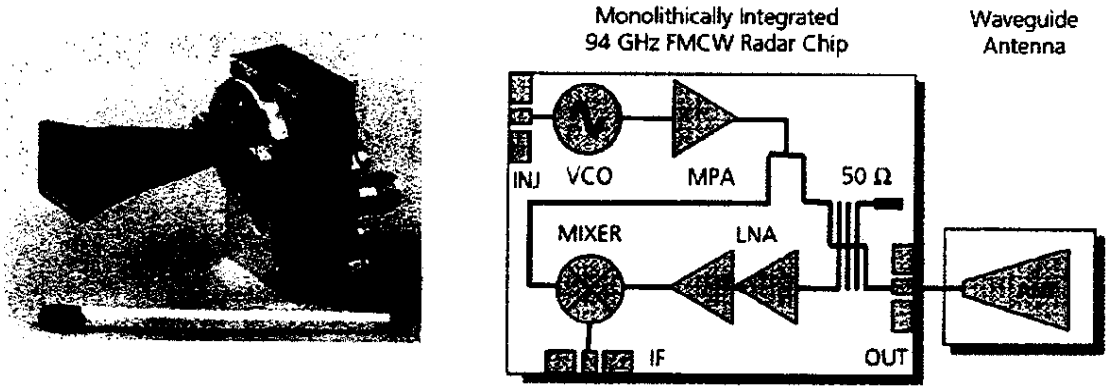
The system will be formed by the following elements:

3.1 Array of reflector antennas:

A set of reflector antennas will be used for increasing the gain of transmitting and receiving radar signal.

3.1 Frequency-Modulated Continuous-Wave (FMCW) Radar:

Each reflector will be fed whit a Frequency-Modulated Continuous-Wave radar, working at the W-band (94 GHz) [1]. The configuration #2 of [1] is proposed and presented in Fig. 5. The FMCW radar consists in transmitting a harmonic signal, with a fundamental frequency varying along time. This frequency is tuned by using a Voltage-Controlled Oscillator (VCO) moving the instant value along a 6 GHz bandwidth. The received signal from a scatter is first amplified by a Low Noise Amplifier (LAN), and later mixed with the harmonic signal produced by the VCO at the receiving time. The later procedure is equivalent to extract phase information form the received signal.



(a) (b)

Fig 14. Frequency-Modulated Continuous-Wave (FMCW) Radar (figures extracted from [6]), (a) physical implementation, (b) chip schematics.

3.2 Function generator

The VCO is controlled by a function generator -plugged at the INJ pin of the chip- and able to transform the non-linear response of the VCO (see Fig. 15) to the linear frequency increment required for the proposed application.

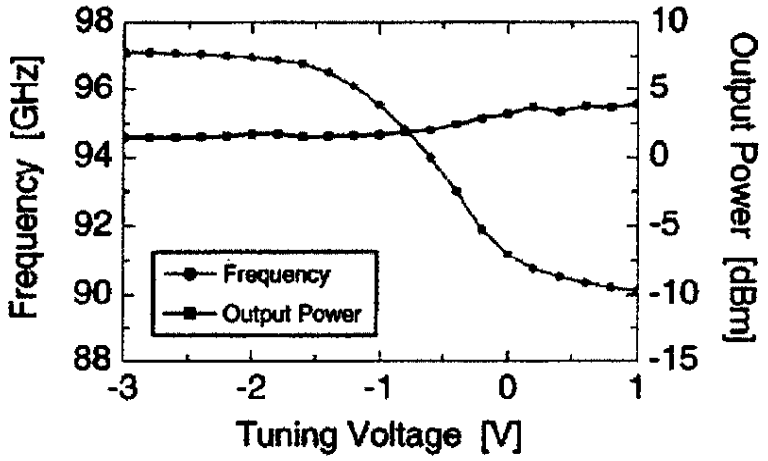


Fig 15. VCO response as a function of the Tuning voltage (figure extracted from [6]).

3.3 IF filtering and Analog to digital converter:

As a result of the mixing procedure, an intermediate frequency (IF) signal is achieved. It is important to emphasize that it has a narrow bandwidth – if compared with the w-band signal – which depends on the difference between the maximum and minimum range as well as the chirp rate of the FM modulation. Finally, the IF signal must be band-filtered and then converted into a digital format by using a Data Acquisition Card (DAC).

3.4 Switching Network:

Each reflector is transmitting at different temporal slots. Under this assumption a switching network can be used to commute the function generator signal to different array elements.

3.4 Personal Computer :

Once the information is received, some digital signal processing algorithms must be applied to the raw data. This task can be performed by using a personal computer.

4. Statement of Work and Schedule for Millimeter-Wave Radar Detection of Suicide Bombers –Phase I Extension

Carey Rappaport, Jose Martinez

Six months of effort

1. Based on the novel wide aperture antenna array concept already modeled and developed in Phase I, establish specifications for, and design a single multi-monostatic mm-wave element of the full array. March 1, 2008

2. Purchase 94 GHz radar hardware with available In-phase and Quadrature output from vendor. Delivery: April 1, 2008

3. Purchase supporting electronics from other vendors. March 15, 2008

4. Purchase, assemble and test data acquisition hardware. March 15, 2008

5. Design and fabricate or purchase a standard gain feed and a reflector antenna for radar. April 15, 2008

6. Build the radar element by combining source, antennas, and drive electronics. May 15, 2008

7. Fabricate an adjustable support structure for mounting and repositioning the single element to simulate a full array of stationary elements. June 1, 2008

8. Test the array antenna mm-wave radar element indoors in a large W-band rated anechoic chamber. Compare with modeled results. August 15, 2008

9. Report on results. September 1, 2008

Budget for Capital Equipment

Single Radar unit	$11,000
Support electronics	3500
Data acquisition hardware	2000
Mounting hardware	1500
Reflector antenna	500
TOTAL	$18,500

5. References

[1] Martinez-Lorenzo, J. A., Rappaport, C. M., Sullivan, R. and Pino, A. G. "A Bi-static Gregorian Confocal Dual Reflector Antenna for a Bomb Detection Radar System". , *AP-S 2007, IEEE AP-S International Symposium*, Honolulu, Hawai'i, USA, Jun. 2007.

[2] Sheen, D., McMakin, D., Hall, T., "Three-Dimensional Millimeter Wave Imaging for Concealed Weapon Detection," *IEEE T-MTT*, Sept., 2001

[3] Gonzalez-Valdes, B., Martínez-Lorenzo, J. A., Pino, A. G. and Rappaport, C. M. "Zooming Techniques for a Gregorian Confocal Dual Reflector Antenna" *AP-S 2007, IEEE AP-S International Symposium*, Honolulu, Hawai'i, USA, Jun. 2007.

[4] Gonzalez-Valdes, B., Martínez-Lorenzo, J. A., Pino, A. G. and Rappaport, C. M "Zooming and scanning a beam by hybrid mechanical-electronic pointing systems". *ESA Antenna Workshop on Space Antenna Systems and Technologies*, Noordwijk, Netherlands, Jun. 2007.

[5] Rappaport, C., "High Resolution Thinned Array Synthesis Based on an Optimized Mapping Function," *1986 Antennas and Propagation Soc. / URSI Symp. Digest*, pp. 375-378, June, 1986.

[6] "Compact single-chip W-band FMCW Radar Modules for commercial high-Resolution Sensor Applications", IEEE T. MTT, vol 50. no. 12, December 2002.

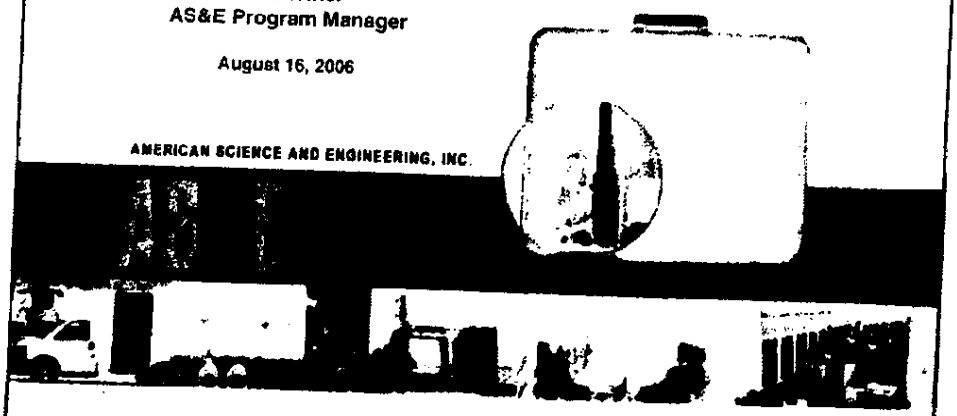
BomDetec

Kick-off Meeting

Mike Winer
AS&E Program Manager

August 16, 2006

AMERICAN SCIENCE AND ENGINEERING, INC.



Team

- *Mike Winer – Program Management*
- *Peter Rothschild – Science (Principle Investigator)*
- *Rajen Sud – Systems Engineer (EE)*
- *John Handy – Software Engineer*
- *TBD – Mechanical Engineer*
- *Brian Sullivan – Finance*
- *Rich Wronski – Product Management*

Task Detail

3.1 **Develop System Hardware Design**
- Work with partners to gather information
  - Mechanical Design
  - Electrical Design (Power, Control, Signal)
  - Thermal Design
  - Software Design (Control Software integration, Data Acquisition, Data Analysis and Fusion)

3.2 **Develop X-ray Sensor Evalustion Criteria**

3.3 **Evaluate X-ray Sensor Data**

3.4 **Develop System Configuration Concept**

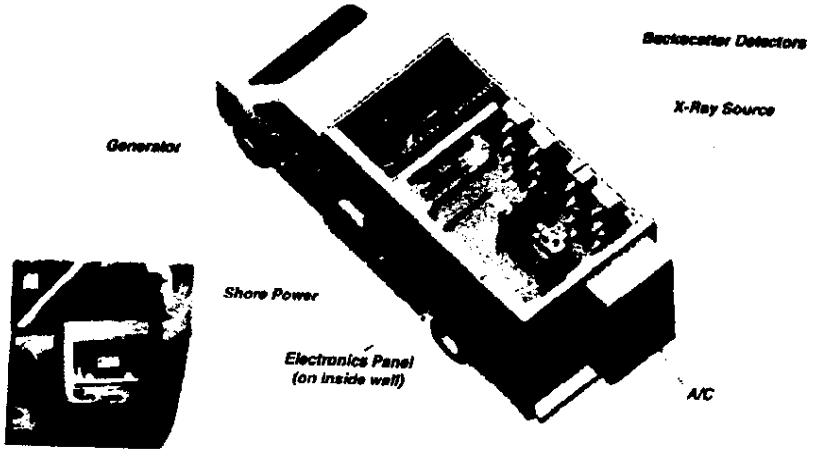
3.5 **Preliminary Design Review (PDR)**
- X-ray sensor and hardware integration

3.6 **Write Phase 1 Final Report**
- X-ray sensor and hardware integration

3.7 **Program Management**
- Technical (planning, tracking, managing)
- Financial (planning, tracking, managing)
- Schedule (Gantt, deliverables, milestones)
- Communication (weekly meeting, monthly technical / cost progress reports, reviews, final report)
- Program Support (travel, meetings, contract)
- System Configuration Concept
- Preliminary Design Review Coordination
- Phase 1 Final Report Coordination

ZBV

Major Components



Needed Sensor Information

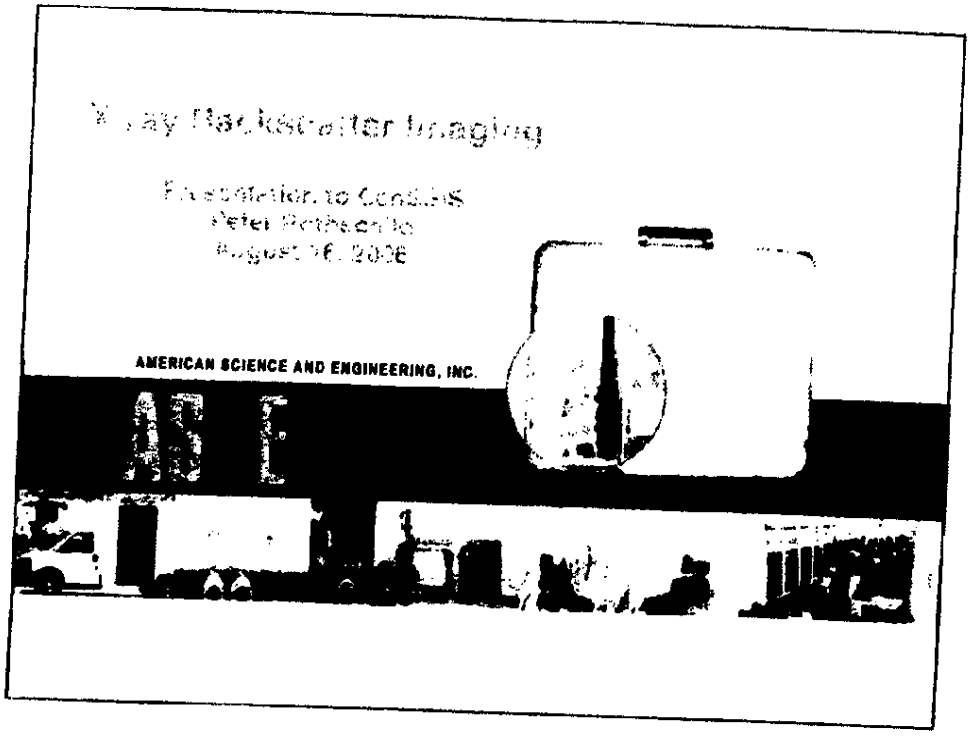
- Power Requirement
  - Voltage
  - Current
  - Peak
  - Continuous
- Size
  - Footprint
  - Volume
- Placement
  - Particular orientation of components
  - Arrangement order
  - Line of site

Needed Sensor Information

- Mechanical interface
  - Mounting holes
  - Couplings
- Motion
  - Any concerns with vibration
- Electrical Interface
  - Power connectors
  - Control I/O connections
  - Communication method and connections
- Grounding
  - Any special grounding needs
  - EMI/RFI
    - Emission issues
    - Susceptibility issues

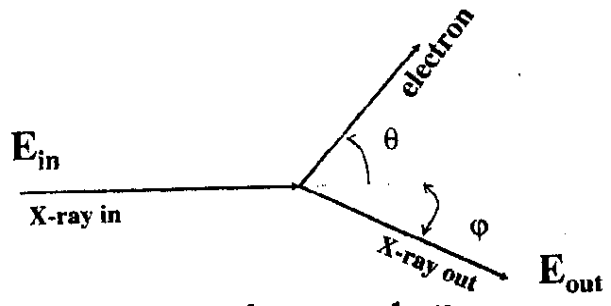
Needed Sensor Information

- Environmental
  - Maximum/minimum operating temperature and humidity
  - Maximum/minimum storage temperature and humidity
  - Cooling Requirements
    - Airflow
- Safety
  - Compliance Requirements
- Theory of Operation
  - Few pages describing how the sensor works
  - Do's and Don'ts



Outline

- Physics of Compton Scatter of X-Rays
- How Is a Backscatter Image Formed?
- Material discrimination with X-Ray backscatter
- AS&E's Z Backscatter Van (ZBV)
- Long Distance Imaging of Suicide Bombers
- Radiation Safety

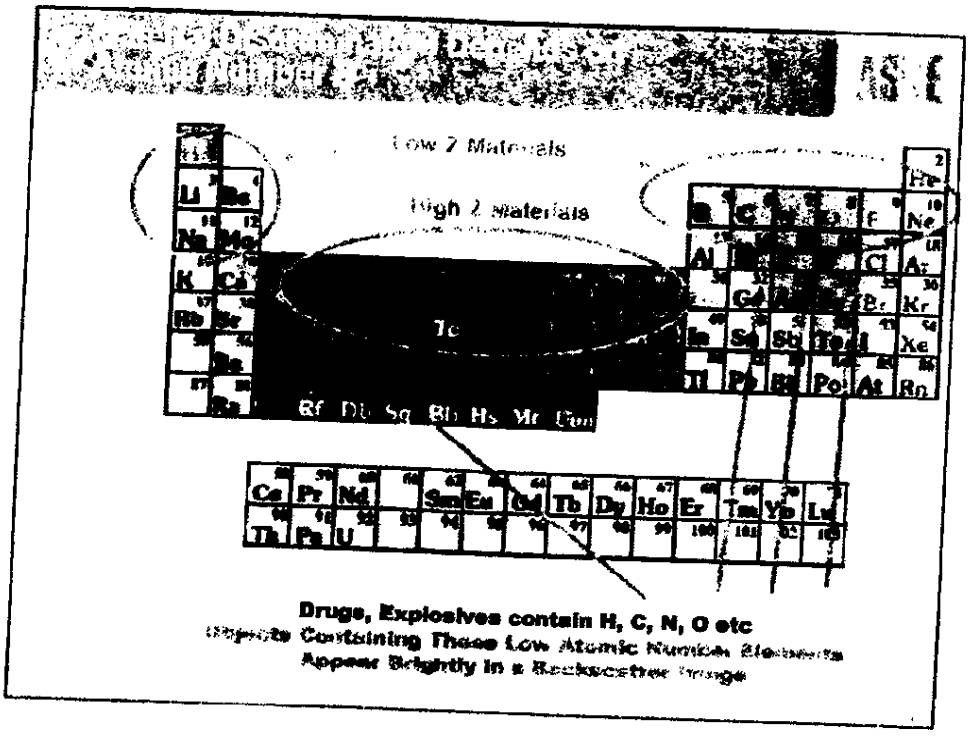


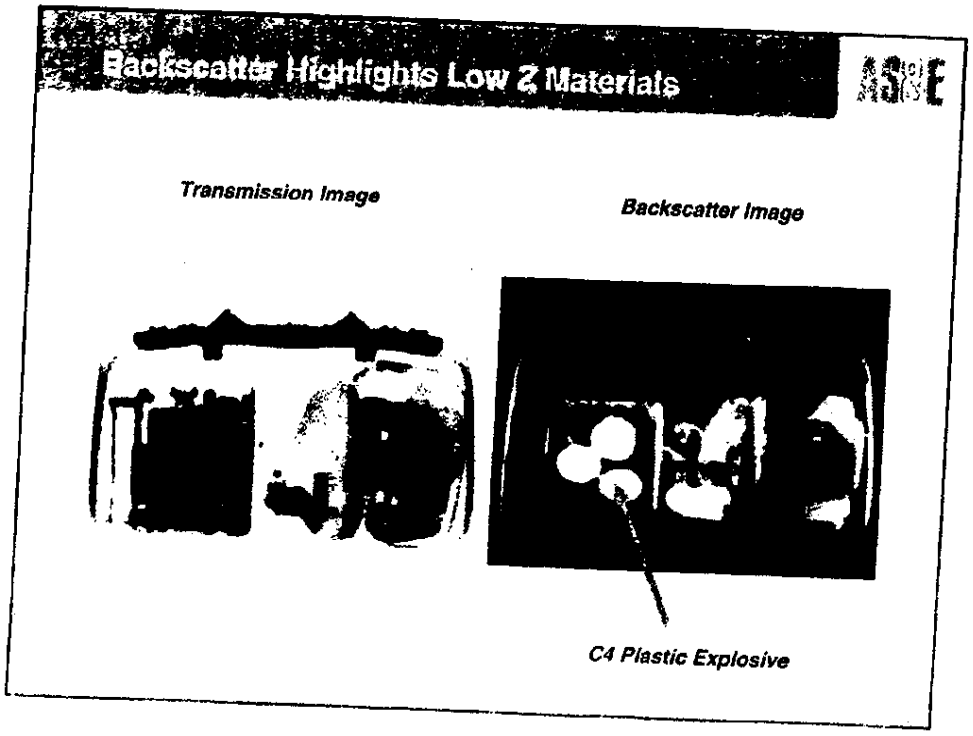
Use energy and momentum conservation to find that:

$$E_{out} / E_{in} = 1 / (1 + \alpha (1 - \cos\varphi))$$

$$\text{where } \alpha = E_{in} / m_e c^2$$

Backscatter Imaging with a Flying Spot


Low Z Materials
High Z Materials
Drugs, Explosives contain H, C, N, O etc


Backscatter Highlights Low Z Materials
Transmission Image
Backscatter Image
C4 Plastic Explosive

Bodysearch Reveals Both Metallic and Non-Metallic Objects

750 gm Cocaine simulant

Wrist Watch

Coin

9mm Handgun

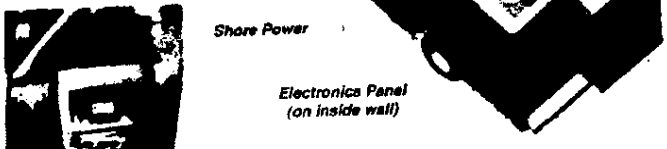
500 gm Cocaine Simulant

9mm Glock with plastic handle

File

Plastic Knife

Schematic of the Z Backscatter Van (ZBV)



Backscatter Detectors

X-Ray Source

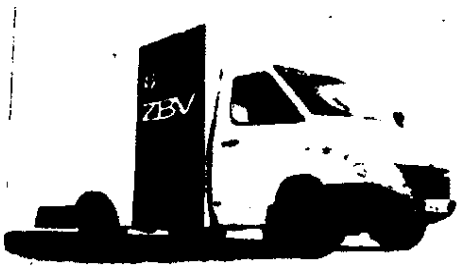
Generator

Shore Power

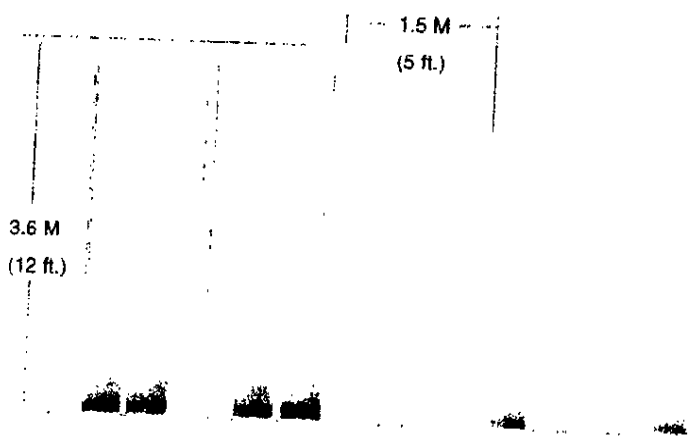
Electronics Panel (on inside wall)

A/C

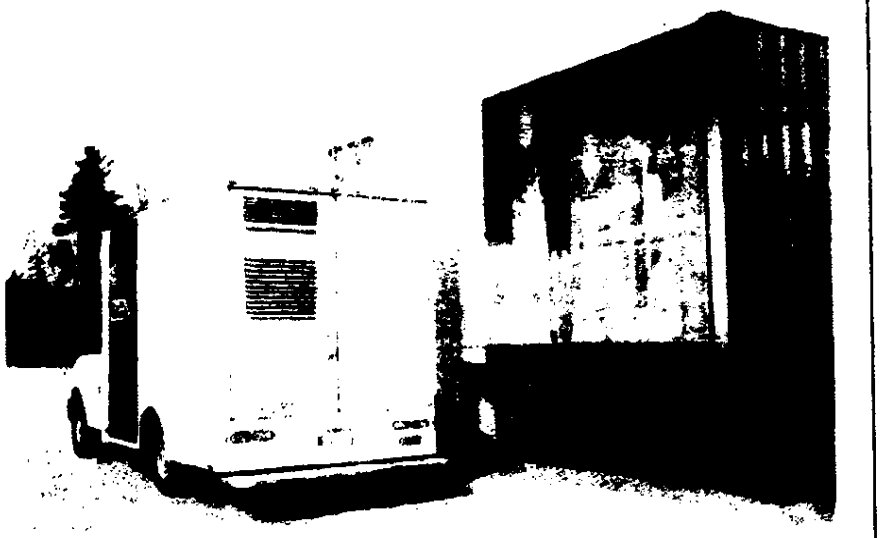
- Single-Sided Inspection
  - Side set at Factory
- Backscatter Only
  - 225 KeV
- Vehicle Offering
  - Mercedes Sprinter (Diesel)
- 1 or 2 Operators
- Multiple Speeds
  - 0.5, 1.5, 5 & 10 kph
  - 0.3, 1, 3, & 7 mph
- RTD Option



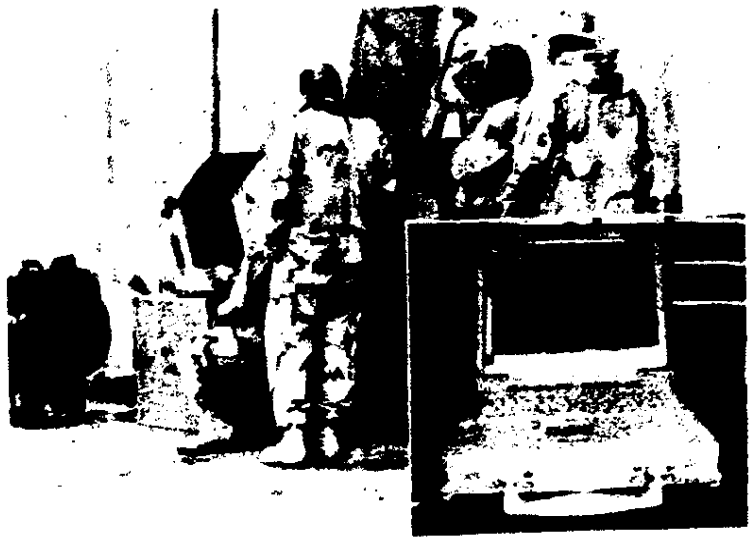
ZBV System Field of View

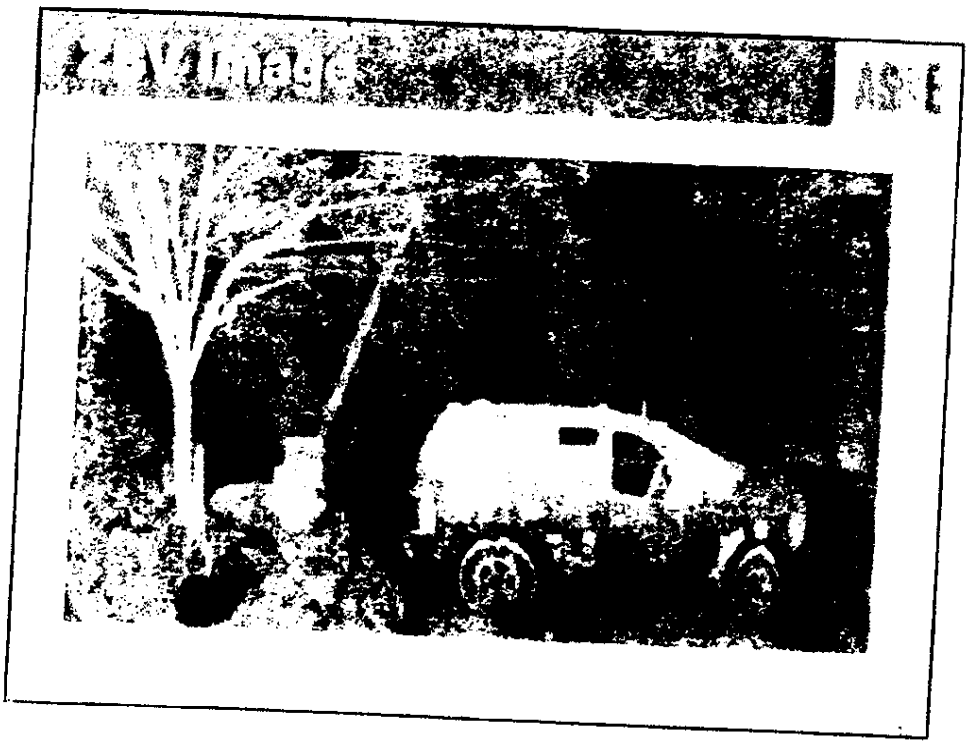


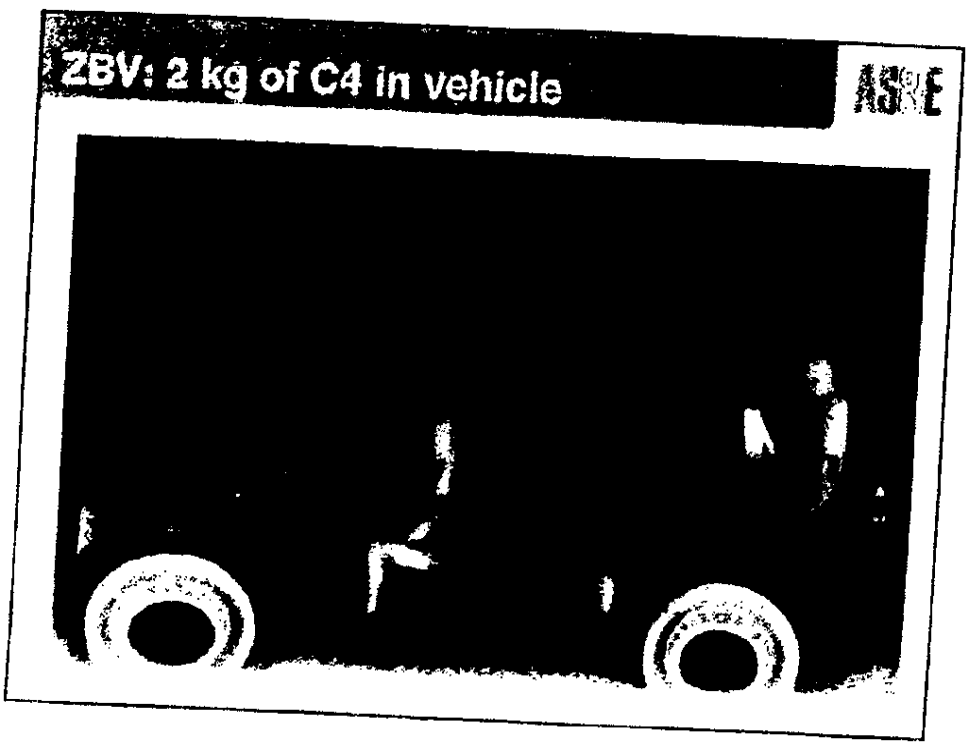
The Effect of ZBV



ZBV Deployment with Remote Operation





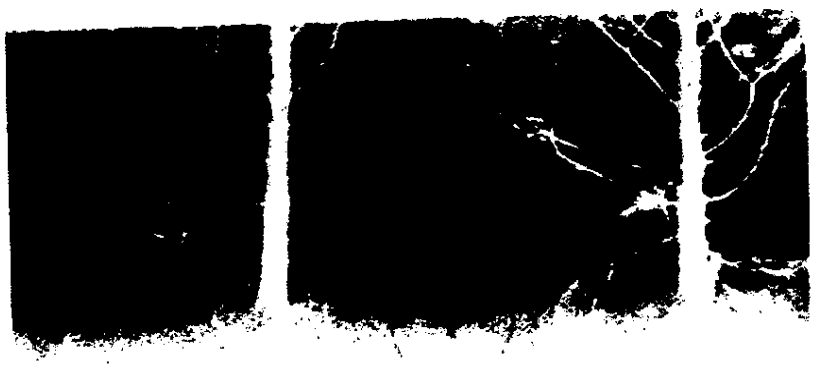

ZBV: 2 kg of C4 in vehicle

A Quick Way to Examine Large Objects

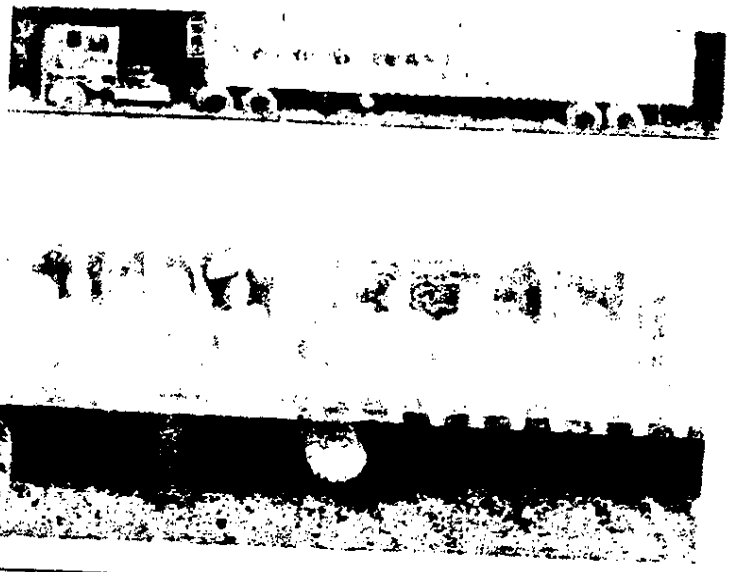
One-sided Imaging Allows for Simple Inspections

Helicopter

X-ray Backscatter Strips Foliage



Backscatter Image of Illegal Immigrants



Challenges with Long-Distance Imaging

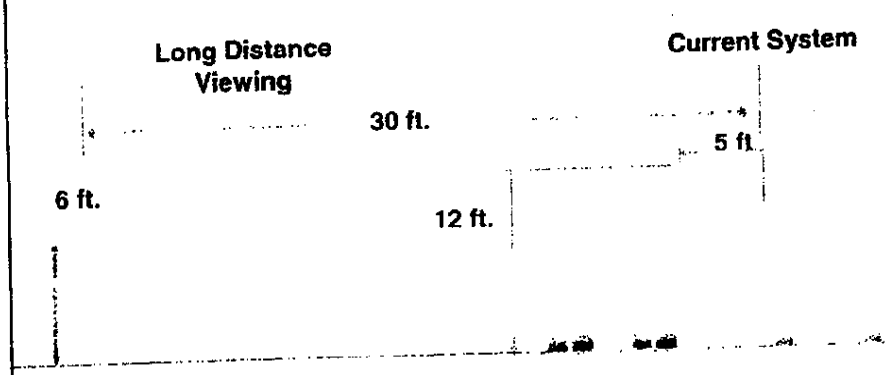
- X-ray beam is diverging so resolution of image decreases rapidly with distance
- Backscatter signal decreases by the square of the distance due to geometry (going from 5 feet to 30 feet reduces the detected signal by 1/36)
- Air scatter further reduces the detected backscatter signal and creates a background "fog"

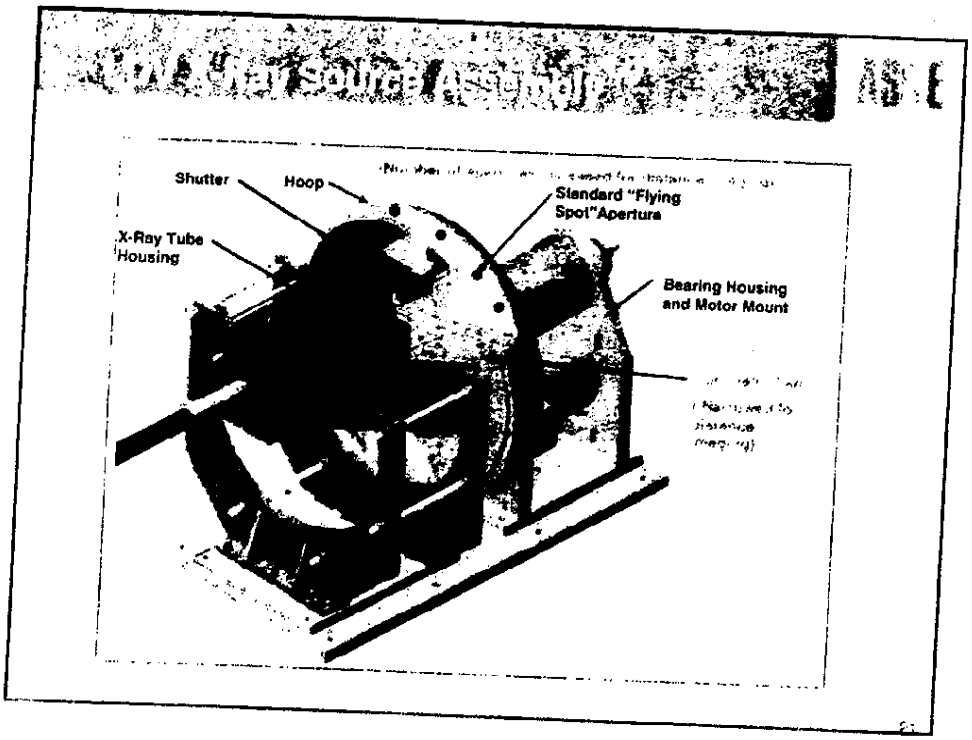
Solution

- High power x-ray source with a small focal spot (powerful beam with low divergence)
- Collimate primary beam to prevent air scatter into detectors
- Collimate detectors so that they cannot see the air scatter
- Used pulsed x-ray sources to reduce contribution of detector noise to the backscatter signal

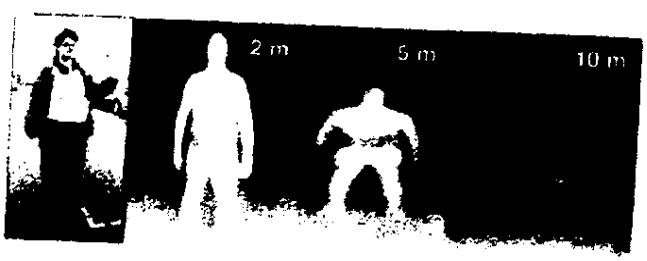
Long Distance Viewing (LDV) – 30 feet

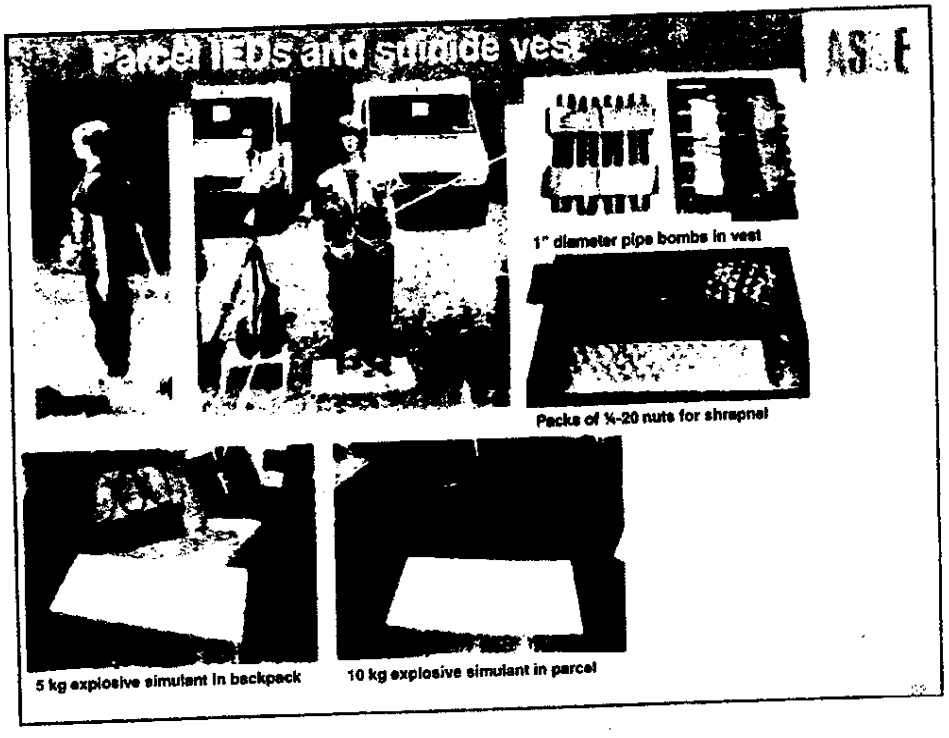
- **Increased range – Requires more X-ray flux**
  - **Can be achieved with a smaller FoV**

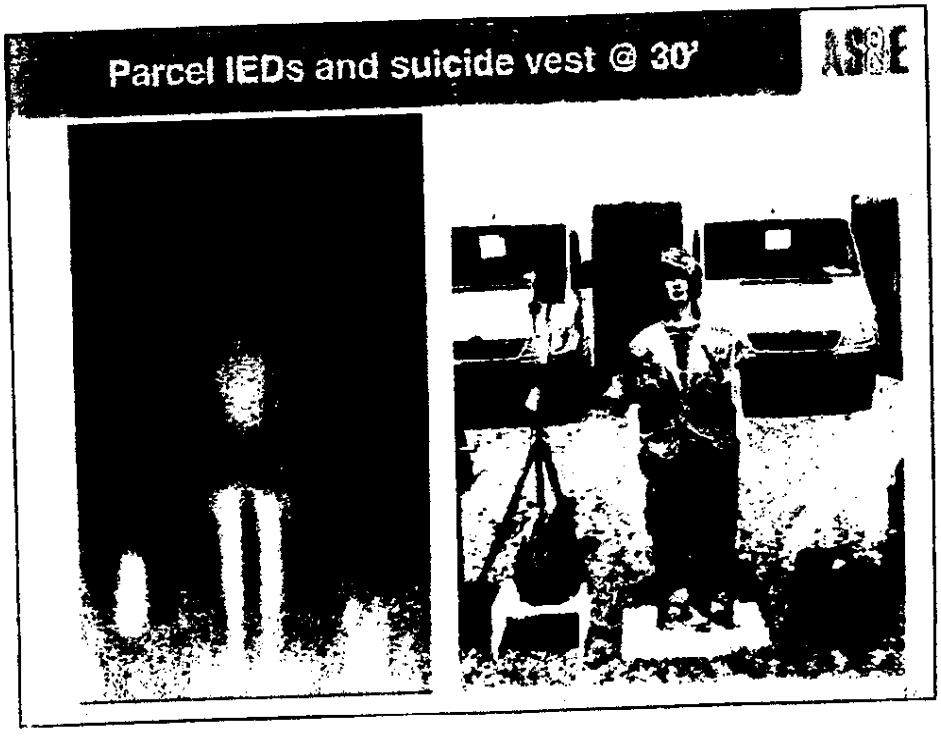




Suicide Bomber at Various Distances




Parcel IEDs and suicide vest
ASSE
1" diameter pipe bombs in vest
Packs of ¼-20 nuts for shrapnel
5 kg explosive simulant in backpack
10 kg explosive simulant in parcel


Parcel IEDs and suicide vest @ 30'
ASSE

Typical Radiation Doses

• 1 SmartCheck Inspection	0.05 μSv
• 1 ZBV Inspection (at 1.5 km/hr)	0.07 μSv
• 1 LDV Inspection	0.25 μSv
• Airplane Flight (10,000 km)	50 μSv
• Chest X-ray	50 - 100 μSv

Note 10 μSv = 1 mrem; 1 μSv=100 μrem

Background radiation ≅ 8 to 10 μSv/day

DISCLAIMER ABOUT SCANNING PEOPLE

- **RADIATION DOSE IS EXTREMELY LOW**
  - Radiation dose from the LDV is measured in tens of micro-R.
  - People who are scanned by the LDV will not be harmed
- **LDV is not, and will not be, a "certified people scanner"**
  - Dose is too high to comply with N43.17, which requires dose per scan ≤ 10 micro-R
  - ANSI N43.17 is the only standard which addresses the issue of irradiating people for security applications
  - This standard was designed for applications such as BodySearch
  - This standard is neither a law nor a regulation. Neither ANSI nor CDRH certifies that equipment complies with the standard.
  - ANSI N43.17 requires many additional safety features which would be difficult or unfeasible to implement in the LDV system
  - ANSI N43.17 requires that people give consent to be scanned. Therefore it is not applicable to covert operations

Center for Subsurface Sensing and Imaging Systems

BomDetec Program
Phase I Kick-Off Meeting
August 16, 2006

HSARPA - Sponsor

Northeastern University (Lead)
- Siemens CR&D
- Raytheon
- AS&E
- RPI
- PPT

Kick – Off Meeting Agenda

- Opening Remarks & Introduction
- Program Overview
- Operational Overview
- BomDetec Sensors
  - Intelligent Video
  - Millimeter Wave Radar
  - X-ray Backscatter
  - Terahertz
- Integration of Software and Hardware
- Programmatic Discussion

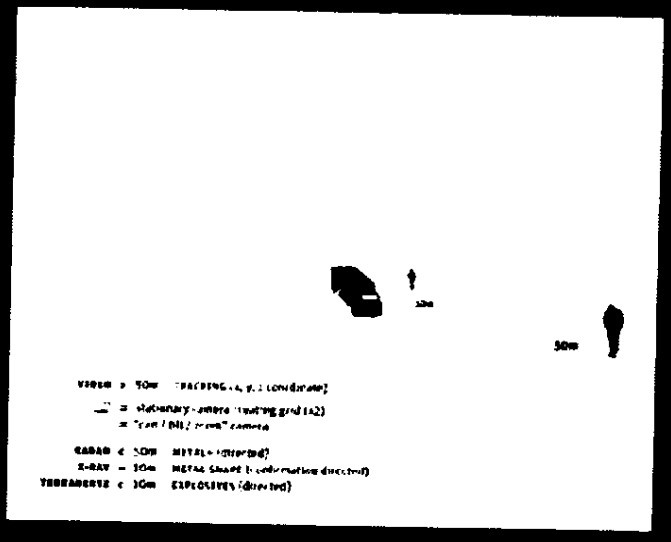
Program Strategy

- Suicide Bomber Detection
  - Person
  - Metal
  - Explosive
- There is No Silver Bullet
- A Flexible Platform or "Mainframe"
  - Capable of Adapting to Future Technological Advances

Program Overview

- A Flexible Mainframe
  - Software
    - Coordinate System (X, Y, Z)
    - Tracking System for People in the FOV
    - GUI
    - Data Analysis, Fusion
    - Database
  - Hardware
    - VAN
      - Power
      - Thermal Regulation
      - Mechanical Support
    - Sensors
    - *(Intelligent Video, Radar, X-ray, Terahertz, Other)*

Program Overview



Program Overview, Contract Issues

- Final revision to Proposal sent by NU to DHS in late June.
- Notice to Proceed Letter Dated 7/10/06 received from DHS Contracting Officer. Stipulates reimbursement contingent on contract execution.
- Northeastern Letters of Authorization sent to four Phase 1 Subcontractors on 7/24/06.
- Ongoing discussion among all Collaborators to ensure appropriate NDA'S are in place for duration of project.
- Request for additional cost detail received from DHS on 8/11 and forwarded to Collaborators on 8/14.
- Potential Contracting Issues that could be stumbling have been discussed with DHS. Appears to be potential resolution.
- Once Contract in place with Northeastern plan is to lift restriction on Subcontractors.

Programmatic Discussion

- Monthly Reports
  - Title Page (1 pg.)
  - Gantt Chart (1 pg.)
  - Hardware Software Status (1 pg.)
  - Funding Profile ($/month, actual & forecast) (1 pg. – graph)
  - Notable Accomplishments & Events (1 pg.)
  - Program Issues and Concerns (1 pg.)
- Measurement Tools
  - Gantt Chart and % Complete by SOW
  - Financial Numbers (expenses) by SOW

Concealed Explosives Detection Using Active Millimeter Wave Radar

Carey Rappaport, Northeastern University
John Firda, Raytheon, Inc.

BomDetect Kick-off Meeting August 16, 2006

Raytheon
Integrated Defense Systems

PPT

Presentations

- Radar and antenna phenomenology background
  - Carey Rappaport, Northeastern University
- Suicide bomber detection, Personal Protection Technologies, Inc.
  - Carey Rappaport
- Radar hardware and testing
  - John Firda, Raytheon, Inc.

Goals for Millimeter Wave Radar Approach for BomDetect

- Long range indicator of potential threat
- Real time operation
- Threat declaration algorithms based on prior work.
  - Bomber with explosive vest has higher radar cross-section than normal subject
  - Bomber indication is polarization sensitive and provides a discriminator
- Validation and performance metrics for explosive target detection/discrimination
- Handover of hardware specifications and data format to systems integrator

Homeland Security

Northeastern University

Polarimetric MMW Radar Discrimination of Hazardous Body-Worn Targets

Carey Rappaport, NEU

BomDetect Kick-off Meeting August 16, 2006

Raytheon Integrated Defense Systems

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Outline

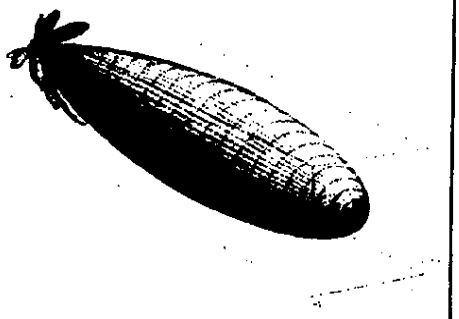
- Basics and tradeoffs of radar explosives detection
- Antenna analysis for best discrimination
- Microwave characteristics of media in scene
- Modeling wave interaction with target/body shapes
- Advantages of polarization feature detection

Basics and Tradeoffs of Radar Detection

- Transmitter sends waves in a beam to objects, which scatter waves back to receiver
- Scattering varies as size/shape/reflectivity of object
- Higher frequency allows for greater resolution/ discrimination with range and across field of view
- Bigger antennas form narrower beams which more selectively illuminate specific objects
- Scattering is proportional to the *cross section* of scatterer, which is usually comparable to projected area

Antenna Analysis

- Antenna beamwidth is inversely proportional to aperture
  - Separation distance between extreme points *D* of array
  - $BW_{3dB} = \lambda/D$
- Sidelobes generate clutter signal



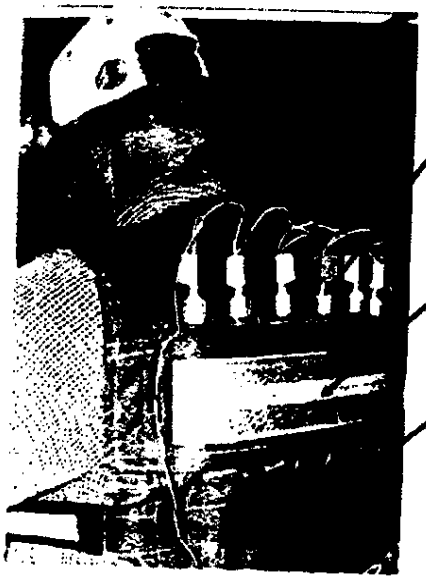
Required Beamwidth for Chest Spot

- At 50m, a 0.5m wide chest subtends 1/100 radian (0.6 deg.)
- The aperture required to produce this beam, ½ power at the edges of the chest is D = 100 λ
- At 77 GHz, λ = 3.9 mm, so the best aperture width is about 40 cm

Microwave Characteristics of Media

- Metal reflects 100% of incident waves
- Clothing (cotton, polyester, wool fabric) are relatively transparent to microwaves
- Human skin and muscle tissue at 77 GHz is very conductive, with $\sigma = 60$ S/m, and dielectric constant $\varepsilon' = 12$
  - Reflection Coefficient $\Gamma = 0.65$
- TNT and other explosives are insulators with a dielectric constant of about 3

Suicide Bomber IED Mock-Up



Metallic Cylinders

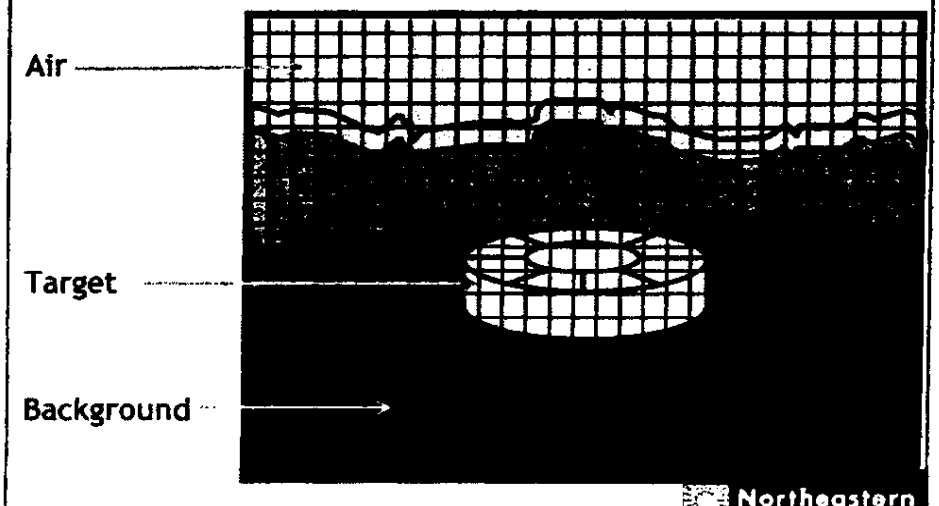
Nails

Polyester Vest

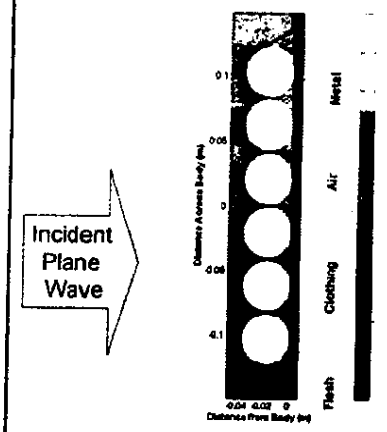
Contrasts / Features of IEDs

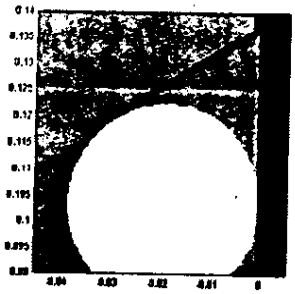
- Metal casing is common
  - –Nails/h ardware increases shrapnel yield
  - –Metal is easiest to detect with electromagnetic waves
- Tubes / pipes are typical
  - –Eas y geometry for packing explosive
  - –Fit on bod y effectively

Finite Difference Modeling



2D Discretization Geometry





Metal Cylinder with Clothing Detail

View from Above

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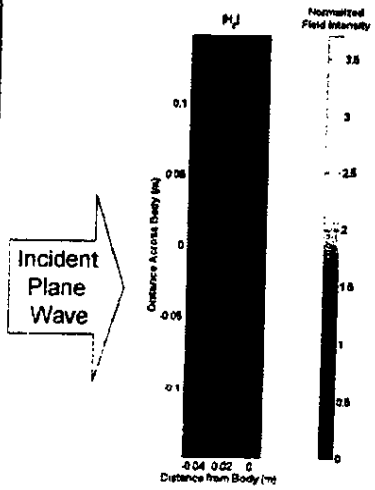
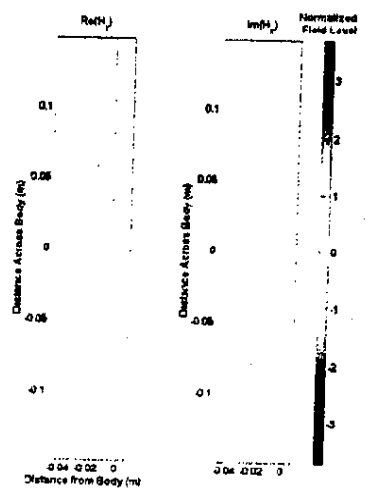
Specular Reflected 25 GHz Field from Flat Body Only





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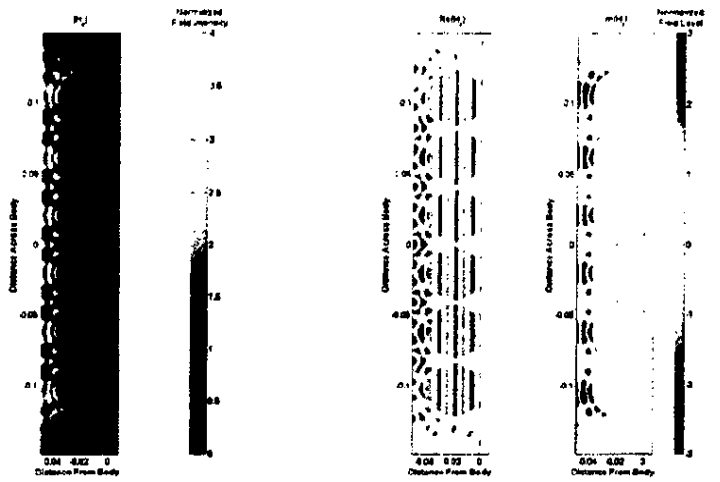
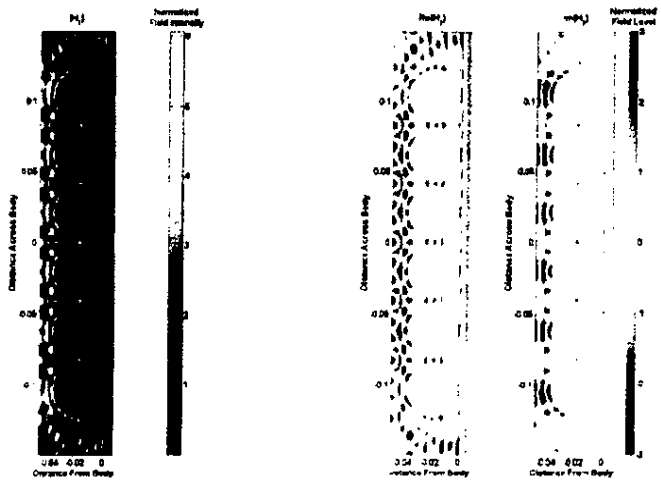
Nearfield 25 GHz Scattered Magnetic Field (H_z) Distribution



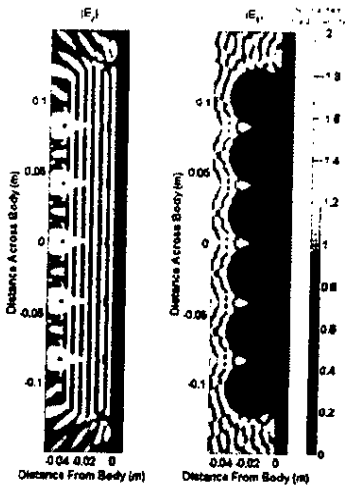
Northeastern University

Horizontal Polarization Total Magnetic Field (H_z)



Northeastern University

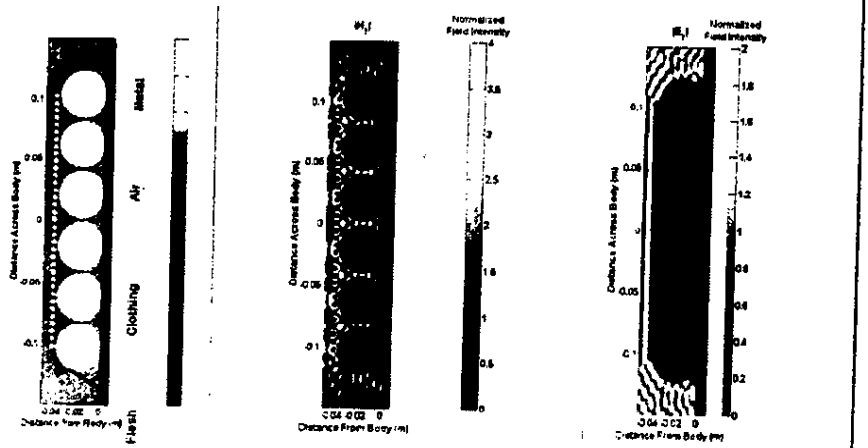
Vertical Polarization (E_z)



Scattered Field Total Field

Northeastern University

6 Metal Cylinders, 35 Nails: Horizontal (H_z) and Vertical (E_z) Polarization

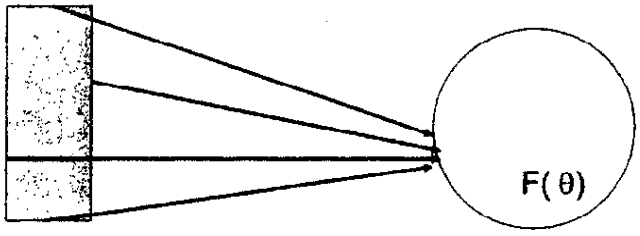


Total H Field Total E Field

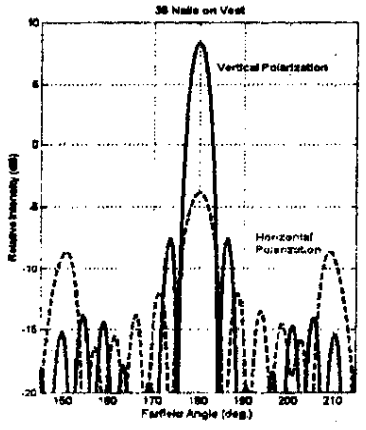
Northeastern University

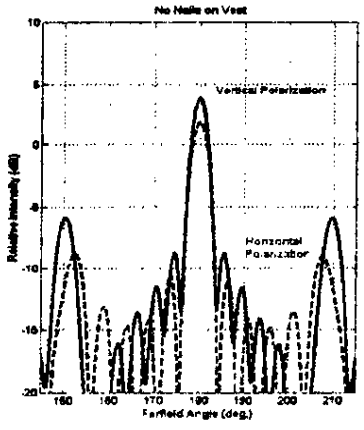
Nearfield to Farfield Conversion

- Integrate fields on bounding box surrounding scatterers
- Use farfield approximations to get intensity as a function of angle



2D Farfield Patterns for Vertically and Horizontally Polarized Illumination





35 Nails on Vest **No Nails on Vest**

Background Conclusions

- Radar effectiveness depends on characteristics of IED target, body, and background
- Antennas play and important role in distinguishing targets
- Modeling is effective in efficiently analyzing scattering of complex objects in the presence of non-ideal media
- Metal cylinders scatter in unexpected ways
- Nails have a noticeable farfield scatting effect
- Scattering is different for vertical and horizontal polarizations
- Polarization may offer a distinguishing feature for body-worn IEDs

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Radar Suicide Bomber Detection Tasks -
Phase I Get radar, configure processing, establish testing

	Primary	Secondary	Secondary
1 Identify radars to be used/studied on the program	Ray		
2 Obtain transmission license approvals	Ray		
3. Provide radar specifications including available data, data output format, data rates	Ray		
4 Define required data output	PPT	Ray	
5 Determine if available data is sufficient for gross conclusions that validate existing data	PPT		
6 Determine if available data is sufficient for algorithm input	PPT		
7 Determine basic modifications to radars (if needed) to provide required data output	PPT	Ray	
8 Determine if modifications needed can be accomplished in Phase I	Ray		
9 Define data output format	PPT	Ray	
10 Run initial, simple experiments to baseline radar performance with and without target simulants	PPT	NEU	Ray
11 Evaluate the results (phenomenonological interpretation)	PPT	NEU	
12 Develop detailed experimental testing protocol in indoor/outdoor environments	NEU		
13 Identify subjects, clothing, targets, innocent objects	PPT	NEU	
14 Identify environmental clutter to be used	PPT	NEU	
15 Define the system requirements, software data requirement specifications for Operating Envelope including antenna coverage size	Ray	PPT	NEU
16 If different antenna required, design wider aperture tighter beam, polarization grating, etc	NEU	Ray	PPT
17 Determine modifications needed to obtain pulse to pulse VV, HH and VH data	NEU		
18 Determine advantages modifications for other polarizations	NEU		
19 Define approach to obtaining pulse to pulse VV, HH, VH, and other polarization data	Ray	PPT	
20 Develop multi-polarization algorithms based on theoretical backscatter predictions	NEU		
21 Design experiments to validate the algorithms	NEU		
22 Investigate clutter reduction approaches	NEU		

Northeastern

Radar Detection of Suicide Bomber Explosives

Carey Rappaport, NEU
Lester Kosowsky (PPT)

BomDetect Kick-off Meeting August 16, 2006

Raytheon
Integrated Defense Systems

PPT

Outline

- Accomplishments to Date
- Program Overview and Statement of Work
- Team and Their Tasks

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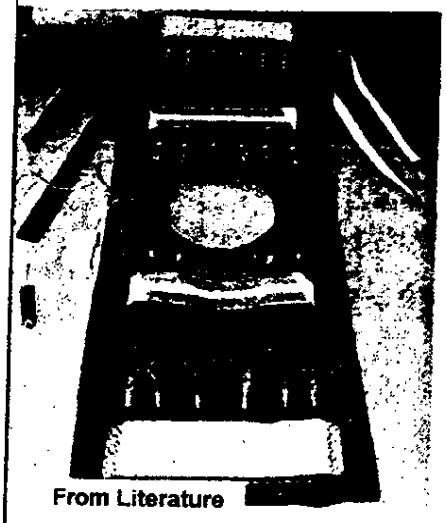
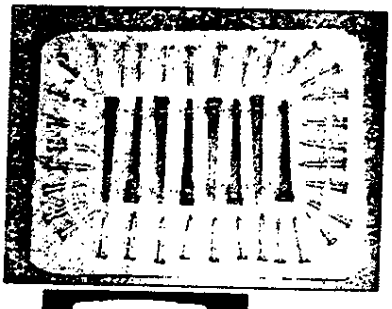
Homicide Vests – Real and Surrogate

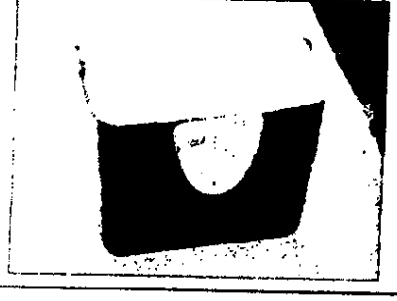


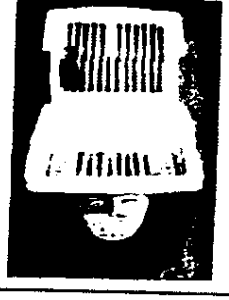
From Literature

PPT Mock-up

Carried in Explosive Surrogate







PPT

MMW Concealed Weapons Detection Requirements – Past Accomplishment

- Detection of concealed explosives or metallic and non-metallic weapons carried on persons under clothing
  - in controlled environments
  - in uncontrolled environments
  - at distances < 20 meters
- Design constraints
  - Appropriate indoors and out
  - Benign to people and property

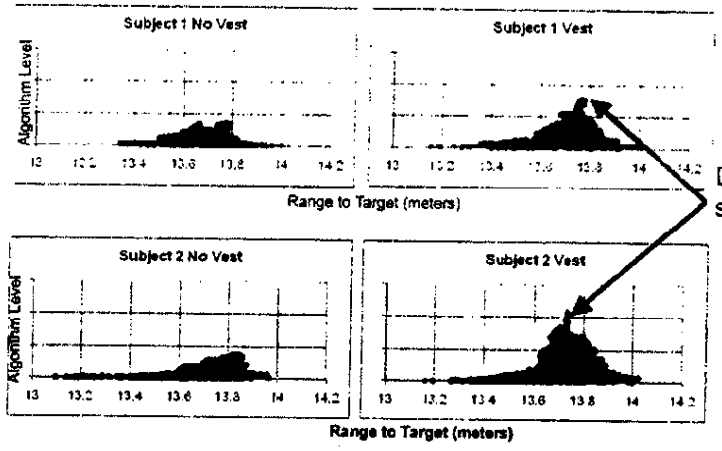
PPT

Typical Set-up – With and Without Vest (Corner Reflector in Background)

Subject at 14 meters from Radar, Reference Corner Reflector at 17 meters

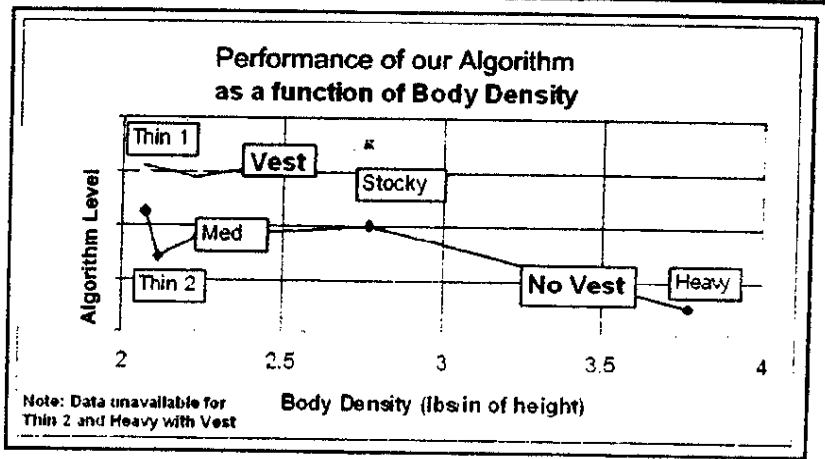
PPT

Performance of Algorithm – Vest



PPT

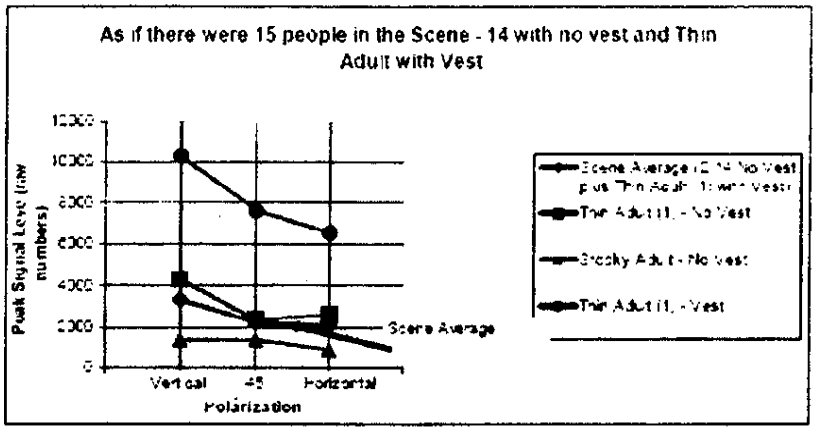
For all Body Densities, a Person Wearing a Vest Always Appeared Dramatically Different



KEY: **Heavy – 5'9" 260 lbs;**
Stocky 5'6" 185 lbs;
Medium – 5'7" 150 lbs;
Thin 1 and Thin 2 – 5'9" 145 lbs

PPT

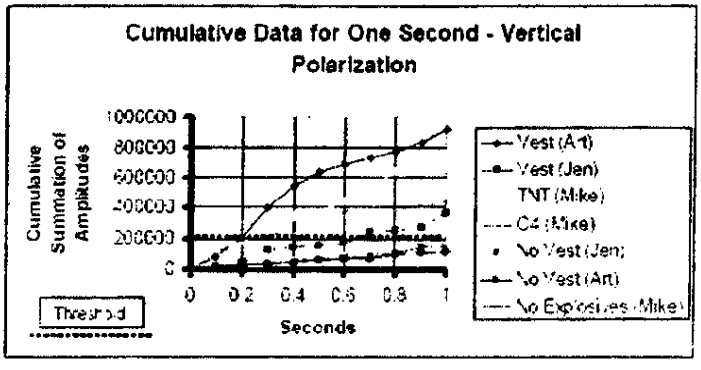
Polarimetric Radar Response from Single Individual Wearing Vest



Person with vest is distinguishable in a crowd

PPT

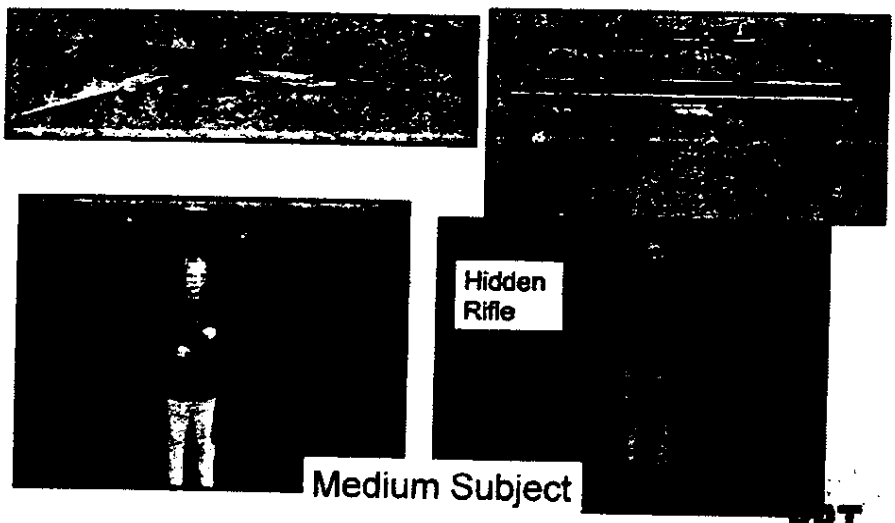
Cumulative Radar Response and Declaration Threshold



Vertical polarization consistently indicates presence of vest

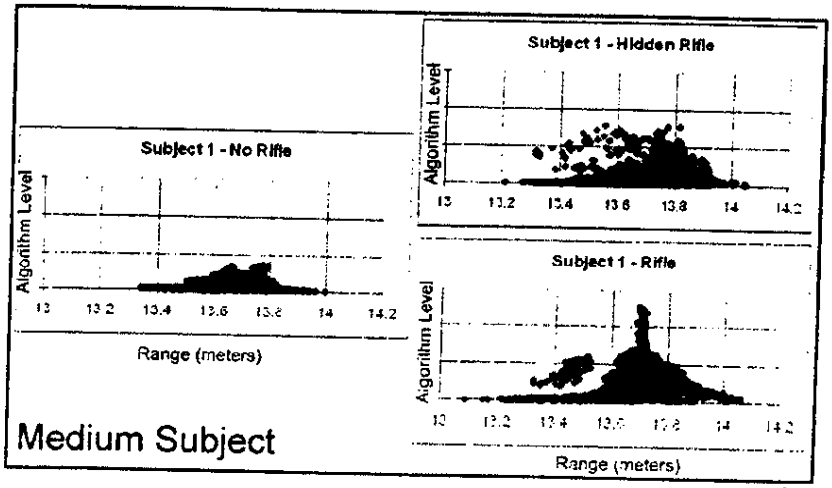
PPT

Rifle and Pistol Measurement Scenarios



PPT

Performance of Algorithm – Rifle



PPT

Deployment Scenarios

- Long Range, on the order of 50 meters, to detect and detain threatening individuals far enough from a potential target to deny a successful attack
- Discrete examination of pedestrian traffic for weapons and explosives at nearer ranges without the need for a designed portal

PPT

Scope

Concealed explosive indications are obtained from measurements of the millimeter wave radar returns using vertical and horizontal polarizations.

PPT

Homeland Security

Statement of Work: PPT Task Description

PPT

Homeland Security

Radar Program

- Identify radars to be used/studied on the program
- Obtain transmission license approvals
- Provide radar specifications
  - data output
  - data rates
- Define required data output and format
- Determine if available data is sufficient for gross conclusions that validate existing data
- Determine if available data is sufficient for algorithm input

PPT

Radar Program

- Determine basic modifications to radars (if needed) to provide required data output
- Determine if modifications to radar can be accomplished in Phase I
- ID outdoor test range
- Run initial, simple experiments to baseline radar performance with and without target simulants: outdoor testing
- Evaluate the results (phenomenonological interpretation)

PPT

Radar Program

- Identify subjects, clothing, targets, innocent objects
- Identify environmental clutter to be used
- Define the system requirements, software/data requirement specifications for Operating Envelope including antenna coverage/size
- Design antenna required for Phase II, design wider aperture/tighter beam, polarization.

PPT

Radar Program

- Define implementation to obtaining pulse to pulse VV and HH
- Develop multi-polarization algorithms based on theoretical backscatter predictions
- Develop System Configuration Concept (w/ team)

PPT

PPT Program Team

- PPT –Algorithm Development, Data Analysis, Experiment Planning and Execution
- ISL – Data Visualization, Algorithm Implementation, Threat Declaration
- Monarch Associates – Sensor Interfaces, Experiment Management
- New Haven Bomb Squad – Test Environment, Test Subjects, Test Objects and User Perspective

PPT

PPT Tasks

- Evaluate results of radar experiments
- Define interfaces and formats to mate radar output with video presentation
  - Raytheon output to ISL data grooming
  - ISL output to real time display of data as gathered
  - ISL output to data analysis methodology
  - ISL output to Siemens software

PPT

ISL Tasks

- Data Analysis
  - Convert Raytheon output to suitable form for PPT analysis
  - Develop a software / process raw radar data to give near real time amplitude distribution, and provide pulse by pulse intensity of both horizontal and vertical polarization returns.
- Algorithm Development
  - Develop algorithms to process input signals to assess the characteristics of the signal returns and determine the threat status of a target based on permutations of the polarizations of the target signals.
  - Suggest data combining methodology that could augment the PPT methodology
  - Develop the software to provide a signals to Siemens and displayed as a threat indicator to operator.
- Probability of correct identification and probability of false alarm
  - Establish thresholds that maximize the probability of detection while minimizing false alarms. Determine the theoretical limits of the identification process to correctly designate a threat, and the resulting false alarm rate.

PPT

Monarch Associates Tasks

- Manage the interaction between Siemens and ISL by :
  - Overseeing establishment of two-way interface protocol with Siemens and ISL
  - Define, with Siemens and Northeastern, the appearance of the user screens
- Manage and coordinate the experiments and measurements at New Haven and other sites
  - Test plans, test subjects, surrogates, site issues, etc
  - Assure a video record of the experiments
  - Organize the test results for subsequent analysis
- Manage and coordinate the final delivery and demonstration
- Develop methodology for
  - Radar hand-off to camera to center and zoom on threat
  - Camera hand-off to radar to evaluate threat
  - Manual pointing of radar/camera to evaluate a threat
  - Sending the result of threat declaration assessment algorithm to Siemens

PPT

New Haven Dept of Police Services

- Key personnel
  - Lieutenant R.K. Rohloff, Commander Hazardous Devices Unit
  - Officer Ray Crowley, Hazardous Devices Technician
- New Haven Police Academy place for experiments
- Realistic scenario enactments
- Wide range of body types and weaponry

PPT

Homeland Security

Radar Hardware and Measurements

John Firda, Raytheon, Inc.

BomDetect Kick-off Meeting August 16, 2006

Raytheon

Homeland Security

Overview

- Team
- Tasks
- Radar description
- Test area overview

Raytheon

Raytheon Key Personnel

- Chris Eversole – Program Lead and System Engineering
- John Firda – Technical Consultant
- Rick McGovern – Contracts
- David Kallmeyer – Hardware Engineering
- Stephen Diehl – DAQ Software Engineering
- Ted Richardson – Mechanical Engineering

Raytheon

Raytheon Tasks

- Raytheon's role is to provide a radar to support experiments and define the antenna for Phase II
- Specific Tasks
  - –Identify radar(s) to be used/studied on the program
  - –Obtain transmission license approvals
  - –Provide radar specifications: data format, data rate
  - –Determine and implement basic modifications to radars (if needed) to provide required data output
  - –Determine if modifications to radar can be accomplished in Phase I
  - –Design antenna required for Phase II, design wider aperture/tighter beam, polarization
  - –Define implementation to obtaining pulse to pulse VV, HH, VH polarization data - radar modification

Raytheon

Raytheon Support Tasks

- Raytheon provides support to related radar tasks
  - –Definition of required data output and format
  - –ID of outdoor test range
  - –Support running initial, simple outdoor experiments to baseline radar performance with and without target simulants
  - –Evaluation of the results
  - –Definition of the system requirements, software/data requirement specifications for Operating Envelope including antenna coverage/size
  - –Develop System Configuration Concept (with team)

Raytheon

Radar Equipment

- Plan to use a W Band millimeter-wave radar to collect dual polarization data
- The radar is a Raytheon owned test asset
  - – Bread board FMCW radar operating in the automotive frequency band
- The radar was developed by Raytheon in the mid 1990's for automotive applications
  - – M.E. Russell et. al., "Millimeter-Wave Radar Sensor for Automotive Intelligent Cruise Control (ICC)", IEEE T. Microwave Theory and Techniques, December 1997.
  - – US Patent 5,929,802 - Automotive Forward Looking Sensor Application.
  - – US Patent 6,107,956 - Automotive Forward Looking Sensor Architecture.
  - – Several other patents

Raytheon

Radar Equipment

Raytheon

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Integrated Defense Systems

Radar Key Characteristics

Characteristic	Value
Operating Frequency	76-77 GHz
Waveform	FMCW
Range	3 – 100 meters
Range Accuracy	< 0.5 m
Antenna	Electronically switched beam bi-static printed-circuit array (Rotman-Turner lens)
Azimuth Field of View	15.4 degrees
	7 switched beams, each 2 degrees
Elevation Field of View	4 degrees

Raytheon

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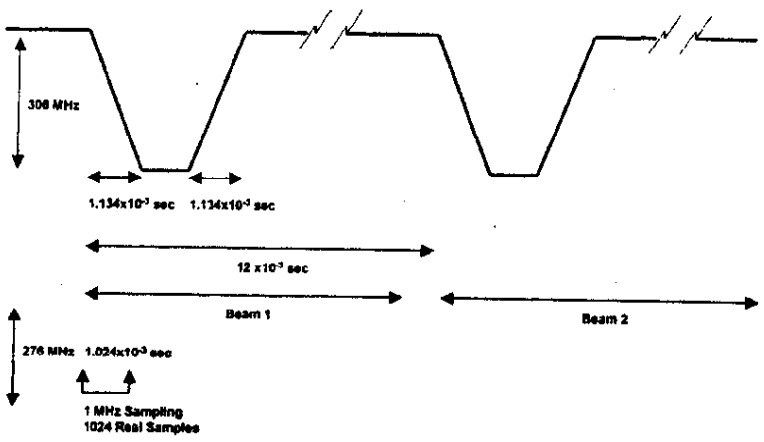
Integrated Defense Systems

Radar Waveform



Raytheon

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Integrated Defense Systems

Radar Test Site

- A number of test sites are under consideration
- Primary location is at the Raytheon IDS Surveillance & Sensors Center (SSC) in Sudbury, MA
  - Minimize shipping of radar equipment
  - Use a cleared parking lot to have better than 50 meters of area to conduct experiments
- Alternatives under consideration
  - PPT test area
  - Northeastern University test area
  - Alternate Raytheon site

Raytheon

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Integrated Defense Systems

U.S. Department of Homeland Security
Washington, DC 20528

Homeland Security

10 July 2006

Northeastern University
360 Huntington Avenue
Boston, MA 02115-5000
Attn: Richard McNeil

Subject: Notice to Proceed

Reference: BAA 05-03, Prototypes and Technology for Improvised Explosives Device Detection

Dear Mr. McNeil,

As you know, the Homeland Security Advanced Research Projects Agency (HSARPA) of the Department of Homeland Security (DHS) is in the process of negotiating a CPFF contract with your organization based upon your proposal submitted under BAA 05-03.

This letter serves as a Notice to Proceed pending issuance of a contract to your organization no later than September 15, 2006.

Allowable costs under said contract will include all costs you incur in connection with the work covered by this contract during the period starting from the date of this letter to the effective date of the contract provided such costs would have been allowable pursuant to the terms of the contract had the contract been in effect during said period. It is further provided that such incurred costs shall not, in the aggregate, exceed $500,000 of the estimated cost of the proposed contract unless such amount is increased in writing by the Contracting Officer. Please be advised that if the parties are unable to reach agreement on the award of the proposed contract the Government shall be under no obligation to reimburse you for any costs incurred.

Please feel free to contact Mr. Albert Dainton at [redacted] or email [redacted] for further assistance or contact me via email at [redacted]

Sincerely,

[redacted]

Tim Davis
Contracting Officer,
Department of Homeland Security

Statement of Work for Intelligent Pedestrian Surveillance Platform
Directorate of Science and Technology
U.S. Department of Homeland Security
Explosives Division

RSEN-09-00040

I. Background

The U.S. Department of Homeland Security (DHS) is committed to using cutting-edge technologies and scientific talent in its quest to make America safer. The DHS Directorate of Science and Technology (S&T) is tasked with researching and organizing the scientific, engineering, and technological resources of the United States and leveraging these existing resources into technological tools to help protect the homeland. DHS S&T is committed to protecting the homeland, its infrastructure, and citizens from threats including those presented by Improvised Explosive Devices (IEDs).

The Counter-IED (C-IED) program at DHS S&T is accomplishing this by developing technologies that aid in the detection of IEDs and their explosive components. DHS S&T customers need a greater capability than what is currently available for detecting IEDs on people, whether at checkpoints or in standoff applications. This is especially relevant at high volume public areas and entrances to important infrastructure.

Intelligent Pedestrian Surveillance Platform will support this effort through providing a potential capability to monitor and track individuals in a crowd.

II. Scope of Work

Siemens Corporate Research will perform the tasks described in this SOW with managerial oversight by Northeastern University. This scope of work is a modification to the original contract (awarded under BAA 05-03 Prototypes and Technologies for Improvised Explosives Device Detection). This SOW is a continuation of Phase I work for Northeastern University's subcontractor, Siemens Corporate Research.

In Phase I, Northeastern University completed the following tasks with the exception of the highlighted ones:

1) Intelligent Video:
   a. Test and analyze the performance of the Intelligent Video
   b. Test the software System architecture, and integration
   c. Test and evaluate visualization front end, policy engine
   d. Develop system configuration Concept (w team)
   e. Write Preliminary Design Review (Intelligent Video, software integration) (PDR)
   f. Write Phase I Final Report (Intelligent Video, and software integration)

2) **Radar:**
   a. **Design experiments to validate the algorithms**
   b. **Investigate clutter reduction approaches**
   c. **Develop system configuration Concept (w/team)**
   d. **Write Preliminary Design Review (radar sensor) (PDR)**
   e. **Based on the existing wide aperture antenna array, establish specifications and design a single multi-monostatic mm-wave element of the full array.**
   f. **Design and fabricate or purchase a standard gain feed and a reflector antenna for radar.**
   g. **Build the radar element by combining source, antennas, and drive electronics.**
   h. **Fabricate an adjustable support structure for mounting and repositioning the single element to simulate a full array of stationary elements.**
   i. **Test the array antenna mm-wave radar element indoors in a large W-band rated anechoic chamber. Compare with modeled results.**
   j. **Write Phase I Final Report (radar sensor)**

3) **X-Ray:**
   a. **Develop System Configuration Concept (w/team)**
   b. **Write Preliminary Design Review (X-ray sensor, hardware integration) (PDR)**
   c. **Write Phase I Final Report (X-ray sensor, hardware integration)**

4) **Terahertz:**
   a. **Develop system Configuration Concept**
   b. **Write Preliminary Design review (THz sensor) (PDR)**
   c. **Write Phase I Final Report (THz sensor)**

5) **Suicide bomber Test subject:**

6) **Hardware and software Integration:**

7) **Program Management:**
   a. **System Configuration Concept**
   b. **Preliminary Design Review (PDR)**
   c. **Phase I Final Report**

In the extension of Phase I, called Phase Ia and Ib here, Northeastern University and their subcontractor will complete the following tasks completing the work highlighted in Section 3 above.

1. **Fast indexing**
   1.1. **Background Subtraction**
   The work involved will be incorporating Siemens background modeling techniques to the demo system and detecting boundaries of pedestrian groups.
   1.2. **Base-level Illumination Compensation**

Fast illumination changes in outdoor environments (e.g. due to fast moving clouds blocking the sun) can cause difficulties in vision algorithm performance. To improve robustness against such lighting changes, we propose to introduce a global illumination compensation component in the system.

1.3. Shape-based Indexing

Siemens will take steps to make the algorithm [Dong07] robust, accurate and real-time. The efforts involve robustness against cast shadow, faster search algorithm and better optimization algorithms.

2. Level 1 Detection and Tracking

2.1. Basic Blob Tracking

The effort involves integrating the tracker and making it perform robustly against environment factors such as changing illumination.

2.2. Discriminative Tracker

Discriminative features are selected that can best separate a pedestrian from the background.

3. Level 2 Detection and Tracking

3.1. *Pedestrian Detection by Segmentation*

Siemens will build upon the algorithm described in [Dong07]. The improvements will be made in the following areas: 1) Improving the speed. Currently, the algorithm takes on average 1 second to segment the people in the group using the Markov Chain Monte Carlo (MCMC) method. This is far from the desired real-time performance (processing one frame in less than 33 milliseconds). Solving this problem will be a major challenge. 2) Improving the accuracy of the segmented people. We will try to reduce misdetected people and false alarms using appearance (color) information and temporal integration.

3.2. *Multiple Pedestrian Tracking in a Small Group*

Siemens will take steps to make multiple-people tracking in level-2 cases accurate, robust and real-time.

3.3. Discriminative Tracking using Discriminative Features Selection and Dynamics of Groups

3.4. Active Sensor Control for acquiring discriminative features (depends on the funding of the prototype system development)

4. Empirical Performance Evaluation

4.1. Empirical Performance Evaluation: Fast Indexing

4.2. *Empirical Performance Evaluation: Detection*

4.3. Empirical Performance Evaluation: Tracking

5. Advanced HMI -- Workflow and Ergonomic/Human Factor Analysis

A novel HMI concept for use within the framework of the intelligent pedestrian tracking is developed.

6. Advanced HMI -- Feasibility of using Eye Tracking in Pedestrian Surveillance HMI Design

An empirical study will evaluate, using human participants, whether the novel HMI concept can feasibly be deployed within the context of the intelligent pedestrian tracker.

Prototype Multi-Camera System and IPSP

7. Sensor System

7.1. Basic Level Sensor Planning

Basic level sensor planning includes the following tasks:
1) Selection of cameras and lens systems, including the overview panoramic camera(s), stereo camera and the PTZ camera. Selected cameras should be compatible with the Surveillance platform for minimum efforts in camera interface development. 2) Camera geometry design, i.e., where to mount and orient the cameras.

7.2. Video Stabilization

Siemens will adapt an internal stabilization algorithm for the IDS VRPV project needs.
Improvements needed include faster processing speed and robustness against moving crowd.

7.3. Camera Calibration

Siemens will use existing calibration algorithms to calibrate the camera systems including the relative displacement and orientation among the overview cameras, the stereo camera, and the PTZ camera.

7.4. Multiple View Video Stitching

Once cameras are *calibrated, the stitching function can be derived.* The emphasis will be on real-time generation of panoramic videos.

7.5. Pan/Tilt/Zoom Slaving

Siemens will design the PTZ pointing function. There are two levels of effort involved. First, when an operator clicks on a pixel in the panorama, the PTZ camera will be directed to the corresponding location using a pre-computed zoom-level. Second, in conjunction with the tracking detection algorithms (work packages 2 and 3), the IVS automatically computes the best pan, tilt angles and zoom level in order to best observe a group of pedestrians.

7.6. Stereo Matching and Triangulation

The emphasis will be on robust feature correspondence and real-time performance. A stereo measurement confidence will also be generated. When correspondences are un-reliable, possibly due to occlusion, low-texture or visual ambiguity, low measurement confidence levels will be reported.

8. Intelligent Pedestrian Surveillance Platform

Siemens will develop:

8.1. System architecture design

8.2. Interface for video processing plug-ins to perform intelligent video tasks

8.3. A simple user interface for tracking result display and enabling an operator to click on a specific tracked pedestrian for a PTZ close-up surveys. The outputs from the *plug-ins will be sent to a second PC (command and control C&C)* as events, utilizing the event handling mechanism of surveillance. A possibly incomplete list of events include: panoramic video frame event, object tracking event, auto-zoom event, and optical tripwire event. The results will then be displayed on the C&C computer screen.

Siemens will define a test protocol and test the software quality and compatibility of the demo system

Program Element / Project	Major Tasks	Key Milestones and Deliverables
Phase I. Previously Funded	1. **BomDetec Integrated Suicide bomber detection platform**	• **Monthly summaries, due NLT 8 business days after month's end** • **Monthly teleconferences with DHS S&T Contracting Officer Technical Representative (COTR), NLT 10 days after month's end** • **Quarterly reports- 3, 6, 9, 12, 15, and 17 months from contract award date** • **Final report-17 months after award date**
Phase Ia. Pedestrian Tracker Base Package Funded by this action.	1 Fast indexing 2 Level 1 Detection and Tracking 3 Level-2 Pedestrian Detection and Tracking 4 Empirical Performance Evaluation 5 Advanced HMI	• **Monthly summaries, due NLT 8 business days after month's end** • **Monthly teleconferences with DHS S&T COTR, NLT 10 days after month's end** • **Demonstration - 6 months after award**

Program Element / Project	Major Tasks	Key Milestones and Deliverables
		• Demonstration-12 months after award • Quarterly reports and reviews- 3, 6, 9, 12, 15, and 17 months from award • Final report-17 months after award date
Phase IIb. Prototype Multi-Camera System and IPSP. Funded by this action.	1 Basic Level Sensor Planning 2 Video Stabilization 3 Camera Calibration 4 Multiple View Video Stitching 5 Pan Tilt Zoom Slaving 6 Stereo Matching and Triangulation 7 Intelligent Pedestrian Surveillance Platform	• Monthly summaries, due NLT 8 business days after month's end • Monthly teleconferences with DHS S&T COTR, NLT 10 days after month's end • Demonstration - 6 months after award • Demonstration-12 months after award • Quarterly reports and reviews- 3, 6, 9, 12, 15, and 17 months from award • Final report and review-17 months after award date • IRL6 Level Prototype Demo

Monthly Status Teleconferences will consist of the following:

A monthly teleconference will take place within 10 business days of the end of the month between the Principal Investigator for Northeastern University and subcontractor Siemens Corporate Research and DHS S&T COTR. In addition, a supplemental document, not to exceed one page in length, will be electronically submitted to the DHS S&T COTR at least 48 hours prior to the scheduled teleconference. This document will describe the previous 30 calendar days' activity, technical progress achieved against goals, difficulties encountered, recovery plans (if needed), plans for the next 30 day period, and financial status. The teleconference and one page document will satisfy monthly reporting requirements.
Due Date: Within 8 business days of the end of the month for summary sheet and 10 days for teleconference.

Quarterly Reports and Reviews will consist of the following:

Quarterly presentations will take place within 5 days of submission of the quarterly reports. Quarterly reports are due as outlined in the chart above and are not to exceed 10 pages with cover page and will be electronically submitted to the DHS S&T COTR. The Quarterly Presentations will be either conducted via phone or in person between the Principal Investigator for Northeastern University and subcontractor Siemens Corporate Research and the DHS S&T COTR to discuss the Quarterly Reports. These reports will describe the previous 90 calendar days' activity (60 days for the final time period), principals involved in the actual work of the period, technical progress achieved against goals, difficulties encountered, funds expended against each sub-task in the previous period, recovery plans (if needed), explicit plans for the next time period, and financial status.
Due Date: 3, 6, 9, 12, 15, and 17 months after award

Final Reports will consist of the following:

For a final report, Northeastern University and subcontractor Siemens Corporate Research will provide a technical report of their work performed during the preceding Phase or Phases. This will include, where applicable, performance predictions, estimates of cost of ownership, and an enumeration of remaining unknowns and uncertainties. This final report will be a cumulative, stand-alone document that describes the work of the entire Phase leading up to it. It must include any technical data gathered, such as, measurements taken, models developed, simulation results, and formulations developed. This final report should also include "lessons learned" from the effort, recommendations for future research in this area, and a comprehensive account of all funds expended. Northeastern University and subcontractor Siemens Corporate Research will develop a plan for executing Phase II of the project. This must include a test plan for evaluating the prototype video analytics system. The final report will also include documentation of the executed work plan, including the contracted Statement of Work (SOW), as well as a work plan and SOW for proposed future efforts where appropriate.
Due Date: 17 months after award

Other Reports:

Additional deliverables will be required depending upon specific program attributes. Northeastern University and subcontractor Siemens Corporate Research and government will come to mutual agreement of the format and extent of such deliverables at the time of award. Additional deliverables may include, but are not limited to:

- Participation in an annual DHS event at the discretion of the DHS S&T Technical Representative. Possible events include presentation or exhibition at Stakeholder's meetings, customer events, or select technical conferences,
- Review meetings include a kickoff meeting and a final review meeting. Location of these meetings will be at the discretion of the DHS S&T Technical Representative, but will likely be at the preferred location of Northeastern University, Siemens Corporate Research or DHS S&T HQ
- Where appropriate, system engineering drawings, blueprints, and specifications will be compiled and delivered to DHS S&T along with the final report.

III. Other Contract Details

A. **Period of Performance.** The period of performance for this SOW is from the contract award date to 18 months after the award date. DHS may give subsequent extension notices to Northeastern University and subcontractor Siemens Corporate Research in writing for further performance in accordance with the terms of this SOW.

B. **Travel.** Travel may be required in the performance of the duties listed herein. It is anticipated that travel will be limited to the Washington DC metro area, Boston, MA and Princeton, NJ. The DHS S&T COTR must approve all additional travel. All travel and other direct costs associated with the execution of the tasks indicated in this SOW will be reimbursed in accordance with the limits set forth in the Federal Travel Regulations, provided the performer provides appropriate supporting documentation.

C. **DHS-Furnished Information.**

1. DHS will provide certain DHS information, materials, and forms unique to DHS to Northeastern University and subcontractor Siemens Corporate Research to support certain tasks under this SOW.

2. The DHS S&T COTR identified in this SOW will be the point of contact (POC) for identification of any required information to be supplied by DHS.

3. Northeastern University and subcontractor Siemens Corporate Research will prepare any documentation according to the guidelines provided by DHS.

D. **DHS-Furnished Facilities, Supplies, and Services.** If work at DHS-provided facilities is necessary for the services being performed under this SOW, such facilities will be provided

at S&T's office in Washington, D.C. Parking facilities are not provided, however several commercial parking facilities are located near S&T's office. Basic facilities such as work space and associated operating requirements (e.g., phones, desks, utilities, desktop computers, and consumable and general purpose office supplies) will be provided to Northeastern University and subcontractor Siemens Corporate Research personnel working in S&T's office.

E. **Place of Performance.** Northeastern University and subcontractor Siemens Corporate Research will perform the work under this SOW at Siemens Corporate Research in Princeton, NJ

F. **DHS-Furnished Property.** DHS property will not be provided to Northeastern University and subcontractor Siemens Corporate Research unless otherwise agreed in a task order issued under this SOW. In such instances, DHS will maintain property records.

Before purchasing any individual item equal to or exceeding $50,000 that is required to support technical tasks performed pursuant to this SOW, Northeastern University and subcontractor Siemens Corporate Research shall obtain the DHS S&T Technical Representative's prior written consent. The DHS S&T COTR may lower or raise the aforementioned $50,000 threshold at his/her discretion and on written notice to Northeastern University and subcontractor Siemens Corporate Research. If the DHS S&T COTR consents to such purchase, such item shall become the property of DHS. Northeastern University and subcontractor Siemens Corporate Research will maintain any such items according to currently existing property accountability procedures. The DHS S&T COTR will determine the final disposition of any such items.

G. **Deliverables.** Northeastern University and subcontractor Siemens Corporate Research will provide all deliverables identified in this SOW directly to the DHS S&T COTR and DHS Contracting Officer with a copy of the transmittal letter to the Financial Analyst.

H. **Program Status Report.** Northeastern University and subcontractor Siemens Corporate Research will deliver a monthly program status report to the DHS S&T COTR and DHS S&T Explosives Business Operations Manager, and DHS S&T Financial Analyst. This document is due within 5 business days of the end of the month and will describe the previous 30 calendar days' activity, technical progress achieved against goals, difficulties encountered, recovery plans (if needed), plans for the next 30 day period, and financial status. The length of the report will not exceed one page.

I. **Funding Requirements.** DHS will provide funding to Northeastern University and subcontractor Siemens Corporate Research in accordance with DHS's appropriations and available funds.

J. **Security Requirements.**

1. All work performed under this SOW is unclassified unless otherwise specified by DHS.
2. If classified work is required under this SOW, DHS will provide specific guidance to Northeastern University and subcontractor Siemens Corporate Research as to which work will be conducted in a classified manner and at which classification level. Northeastern University and subcontractor Siemens Corporate Research will also adhere to other applicable Government orders, guides, and directives pertaining to classified or confidential work.

IV. Points of Contact

Northeastern University Points of Contact (POCs) are as follows:

Technical POC(s) –

Michael Silevitch
Northeastern University
360 Huntington Avenue, 302 Stearns Center
Boston, MA 02115

Financial POC(s) –

John Harris
Director of Research and Property Accounting
Northeastern University, 251RI
360 Huntington Avenue
Boston, MA 02115
Tel: [redacted]
[redacted]

Lawrence W. Barnett
Acting Director, Division of Sponsored Projects Administration
Northeastern University
360 Huntington Avenue, 405 Lake Hall
Boston, MA 02115
Tel: [redacted]
Fax: 617-373-4595
[redacted]

Anne Magrath, CRA
Director of Finance & Research Contracts Administration Operations
The Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems
Northeastern University
360 Huntington Avenue, 302 Stearns Center
Boston, MA 02115
Tel: [redacted]

Cell: [redacted]
Fax: 617-373-8627

Northeastern University may change the individual designated as a POC upon notice to DHS S&T of such change.

The DHS POCs are as follows:

DHS S&T COTR –
Michael Shepard, PhD
Department of Homeland Security
ATTN: Science and Technology Directorate
Explosives Division
245 Murray Lane
Washington, DC 20528
Tel: [redacted]
Fax: 202-254-5396
[redacted]

DHS S&T Explosives Operations Manager -
Wallicia Tapscott
Department of Homeland Security
ATTN: Science and Technology Directorate
Explosives Division
245 Murray Lane
Washington, DC 20528
Tel: [redacted]
Fax: 202-254-5395
[redacted]

DHS S&T Financial Analyst -
Omar Canales
Contractor in Support of:
Department of Homeland Security
ATTN: Science and Technology Directorate
Office of Chief Financial Officer
245 Murray Lane
Washington, DC 20528
Tel: [redacted]
Fax: 202-254-5392
[redacted]

DHS S&T may change the individual designated as a POC upon notice to Northeastern University and subcontractor Siemens Corporate Research of such change.

AWARD/CONTRACT	1. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 350)	RATING	PAGE OF PAGES 1 31
2. CONTRACT (Proc. Inst. Ident.) NO. HSHQDC-07-C-00016	3. EFFECTIVE DATE 07/10/2006	4. REQUISITION/PURCHASE REQUEST/PROJECT NO. RSEN-07-00014	

5. ISSUED BY	CODE DHS/OPO/S&T/S&T	6. ADMINISTERED BY (If other than Item 5)	CODE DHS/OPO/S&T/S&T
U.S. Dept. of Homeland Security Office of Procurement Operations S&T Acquisition Branch 245 Murray Lane, SW Building 410 Washington DC 20528		OPO S&T Acquisition Branch	

7. NAME AND ADDRESS OF CONTRACTOR (No., Street, City, County, State and ZIP Code)	8. DELIVERY FOB ORIGIN x OTHER (See below)
NORTHEASTERN UNIVERSITY 360 HUNTINGTON AVENUE 251 RI BOSTON MA 021155000	9. DISCOUNT FOR PROMPT PAYMENT Net 30
	10. SUBMIT INVOICES (4 copies unless otherwise specified) TO THE ADDRESS SHOWN IN ITEM

CODE 0014216310000	FACILITY CODE

11. SHIP TO/MARK FOR	CODE DHS	12. PAYMENT WILL BE MADE BY	CODE
Department of Homeland Security 245 Murray Lane Bldg. 410 Washington DC 20528		Department of Homeland Security Science and Technology Directorate 245 Murray Lane Building 410 Attn: Ms. Deborah DeVault Washington DC 20528	

13. AUTHORITY FOR USING OTHER THAN FULL AND OPEN COMPETITION	14. ACCOUNTING AND APPROPRIATION DATA
10 U.S.C. 2304 (c)( ) 41 U.S.C. 253 (c)( )	See Schedule

15A. ITEM NO	15B. SUPPLIES/SERVICES	15C. QUANTITY	15D. UNIT	15E. UNIT PRICE	15F. AMOUNT
	Continued				
	15G. TOTAL AMOUNT OF CONTRACT				$1,305,181.00

16. TABLE OF CONTENTS

(X)	SEC.	DESCRIPTION	PAGE(S)	(X)	SEC.	DESCRIPTION	PAGE(S)
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CONTRACTING OFFICER WILL COMPLETE ITEM 17 OR 18 AS APPLICABLE

17. [X] CONTRACTOR'S NEGOTIATED AGREEMENT (Contractor is required to sign this document and return 1 copies to issuing office.) Contractor agrees to furnish and deliver all items or perform all the services set forth or otherwise identified above and on any continuation sheets for the consideration stated herein. The rights and obligations of the parties to this contract shall be subject to and governed by the following documents: (a) this award/contract, (b) the solicitation, if any, and (c) such provisions, representations, certifications, and specifications, as are attached or incorporated by reference herein. (Attachments are listed herein.)

18. [ ] AWARD (Contractor is not required to sign this document.) Your offer on Solicitation Number _____ including the additions or changes made by you which additions or changes are set forth in full above, is hereby accepted as to the items listed above and on any continuation sheets. This award consummates the contract which consists of the following documents: (a) the Government's solicitation and your offer, and (b) this award/contract. No further contractual document is necessary.

19A. NAME AND TITLE OF SIGNER (Type or print)	20A. NAME OF CONTRACTING OFFICER
Maureen A. Joyce, Director, DSPA	Wanda J. Armwood
19B. NAME OF CONTRACTOR BY [redacted] (Signature of person authorized to sign)	19C. DATE SIGNED 12-4-2006
20B. UNITED STATES OF AMERICA BY [redacted] (Signature of the Contracting Officer)	20C. DATE SIGNED 12/6/06

NSN 7540-01-152-8067
PREVIOUS EDITION IS UNUSABLE

STANDARD FORM 33 (Rev. 4-85)
Prescribed by GSA
FAR (48 CFR) 53.214(a)

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Tax ID Number: 04-1679980 DUNS Number: 001423631+0000 FOB: Destination				
0001	PTIEDD - Phase I: BomDetec Project Including Data Deliverables Fully Funded Obligation Amount$1,711,383.00 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 04/09/2007 Accounting Info: NONE000-000-RX-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $903,678.00 Accounting Info: NONE000-000-5X-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $120,500.00 Accounting Info: NONE000-000-5X-06-20-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $281,003.00 CLIN 0001 Total Estimated Cost: $1,687,533 CLIN 0001 Total Fixed Fee: $23,850 CLIN 0001 Total CPFF: $1,711,383 CLIN 0001 is incrementally funded in the amount of $1,305,181. This amount appears in Block 15G of the SF26 as the amount obligated with this action.	1	LO	1,711,383.00	1,305,181.00
0002	OPTION 1: PTIEDD - Phase II: BomDetec Project Including Data Deliverables Amount: $1,697,743.00(Option Line Item) 04/09/2007 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 365 Days After Award Accounting Info: CLIN 0002 Total Estimated Cost: $1,564,740 CLIN 0002 Total Fixed Fee: $133,003 CLIN 0002 Total CPFF: $1,697,743 Continued ...	1	LO	1,697,743.00	0.00

NAME OF OFFEROR OR CONTRACTOR

NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
0003	OPTION 2: PTIEDD - Phase III: BomDetec Project Including Data Deliverables Amount: $523,332.00(Option Line Item) 04/06/2008 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 180 Days After Award Accounting Info: CLIN 0003 Total Estimated Cost: $482,334 CLIN 0003 Total Fixed Fee: $40,998 CLIN 0003 Total CPFF: $523,332 If and to the extent that all options are exercised: The total amount of award: $3,932,458.00. The obligation for this award is shown in box 15G.	1	LO	523,332.00	0.00

SECTION B - SUPPLIES/SERVICES AND PRICES/COSTS

B-1: CONTRACT TYPE AND SCHEDULE OF ITEMS

The purpose of this cost-type contract is to provide prototype research and development (R&D) for the Department of Homeland Security for the Prototypes and Technology for Improvised Explosives Device Detection program (PTIEDD) program which seeks to support R&D of next generation or novel technologies or prototypes for detection of improvised explosives in vehicles, in leave-behind packages, or carried by suicide bombers.

B-2: CONTRACT LINE ITEMS

1. The Contractor shall perform the R&D Contract Line Item Numbers (CLINs) identified below on a Cost-Plus-Fixed-Fee (CPFF) basis. The fixed fee for all CLINs is based on 8.50%. The Contractor shall consider the Option CLINs Estimated Costs/Fixed Fees to be Not-To-Exceed (NTE) ceilings that can be changed only through a contract modification.

Base Period:

CLIN	Description	Qty	Unit	Total Estimated Cost	Fixed Fee	Total CPFF
0001	PTIEDD – Phase I: BomDetec Project Including Data Deliverables	1	Lot	$1,687,533	$23,850	$1,711,383

Option 1: Phase II

CLIN	Description	Qty	Unit	Total Estimated Cost	Fixed Fee (estimated)	Total Estimated CPFF
0002	PTIEDD – Phase II: BomDetec Project Including Data Deliverables	1	Lot	$1,564,740	$133,003	$1,697,743

Option 2: Phase III

CLIN	Description	Qty	Unit	Total Estimated Cost	Fixed Fee (estimated)	Total Estimated CPFF
0003	PTIEDD Phase III: BomDetec Project Including Data Deliverables	1	Lot	$482,334	$40,998	$523,332

2. The intent of the Government is that this contract be considered a "completion" cost effort. That is, the contractor is obliged to perform through to phase completion. Minor increases in costs will most likely be covered. Significant changes due to the Contractor's underestimating the level of effort or any changes to the Contractor's technical approach will require Government evaluation of the Contractor's progress. The Contracting Officer may

request a revised proposal at any time should the situation warrant. The Contractor is obligated to notify the Contracting Officer upon exhaustion of 75% of funding. All decisions regarding additional funding will be subject to the availability of funds.

B-3: OPTIONS

1. This PTIEDD project is being conducted in three phases: Phase I (CLIN 0001), develops the idea sufficient to conduct a Preliminary Design Review; Phase II (CLIN 0002, Option 1) develops the idea further and completes a Breadboard design; Phase III (CLIN 0003, Option 2) is the final development and completion of the Preproduction design.

SECTION C - DESCRIPTION/SPECIFICATIONS

C-1: STATEMENT OF WORK

The BomDetec -- Wide Area Surveillance and Suicide Bomber Detection at >10M project is comprised of three (3) phases. At this time, only Phase I is funded and authorized to proceed. The work described below shall be accomplished in Phase I. As the Option Phases II and III are authorized and funded, additional work statements will be incorporated into this contract by modification.

PHASE I

Scope: In Phase I, four existing sensors will be tested or assessed and evaluated independently to determine the most effective combination of sensors. The sensors include (1) intelligent video, (2) Millimeter Wave Radar (MMW Radar), (3) X-Ray, and (4) Terahertz Wave (THz). Each sensor will be evaluated against a set of simulated suicide bomber dummies in laboratory and field conditions. If a sensor makes a substantive contribution, it will be included in the design for the Phase II breadboard.

Tasks:

1.0 Intelligent Video:

The intelligent video portion of this effort will use multiple static cameras at different corners of a Z Backscatter Van (ZBV) in the final product and also potentially on utility poles and or buildings. The capability to detect and track humans using one camera has already been demonstrated. Enhancements will be made to detect and track one or more persons and objects using multiple cameras. Appearance models will also be developed to improve tracking performance after temporary occlusion. In addition to developing the Intelligent Video Sensor, Siemens will obtain the data needed to control and gather data from the other sensors (Radar, X-ray backscatter). They will also consider the Graphical User Interface (GUI) and concepts of operation (CONOPS) during Phase I. Under this task, the contractor shall:

- 1.1 Evaluate sensor data
  - 1.1.1 Radar data analysis
  - 1.1.2 Backscatter X-ray preprocess/enhance--based on physical model
  - 1.1.3 Backscatter X-ray data analysis

1.2 Design and integrate threat measure
1.3 Design user interface scheme
1.4 Define data communication protocol
1.5 Define Integration and testing protocol
1.6 Define software architecture and data structures
1.7 Define requirements specification
1.8 Select Intelligent Video subsystems
1.9 Develop Persistent tracking
1.10 Develop Feature based target classification
1.11 Develop Multi-sensor calibration
1.12 Develop Intelligent Video test plan
1.13 Test and analyze the performance of Intelligent Video
1.14 Test the software System architecture, and integration
1.15 Test and evaluate visualization front end, policy engine
1.16 Develop System Configuration Concept (w team)
1.17 Write Preliminary Design Review (Intelligent Video, software integration) (PDR)
1.18 Write Phase I Final Report (Intelligent Video, and software integration)

2.0 Radar

The radar portion of this effort will use W-band millimeter wave radar to obtain dual polarization data for long range threat detection. The result of prior work establishes a preliminary assessment of the capability of polarimetric millimeter wave radar to detect the threats. This provides the basis for following this approach as opposed to considering alternatives. Measurements will be made using single polarization radar in such a way as to obtain data for two orthogonal polarizations for subsequent analysis. The data will show the threat detection capability of dual polarization millimeter wave radar as a part of a sensor suite for Phase II. Modifications to the radar to support a polarimetric mode operationally will be designed in Phase I and implemented in Phase II. Under this task the contractor shall:

2.1 Identify radars to be used/studied on the program
2.2 Obtain transmission license approvals
2.3 Provide radar specifications including: data output, data rates
2.4 Define required data output and format
2.5 Determine if available data is sufficient for gross conclusions that validate existing data
2.6 Determine if available data is sufficient for algorithm input
2.7 Determine basic modifications to radars (if needed) to provide required data output
2.8 Determine if modifications to radar can be accomplished in Phase I
2.9 Identify outdoor test range
2.10 Run initial, simple experiments to baseline radar performance with and without target simulants at an outdoor test range
2.11 Evaluate the results (phenomenonological interpretation)
2.12 Develop detailed experimental testing protocol for indoor/outdoor environments
2.13 Identify subjects, clothing, targets, innocent objects
2.14 Identify environmental clutter to be used
2.15 Define the system requirements, software/data requirement specifications for Operating Envelope including antenna coverage/size

2.16 Design antenna required for Phase II, design wider aperture/tighter beam, polarization.
2.17 Determine advantages/modification for other polarizations
2.18 Define implementation to obtaining pulse to pulse VV, HH, and VH and other polarization data – radar modification
2.19 Develop multi-polarization algorithms based on theoretical backscatter predictions
2.20 Design experiments to validate the algorithms
2.21 Investigate clutter reduction approaches
2.22 Develop System Configuration Concept (w team)
2.23 Write Preliminary Design Review (radar sensor) (PDR)
2.24 Write Phase I Final Report (radar sensor)

3.0 X-Ray (Phase I)

In the X-ray Backscatter portion of this effort, the contractor will assess the ability of a Long Distance Viewing X-ray system to determine its ability to differentiate between people with metal and people without metal (and people with and without appropriate density plastic) at distances up to 10 meters. The X-ray sensor's ability to image metal conformation at approximately 10 meters will be investigated. This assessment will be accomplished using existing data previously collected using a Long Distance Viewing (LDV)-configured Z Backscatter Van (ZBV). Differences between a standard ZBV and the LDV will be analyzed for applicability to suicide bomber detection. Under this task the contractor shall:

3.1 Develop system hardware design
  3.1.1 Mechanical Design
  3.1.2 Electrical Design
    3.1.2.1 Power
    3.1.2.2 Control
    3.1.2.3 Signal
  3.1.3 Thermal Design
  3.1.4 Software Design
    3.1.4.1 Control Software Integration
    3.1.4.2 Data Acquisition
    3.1.4.3 Data Analysis and Fusion
3.2 Develop X-ray sensor evaluation criteria
3.3 Evaluate X-ray sensor data (using data on hand)
3.4 Develop System Configuration Concept (w team)
3.5 Write Preliminary Design Review (X-ray sensor, hardware integration) (PDR)
3.6 Write Phase I Final Report (X-ray sensor, hardware integration)

4.0 Terahertz (THz)

THz radiation will be used for spectroscopic confirmation of a threat. In this portion of the effort, THz technology will be evaluated to determine the appropriate configuration to use with the system. Frequency resonances (signatures) of selected explosives and their related compounds will be tested with distance (up to 10 meters) and weather condition variables. The standoff detection distance will be optimized in Phase I. Under this task the contractor shall:

4.1 Select appropriate THz technology
4.2 THz sensor test bed system
  4.2.1 Refine the library of THz-TDS signatures of explosives
4.3 Develop fast acquisition system – Optical delay line
4.4 Develop THz beam focusing subsystem
4.5 Improve the sensitivity-THz emitter and detector technology
4.6 Design Stand-off detection optics system
4.7 Design probe pulse circulator
4.8 Assemble THz laboratory system
  4.8.1 Hardware
  4.8.2 Electronics
  4.8.3 Software
4.9 Develop laboratory test
4.10 Test and evaluate performance
4.11 Develop System Configuration Concept
4.12 Write Preliminary Design review (THz sensor)(PDR)
4.13 Write Phase I Final Report (THz sensor)

5.0 Suicide Bomber Test Subject

The contractor has an X-ray mannequin that can be used as a subject and an amateur suicide bomber vest that can be used. The Government will provide information to assist the contractor design simulated suicide bomber test objects.

5.1 Procure or investigate bomber test subject
5.2 Design bomber test subject
5.3 Fabricate typical suicide bomber test objects

6.0 Hardware and Software Integration (Phase I)

As described in section 3.0 X-ray, the hardware integrator will gather general information about each of the sensors and will perform an initial assessment of the mechanical, electrical, thermal, and optical integration issues of the sensors into their ZBV. A preliminary integration design will be presented at the PDR. As described in section 1.0 Intelligent Video, the software integrator will gather general software information about each sensor and will obtain information about the sensors data for signal and control. The contractor will design a preliminary sensor fusion and command and control system, which will be presented at the PDR.

7.0 Program Management

To manage the BomDetec Project Phase I effort, the contractor shall appoint a Program/Project Manager and implement processes to monitor the following areas:

7.1 Technical (planning, tracking, managing)
7.2 Financial (planning, tracking, managing)
7.3 Schedule (Gantt, deliverables, milestones)
7.4 Communication (weekly meeting, monthly technical / cost progress reports, reviews, final report)
7.5 Program Support (travel, meetings, contract)
7.6 System Configuration Concept
7.7 Preliminary Design Review (PDR)
7.8 Phase I Final Report

8.0 Deliverables

	Item	Time After Award
1.	Monthly Technical Progress and Cost Reports	Monthly
2.	Report on Laboratory and Field Evaluation Criteria	Thirty (30) Weeks
3.	Report on Laboratory and Field Evaluation Results for each sensor	Thirty-four (34) weeks
4.	Independent Review Board Report on the use of Human Test Subjects	Thirty (30) days prior to testing
5.	System Configuration Concept	Thirty-six (36) weeks
6.	Preliminary Design Review (PDR)	Thirty-six (36) weeks
7.	Final Report Phase I	Nine (9) months

SECTION D - PACKAGING AND MARKING

D-1: PACKAGING AND MARKING

(a) Data contained in the List of Deliverables delivered under this contract shall be electronically submitted to [redacted] If delivery is submitted by mail, the contractor shall preserve, pack and package in such a way to ensure complete delivery at destination without damage or deterioration of the supplies due to the hazards of shipping, handling or storage. Standard commercial preservation, packaging and packing shall be employed to meet the packaging requirements of the carrier and to insure delivery, to the addressee at destination. See G-2 for specific delivery address.

(b) The Contractor shall mark all shipments under this contract with the contract number and recipients' name. This same data shall also be included on the following: shipping documentation, date submitted, invoices and correspondence pertaining to a particular delivery. NOTE: Failure to mark all packages, boxes, etc., as indicated above, may result in return of the shipment at the contractor's expense.

SECTION E - INSPECTION AND ACCEPTANCE

E-1: CLAUSES INCORPORATED BY REFERENCE

The following FAR clauses are available in full text at http://farsite.hill.af.mil and incorporated by reference into this contract:

52.246-8	Inspection of Research and Development – Cost Reimbursement	May 2001

E-2: INSPECTION AND ACCEPTANCE BY THE GOVERNMENT

The Contracting Officer's Technical Representative (COTR) identified in Section G of this Contract is responsible for inspection and acceptance of all services, incoming shipments, documents, and services performed specifically for the Contract.

E-3: ACCEPTANCE CRITERIA

Certification by the Government of satisfactory services provided is contingent upon the Contractor performing in accordance with the terms and conditions of the contract and all modifications.

SECTION F - DELIVERIES OR PERFORMANCE

F-1: CLAUSES INCORPORATED BY REFERENCE

The following FAR clauses are available in full text at http://farsite.hill.af.mil and incorporated by reference into this contract:

52.242-15	Stop-Work Order	Aug 1989
Alt I	(Alternate I)	Apr 1984 (Alt I)
52.247-34	F.O.B. Destination	Nov 1991

F-2: PERIOD OF PERFORMANCE

The period of performance of Phase I of this Contract is from date of authorization to proceed through nine (9) months. Authorization to proceed was granted by the Contracting Officer on 10 Jul 2006. Therefore the Phase I period of performance shall conclude on 9 April 2007. The period of performance for all optional phases, if exercised, is as follows:

Option 1: CLIN 0002 (Phase II) – From date of option exercise through twelve (12) months
Option 2: CLIN 0003 (Phase III) – From date of option exercise through six (6) months

The total period of performance for this contract, if all options are exercised, shall not exceed twenty-seven (27) months from date of authorization to proceed.

F-3: PLACE OF PERFORMANCE

The research and development efforts shall be performed at the contractor, or designated subcontractor, facility.

F-4: DELIVERY ADDRESS

All deliverables shall be submitted electronically to the Government Program Manager identified in Section G of this Contract.

F-5: METHOD OF DELIVERY

Electronic copies shall be delivered in Microsoft Office formatted files, unless otherwise specified by the COTR. Electronic submission shall be made via e-mail, unless otherwise directed by the COTR.

F-6: DELIVERABLE /DELIVERY SCHEDULE

All deliverable schedules are contained in Section C, Statement of Work.

SECTION G - CONTRACT ADMINISTRATION DATA

G-1: CONTRACTING OFFICER (CO)

The Contracting Officer for this Contract is identified below:

Name:	Wanda J. Armwood
Title:	Contracting Officer
Agency:	Department of Homeland Security Homeland Security Advanced Research Projects Agency / Office of Procurement Operations
Address:	Washington, DC 20598
Voice:	[redacted]
Fax:	(202) 254-6167
Email:	[redacted]

G-2: CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE (COTR)

The COTR for this Contract is identified below:

Name:	Trent DePersia
Title:	Program Manager
Agency:	Department of Homeland Security Homeland Security Advanced Research Projects Agency
Address:	Washington, DC 20598
Voice:	[redacted]
Fax:	(202) 254-6170
Email:	[redacted]

G-3: CONTRACTING OFFICER'S AUTHORITY

The Contracting Officer (CO) assigned to this contract has responsibility for ensuring the performance of all necessary actions for effective contracting; ensuring compliance with the terms of the contract and safeguarding the interests of the United States in its contractual relationships. The CO is the only individual who has the authority to enter into, administer, or terminate this contract and is the only person authorized to approve changes to any of the

requirements under this contract, and notwithstanding any provision contained elsewhere in this contract, this authority remains solely with the CO.

It is the Contractor's responsibility to contact the CO immediately if there is even the appearance of any technical direction that is or may be outside the scope of the contract. The Government will not reimburse the Contractor for any work not authorized by the CO, including work outside the scope of the contract.

G-4: CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE (HSAR 3052.242-72) (DEC 2003)

(a) The Contracting Officer may designate Government personnel to act as the Contracting Officer's Technical Representative (COTR) to perform functions under the contract such as review or inspection and acceptance of supplies, services, including construction, and other functions of a technical nature. The Contracting Officer will provide a written notice of such designation to the Contractor within five working days after contract award or for construction, not less than five working days prior to giving the contractor the notice to proceed. The designation letter will set forth the authorities and limitations of the COTR under the contract.

(b) The Contracting Officer cannot authorize the COTR or any other representative to sign documents, such as contracts, contract modifications, etc., that require the signature of the Contracting Officer.

G-5: INTERPRETATION OR MODIFICATION

No oral statement by any person, and no written statement by anyone other than the Contracting Officer (CO), or his/her authorized representative acting within the scope of his/her authority, shall be interpreted as modifying or otherwise affecting the terms of this contract. All requests for interpretation or modification shall be made in writing to the CO.

G-6: ACCOUNTING AND APPROPRIATION DATA

The accounting and appropriation data corresponding to this contract is found in Block 14 on the award cover page (SF-26).

CLIN 0001 of this contract is incrementally funded. The sum of $1,305,181 is obligated under this action and allotted to CLIN 0001. As such, the Limitation of Funds clause (FAR 52.232-22) applies to this contract. If and when funding becomes available, the Government will unilaterally modify this contract to provide additional funds.

G-7: INVOICING INSTRUCTIONS

In order to initiate payment, the Contractor shall submit proper invoices for payment in the manner and format described herein:

The Contractor shall submit an original invoice or send via facsimile or email to the following address:

Department of Homeland Security
Science & Technology Directorate
Attn: PPB / Deborah DeVault
Washington, DC 20528
Email address: [redacted]

Each invoice shall include the following:

1) Contract Number
2) Contractor Name
3) Date of Invoice
4) Invoice/voucher Number
5) Material
6) Labor
7) Benefits
8) Overhead
9) Other Direct Cost (ODCs)
10) Travel
11) Total Costs

G-8: TRAVEL

(a) Approval of Foreign Travel: The cost of foreign travel is allowable only when the specific written approval of the Contracting Officer or Contract Specialist responsible for administration of the contract is obtained prior to commencing the trip. Approval must be requested at least 30 days before the scheduled departure date in order that all necessary clearances may be processed. Each individual trip must be approved separately even though it may have been include in a previously approved budget Foreign travel is defined as any travel outside of Canada and the United States and its territories and possessions.

(b) Domestic/local travel shall take place in accordance with the applicable Cost Principles for Universities (FAR 31.3) and the Federal Travel Regulations for Industrial Subcontractors.

G-9: GOVERNMENT FURNISHED EQUIPMENT/INFORMATION/MATERIALS

For performance of the Phase I effort, the Program Manager will provide information regarding the characteristics of a simulated suicide bomber vest and/or other suicide bomber objects. This Government Furnished Information will be provided to assist the contractor prior to the sensor evaluation testing/suicide bomber simulation. Should GFE/GFI/GFM be required in Phases II and/or III, the Government and Contractor will follow the necessary steps to provide such property.

SECTION H - SPECIAL CONTRACT REQUIREMENTS

H-1: CONFIDENTIALITY OF INFORMATION

(a) To the extent that the work under this contract requires that the Contractor be given access to or be furnished with confidential or proprietary business, technical, or financial information or data belonging to other entities which is clearly marked as confidential or proprietary, the Contractor shall, after receipt thereof, treat such information in confidence and agrees not to appropriate such information to its own use or to disclose such information to third parties unless specifically authorized in writing by the Contracting Officer. The foregoing obligations, however, shall not apply to:

(1) Information or data which is in the public domain at the time of receipt by the Contractor;

(2) Information or data which is published or otherwise subsequently becomes part of the public domain through no fault of the Contractor;

(3) Information or data which the Contractor can demonstrate was already in its possession at the time of receipt thereof; or

(4) Information or data which the Contractor can demonstrate was received by it from a third party who did not require the Contractor to treat it in confidence.

(b) The Contractor agrees (1) to enter into an agreement, identical in all material respects to the requirements of paragraph (a) above, with each entity requesting such agreement and that is supplying such confidential or proprietary information or data to the Contractor under this contract and (2) to supply a copy of such agreement to the Contracting Officer, upon written request.

(c) This clause shall be included in any subcontract under which there is a requirement or there becomes a requirement that the subcontractor be given access to or be furnished with confidential or proprietary business, technical, or financial information or data.

H-2: RELEASE OF INFORMATION

The Contractor shall closely coordinate with the COTR regarding any proposed scientific, technical, or professional publication of the results of the work performed or any data developed under this contract. The Contractor shall provide the COTR an opportunity to review any proposed manuscripts describing, in whole or in part, the results of the work performed or any data developed under this contract al lead forty-five (45) days prior to publication. The COTR will review the proposed publication and provide comments. A response shall be provided to the Contractor within forty-five (45) days; otherwise, the Contractor may assume that the COTR has no comments. The Contractor agrees to address any concerns or issues identified by the COTR prior to publication.

H-3: OPTION TO EXTEND THE TERM OF THE CONTRACT (MAR 2000) FAR 52.217-9

(a) The Government may extend the term of this contract by written notice to the Contractor within 30 days of contract expiration; provided that the Government gives the Contractor a preliminary written notice of its intent to extend at least thirty (30) days before the contract expires. The preliminary notice does not commit the Government to an extension.

(b) If the Government exercises this option, the extended contract shall be considered to include this option clause.

(c) The total duration of this contract, including the exercise of any options under this clause, shall not exceed twenty-seven (27) months.

H-4: PROTECTION OF HUMAN SUBJECTS

(a) The Contractor agrees that the rights and welfare of human subjects involved in research under this contract shall be protected in accordance with 45 CFR Part 46, as implemented by Department of Homeland Security Management Directive 10300, *PROTECTION OF HUMAN SUBJECTS*, and with the Contractor's current Assurance of Compliance on file with the Department of Health and Human Services. The Contractor further agrees to provide certification to the Contracting Officer at least annually that the Institutional Review Board has reviewed and approved the procedures, which involve human subjects in accordance with 45 CFR Part 46 and the Assurance of Compliance.

(b) The Contractor shall bear full responsibility for the performance of all work and services involving the use of human subjects under this contract in a proper manner and as safely as is feasible. The parties hereto agree that the Contractor retains the right to control and direct the performance of all work under this contract. Nothing in this contract shall be deemed to constitute the Contractor or a subcontractor, agent or employee of the Contractor, or any other person, organization, institution, or group of any kind whatsoever, as the agent or employee of the Government. The Contractor agrees that it has entered into this contract and will discharge its obligations, duties, and undertakings and the work pursuant thereto, whether requiring professional judgment or otherwise, as an independent contractor without imputing liability on the part of the Government for the acts of the Contractor or its employees.

(c) If at any time during the performance of this contract, the Contracting Officer determines, in consultation with the Regulatory Compliance Office (RCO) of the Directorate of Science and Technology for the Department of Homeland Security, that the Contractor is not in compliance with any of the requirements and/or standards stated in paragraphs (a) and (b) above, the Contracting Officer may immediately suspend, in whole or in part, work and further payments under this contract until the Contractor corrects the noncompliance. Notice of the suspension may be communicated by telephone and confirmed in writing. If the Contractor fails to complete corrective action within the period of time designated in the Contracting Officer's written notice of suspension, the Contracting Officer may, in

consultation with RCO, terminate this contract in whole or in part, and the Contractor's name may be removed from the list of those contractors with approved Health and Human Services Human Subject Assurances.

SECTION I - CONTRACT CLAUSES

I-1: CLAUSES INCORPORATED BY REFERENCE (FAR 52.252-2) (FEB 1998)

This contract incorporates one or more clauses by reference, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available. Also, the full text of a clause may be accessed electronically at this/these URLs:

http://farsite.hill.af.mil (FAR Clauses 52.###)

http://www.dhs.gov/dhspublic/interweb/assetlibrary/DHS_HSAR_With_Notice_04-01.pdf (HSAR Clauses 30##.###)

I-2: CLAUSES INCORPORATED BY REFERENCE

The following FAR and HSAR clauses are incorporated by reference into this contract:

52.202-1	Definitions	Jul 2004
52.203-3	Gratuities	Apr 1984
52.203-5	Covenant Against Contingent Fees	Apr 1984
52.203-7	Anti-Kickback Procedures	Jul 1995
52.203-8	Cancellation, Recession and Recovery of Funds for Illegal or Improper Activity	Jan 1997
52.203-10	Price or Fee Adjustment for Illegal or Improper Activity	Jan 1997
52.203-12	Limitation on Payments to Influence Certain Federal Transactions	Jun 2003
52.204-4	Printed or Copied Double Sided on Recycled Paper	Aug 2000
52.204-7	Central Contractor Registration	Oct 2003
52.209-6	Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment	Jan 2005
52.215-2 Alt II	Audit and Records – Negotiation - Alternate II	Jun 1999
52.215-8	Order of Precedence – Uniform Contract Format	Oct 1997
52.215-10	Price Reduction for Defective Cost or Pricing Data	Oct 1997
52.215-12	Subcontractor Cost or Pricing Data	Oct 1997
52.215-14	Integrity of Unit Prices	Oct 1997
52.215-15	Pension Adjustments and Asset Reversions	Oct 2004

52.215-17	Waiver of Facilities Capital Cost of Money	Oct 1997
52.215-18	Reversion or Adjustment of Plans for Postretirement Benefits (PRB) Other Than Pensions	Oct 1997
52.215-21	Requirements for Cost or Pricing Data or Information Other Than Cost or Pricing Data – Modifications	Oct 1997
52.216-7	Allowable Cost and Payment (Delete "31.2" and replace with "31.3")	Dec 2002
52.216-8	Fixed Fee	Mar 1997
52.219-8	Utilization of Small Business Concerns	May 2004
52.219-9	Small Business Subcontracting Plan	Sept 2006
52.219-16	Liquidated Damages – Subcontracting Plan	Jan 1999
52.222-1	Notice to the Government of Labor Disputes	Feb 1997
52.222-2	Payment for Overtime Premiums (a) fill-in: zero (0)	Jul 1990
52.222-3	Convict Labor	Jun 2003
52.222-21	Prohibition of Segregated Facilities	Feb 1999
52.222-26	Equal Opportunity	Apr 2002
52.222-35	Equal Opportunity for Disabled Veterans, Veterans of the Vietnam Era and Other Eligible Veterans	Dec 2001
52.222-36	Affirmative Action for Workers with Disabilities	Jun 1998
52.222-37	Employment Reports on Special Disabled Veterans, Veterans of the Vietnam Era and Other Eligible Veterans	Dec 2001
52.223-3 Alt I	Hazardous Material Identification and Material Safety Data – Alternate I (*Jul 1995*)	Jan 1997,
52.223-6	Drug Free Workplace	May 2001
52.223-7	Notice of Radioactive Materials	Jan 1997
52.223-14	Toxic Chemical Release Reporting	Aug 2003
52.225-13	Restrictions on Certain Foreign Purchases	Mar 2005
52.226-1	Utilization of Indian Organizations and Indian-Owned Economic Enterprises	Jun 2000
52.227-1 Alt I	Authorization and Consent - Alternate I (*Apr 1984*)	Jul 1995
52.227-2	Notice and Assistance Regarding Patent and Copyright Infringement	Aug 1996
52.227-11	Patent Rights - Retention by Contractor (Short Form)	Jun 1997
52.227-14/ Alt. IV	Rights in Data – General - Alternate IV	Jun 1987
52.227-16	Additional Data Rights	Jun 1987
52.228-7	Insurance – Liability to Third Persons	Mar 1996
52.230-5	Cost Accounting Standards – Educational Institution	Apr 1998
52.230-6	Administration of Cost Accounting Standards	Nov 1999
52.232-9	Limitation on Withholding of Payments	Apr 1984
52.232-17	Interest	Jun 1996

52.232-22	Limitation of Funds	Apr 1984
52.232-23	Assignment of Claims	Jan 1986
52.232-25	Prompt Payment	Oct 2003
52.232-33	Payment by Electronic Funds Transfer – Central Contractor Registration	Oct 2003
52.233-1	Disputes	Jul 2002
52.233-3 Alt I	Protest After Award – Alternate I (*Jun 1985*)	Aug 1996
52.233-4	Applicable Law for Breach of Contract Claim	Oct 2004
52.242-1	Notice of Intent to Disallow Costs	Apr 1984
52.242-3	Penalties for Unallowable Costs	May 2001
52.242-4	Certification of Final Indirect Costs.	Jan 1997
52.242-13	Bankruptcy	Jul 1995
52.243-2 Alt V	Changes – Cost Reimbursement – Alternate V (*Apr 1984*)	Aug 1987
52.244-2 Alt II	Subcontracts – Alternate II (*Aug 1998*)	Aug 1998
52.244-5	Competition in Subcontracting	Dec 1996
52.244-6	Subcontracts for Commercial Items	Dec 2004
52.245-5 Alt I	Government Property (Cost-Reimbursement, Time-and-Materials, or Labor Hour Contracts) - Alternate I (*Jun 2003*)	May 2004
52.246-23	Limitation of Liability	Feb 1997
52.247-1	Commercial Bill of Lading Notations	Apr 1984
52.247-63	Preference for U.S. Flag Air Carriers	Jun 2003
52.249-5	Termination (Cost Reimbursement)	Sep 1996
52.249-14	Excusable Delays	Apr 1984
52.251-1	Government Supply Sources	Apr 1984
52.253-1	Computer Generated Forms	Jan 1991
3052.219-70	Small Business Subcontracting Program Reporting	Jun 2006
3052.245-70	Government Property Records	Jun 2006

I-3: NOTIFICATION OF OWNERSHIP CHANGES (FAR 52.215-19) (OCT 1997)

(a) The Contractor shall make the following notifications in writing:

(1) When the Contractor becomes aware that a change in its ownership has occurred, or is certain to occur, that could result in changes in the valuation of its capitalized assets in the accounting records, the Contractor shall notify the Administrative Contracting Officer (ACO) within 30 days.

(2) The Contractor shall also notify the ACO within 30 days whenever changes to asset valuations or any other cost changes have occurred or are certain to occur as a result of a change in ownership.

(b) The Contractor shall:

(1) Maintain current, accurate, and complete inventory records of assets and their costs;

(2) Provide the ACO or designated representative ready access to the records upon request;

(3) Ensure that all individual and grouped assets, their capitalized values, accumulated depreciation or amortization, and remaining useful lives are identified accurately before and after each of the Contractor's ownership changes; and

(4) Retain and continue to maintain depreciation and amortization schedules based on the asset records maintained before each Contractor ownership change.

(c) The Contractor shall include the substance of this clause in all subcontracts under this contract that meet the applicability requirement of FAR 15.408(k).

I-4: NOTIFICATION OF EMPLOYEES RIGHTS CONCERNING PAYMENT OF UNION DUES AND FEES (FAR 52.222-39) (DEC 2004)

(a) *Definition.* As used in this clause—

"United States" means the 50 States, the District of Columbia, Puerto Rico, the Northern Mariana Islands, American Samoa, Guam, the U.S. Virgin Islands, and Wake Island.

(b) *Except* as provided in paragraph (e) of this clause, during the term of this contract, the Contractor shall post a notice, in the form of a poster, informing employees of their rights concerning union membership and payment of union dues and fees, in conspicuous places in and about all its plants and offices, including all places where notices to employees are customarily posted. The notice shall include the following information (except that the information pertaining to National Labor Relations Board shall not be included in notices posted in the plants or offices of carriers subject to the Railway Labor Act, as amended (45 U.S.C. 151-188)).

Notice to Employees

Under Federal law, employees cannot be required to join a union or maintain membership in a union in order to retain their jobs. Under certain conditions, the law permits a union and an employer to enter into a union-security agreement requiring employees to pay uniform periodic dues and initiation fees. However, employees who are not union members can object to the use of their payments for certain purposes and can only be required to pay their share of union costs relating to collective bargaining, contract administration, and grievance adjustment.

If you do not want to pay that portion of dues or fees used to support activities not related to collective bargaining, contract administration, or grievance adjustment, you are entitled to an appropriate reduction in your payment. If you believe that you have been required to pay dues or fees used in part to support activities not related to collective bargaining, contract administration, or grievance adjustment, you may be entitled to a refund and to an appropriate reduction in future payments.

For further information concerning your rights, you may wish to contact the National Labor Relations Board (NLRB) either at one of its Regional offices or at the following address or toll free number:

National Labor Relations Board
Division of Information
1099 14th Street, N.W.
Washington, DC 20570
1-866-667-6572
1-866-316-6572 (TTY)

To locate the nearest NLRB office, see NLRB's website at http://www.nlrb.gov.

(c) The Contractor shall comply with all provisions of Executive Order 13201 of February 17, 2001, and related implementing regulations at 29 CFR Part 470, and orders of the Secretary of Labor.

(d) In the event that the Contractor does not comply with any of the requirements set forth in paragraphs (b), (c), or (g), the Secretary may direct that this contract be cancelled, terminated, or suspended in whole or in part, and declare the Contractor ineligible for further Government contracts in accordance with procedures at 29 CFR Part 470, Subpart B—Compliance Evaluations, Complaint Investigations and Enforcement Procedures. Such other sanctions or remedies may be imposed as are provided by 29 CFR Part 470, which implements Executive Order 13201, or as are otherwise provided by law.

(e) The requirement to post the employee notice in paragraph (b) does not apply to—

(1) Contractors and subcontractors that employ fewer than 15 persons;

(2) Contractor establishments or construction work sites where no union has been formally recognized by the Contractor or certified as the exclusive bargaining representative of the Contractor's employees;

(3) Contractor establishments or construction work sites located in a jurisdiction named in the definition of the United States in which the law of that jurisdiction forbids enforcement of union-security agreements;

(4) Contractor facilities where upon the written request of the Contractor, the Department of Labor Deputy Assistant Secretary for Labor-Management Programs has waived the posting requirements with respect to any of the Contractor's facilities if the Deputy Assistant Secretary finds that the Contractor has demonstrated that—

(i) The facility is in all respects separate and distinct from activities of the Contractor related to the performance of a contract; and

(ii) Such a waiver will not interfere with or impede the effectuation of the Executive order; or

(5) Work outside the United States that does not involve the recruitment or employment of workers within the United States.

(f) The Department of Labor publishes the official employee notice in two variations; one for contractors covered by the Railway Labor Act and a second for all other contractors. The Contractor shall—

(1) Obtain the required employee notice poster from the Division of Interpretations and Standards, Office of Labor-Management Standards, U.S. Department of Labor, 200 Constitution Avenue, NW, Room N-5605, Washington, DC 20210, or from any field office of the Department's Office of Labor-Management Standards or Office of Federal Contract Compliance Programs;

(2) Download a copy of the poster from the Office of Labor-Management Standards website at http://www.olms.dol.gov; or

(3) Reproduce and use exact duplicate copies of the Department of Labor's official poster.

(g) The Contractor shall include the substance of this clause in every subcontract or purchase order that exceeds the simplified acquisition threshold, entered into in connection with this contract, unless exempted by the Department of Labor Deputy Assistant Secretary for Labor-Management Programs on account of special circumstances in the national interest under authority of 29 CFR 470.3(c). For indefinite quantity subcontracts, the Contractor shall include the substance of this clause if the value of orders in any calendar year of the subcontract is expected to exceed the simplified acquisition threshold. Pursuant to 29 CFR Part 470, Subpart B—Compliance Evaluations, Complaint Investigations and Enforcement Procedures, the Secretary of Labor may direct the Contractor to take such action in the enforcement of these regulations, including the imposition of sanctions for noncompliance with respect to any such subcontract or purchase order. If the Contractor becomes involved in litigation with a subcontractor or vendor, or is threatened with such involvement, as a result of such direction, the Contractor may request the United States, through the Secretary of Labor, to enter into such litigation to protect the interests of the United States.

I-5: NOTIFICATION OF CHANGES (FAR 52.243-7) (APR 1984)

(a) Definitions. "Contracting Officer," as used in this clause, does not include any representative of the Contracting Officer.
"Specifically Authorized Representative (SAR)," as used in this clause, means any person the Contracting Officer has so designated by written notice (a copy of which shall be provided to the Contractor) which shall refer to this paragraph and shall be issued to the designated representative before the SAR exercises such authority.
(b) *Notice.* The primary purpose of this clause is to obtain prompt reporting of Government conduct that the Contractor considers to constitute a change to this contract. Except for changes identified as such in writing and signed by the Contracting Officer, the Contractor shall notify the Administrative Contracting Officer in writing promptly, within fifteen (15) calendar days from the date that the Contractor identifies any Government conduct (including actions, inactions, and written or oral communications) that the Contractor regards as a change to the contract terms and conditions. On the basis of the most accurate information available to the Contractor, the notice shall state—

(1) The date, nature, and circumstances of the conduct regarded as a change;
(2) The name, function, and activity of each Government individual and Contractor official or employee involved in or knowledgeable about such conduct;
(3) The identification of any documents and the substance of any oral communication involved in such conduct;
(4) In the instance of alleged acceleration of scheduled performance or delivery, the basis upon which it arose;
(5) The particular elements of contract performance for which the Contractor may seek an equitable adjustment under this clause, including—

(i) What contract line items have been or may be affected by the alleged change;
(ii) What labor or materials or both have been or may be added, deleted, or wasted by the alleged change;
(iii) To the extent practicable, what delay and disruption in the manner and sequence of performance and effect on continued performance have been or may be caused by the alleged change;
(iv) What adjustments to contract price, delivery schedule, and other provisions affected by the alleged change are estimated; and

(6) The Contractor's estimate of the time by which the Government must respond to the Contractor's notice to minimize cost, delay or disruption of performance.

(c) *Continued performance.* Following submission of the notice required by paragraph (b) of this clause, the Contractor shall diligently continue performance of this contract to the maximum extent possible in accordance with its terms and conditions as construed by the Contractor, unless the notice reports a direction of the Contracting Officer or a communication from a SAR of the Contracting Officer, in either of which events the Contractor shall continue performance; provided, however, that if the Contractor regards the direction or communication as a change as described in paragraph (b) of this clause, notice shall be given in the manner provided. All directions, communications, interpretations, orders and similar actions of the SAR shall be reduced to writing promptly and copies furnished to

the Contractor and to the Contracting Officer. The Contracting Officer shall promptly countermand any action which exceeds the authority of the SAR.

(d) *Government response.* The Contracting Officer shall promptly, within thirty (30) calendar days after receipt of notice, respond to the notice in writing. In responding, the Contracting Officer shall either—

(1) Confirm that the conduct of which the Contractor gave notice constitutes a change and when necessary direct the mode of further performance;

(2) Countermand any communication regarded as a change;

(3) Deny that the conduct of which the Contractor gave notice constitutes a change and when necessary direct the mode of further performance; or

(4) In the event the Contractor's notice information is inadequate to make a decision under paragraphs (d) (1), (2), or (3) of this clause, advise the Contractor what additional information is required, and establish the date by which it should be furnished and the date thereafter by which the Government will respond.

(e) Equitable adjustments.

(1) If the Contracting Officer confirms that Government conduct effected a change as alleged by the Contractor, and the conduct causes an increase or decrease in the Contractor's cost of, or the time required for, performance of any part of the work under this contract, whether changed or not changed by such conduct, an equitable adjustment shall be made—

(i) In the contract price or delivery schedule or both; and

(ii) In such other provisions of the contract as may be affected.

(2) The contract shall be modified in writing accordingly. In the case of drawings, designs or specifications which are defective and for which the Government is responsible, the equitable adjustment shall include the cost and time extension for delay reasonably incurred by the Contractor in attempting to comply with the defective drawings, designs or specifications before the Contractor identified, or reasonably should have identified, such defect. When the cost of property made obsolete or excess as a result of a change confirmed by the Contracting Officer under this clause is included in the equitable adjustment, the Contracting Officer shall have the right to prescribe the manner of disposition of the property. The equitable adjustment shall not include increased costs or time extensions for delay resulting from the Contractor's failure to provide notice or to continue performance as provided, respectively, in paragraphs (b) and (c) of this clause.

I-6: PROHIBITION ON CONTRACTS WITH CORPORATE EXPATRIATES (HSAR 3052.209-70) (DEC 2003)

(a) Prohibitions.

Section 835 of Public Law 107-296, prohibits the Department of Homeland Security from entering into any contract with a foreign incorporated entity after November 25, 2002, which is treated as an inverted domestic corporation as defined in this clause. The Secretary shall waive the prohibition with respect to any specific contract if the Secretary determines that the waiver is required in the interest of homeland security, or to prevent the loss of any jobs in

the United States or prevent the Government from incurring any additional costs that otherwise would not occur.

(b) Definitions. As used in this clause:

"Expanded Affiliated Group" means an affiliated group as defined in section 1504(a) of the Internal Revenue Code of 1986 (without regard to section 1504(b) of such Code), except that section 1504 of such Code shall be applied by substituting 'more than 50 percent' for 'at least 80 percent' each place it appears. "Foreign Incorporated Entity" means any entity which is, or but for subsection (b) of Section 835 of the Homeland Security Act, Public Law 107-296, would be, treated as a foreign corporation for purposes of the Internal Revenue Code of 1986.

"Inverted Domestic Corporation." A foreign incorporated entity shall be treated as an inverted domestic corporation if, pursuant to a plan (or a series of related transactions)—

(1) The entity completes after November 25, 2002, the direct or indirect acquisition of substantially all of the properties held directly or indirectly by a domestic corporation or substantially all of the properties constituting a trade or business of a domestic partnership;

(2) After the acquisition at least 80 percent of the stock (by vote or value) of the entity is held—

(i) In the case of an acquisition with respect to a domestic corporation, by former shareholders of the domestic corporation by reason of holding stock in the domestic corporation; or

(ii) In the case of an acquisition with respect to a domestic partnership, by former partners of the domestic partnership by reason of holding a capital or profits interest in the domestic partnership; and

(3) The expanded affiliated group which after the acquisition includes the entity does not have substantial business activities in the foreign country in which or under the law of which the entity is created or organized when compared to the total business activities of such expanded affiliated group. "Person", "domestic", and "foreign" have the meanings given such terms by paragraphs (1), (4), and (5) of section 7701(a) of the Internal Revenue Code of 1986, respectively.

(c) Special rules. The following definitions and special rules shall apply when determining whether a foreign incorporated entity should be treated as an inverted domestic corporation.

(1) Certain Stock Disregarded. For the purpose of treating a foreign incorporated entity as an inverted domestic corporation these shall not be taken into account in determining ownership:

(i) stock held by members of the expanded affiliated group which includes the foreign incorporated entity; or

(ii) stock of such entity which is sold in a public offering related to the acquisition described in subsection (b)(1) of Section 835 of the Homeland Security Act, Public Law 107-296.

(2) Plan Deemed In Certain Cases. If a foreign incorporated entity acquires directly or indirectly substantially all of the properties of a domestic corporation or partnership during the 4-year period beginning on the date which is after the date of enactment of this Act and which is 2 years before the ownership requirements of subsection (b)(2) are met, such actions shall be treated as pursuant to a plan.

(3) Certain Transfers Disregarded. The transfer of properties or liabilities (including by contribution or distribution) shall be disregarded if such transfers are part of a plan a principal purpose of which is to avoid the purposes of this section.

(d) Special Rule for Related Partnerships.

For purposes of applying Section 835(b) of Public Law 107-296 to the acquisition of a domestic partnership, except as provided in regulations, all domestic partnerships which are under common control (within the meaning of section 482 of the Internal Revenue Code of 1986) shall be treated as a partnership.

(e) Treatment of Certain Rights.

(1) Certain rights shall be treated as stocks to the extent necessary to reflect the present value of all equitable interests incident to the transaction, as follows:

(i) warrants;
(ii) options;
(iii) contracts to acquire stock;
(iv) convertible debt instruments; and
(v) others similar interests.

(2) Rights labeled as stocks shall not be treated as stocks whenever it is deemed appropriate to do so to reflect the present value of the transaction or to disregard transactions whose recognition would defeat the purpose of Section 835.

(f) Disclosure.

By signing and submitting its offer, an Offeror under this solicitation represents that it not a foreign incorporated entity that should be treated as an inverted domestic corporation pursuant to the criteria of Section 835 of the Homeland Security Act, Public Law 107-296 of November 25, 2002.

(g) If a waiver has been granted, a copy of the approved waiver shall be attached to the bid or proposal.

I-7: INSURANCE (HSAR 3052.228-70) (DEC 2003)

In accordance with the clause entitled "Insurance - Work on a Government Installation" [or Insurance - Liability to Third Persons] in Section I, insurance of the following kinds and minimum amounts shall be provided and maintained during the period of performance of this contract:

(a) Worker's compensation and employer's liability. The contractor shall, as a minimum, meet the requirements specified at (FAR) 48 CFR 28.307-2(a).

(b) General liability. The contractor shall, as a minimum, meet the requirements specified at (FAR) 48 CFR 28.307-2(b).

(c) Automobile liability. The contractor shall, as a minimum, meet the requirements specified at (FAR) 48 CFR 28.307-2(c).

I-8: PRECONTRACT COSTS (HSAR 3052.231-70) (DEC 2003)

The Contractor shall be entitled to reimbursement for pre-contract costs incurred on or after 10 July 2006 in an amount not to exceed $500,000 that, if incurred after this contract had been entered into, would have been reimbursable under this contract.

SECTION J - ATTACHMENTS

RESERVED

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SECTION K - REPRESENTATIONS, CERTIFICATIONS, AND OTHER STATEMENTS OF BIDDERS

K-1: Annual Representations and Certifications. (JAN 2006) 52.204-8

(a)(1) The North American Industry Classification System (NAICS) code for this acquisition is: 611310.

(2) The small business size standard is $6.5M.

(3) The small business size standard for a concern which submits an offer in its own name, other than on a construction or service contract, but which proposes to furnish a product which it did not itself manufacture, is 500 employees.

(b)(1) If the clause at 52.204-7, Central Contractor Registration, is included in this solicitation, paragraph (c) of this provision applies.

(2) If the clause at 52.204-7 is not included in this solicitation, and the offeror is currently registered in CCR, and has completed the ORCA electronically, the offeror may choose to use paragraph (c) of this provision instead of completing the corresponding individual representations and certifications in the solicitation. The offeror shall indicate which option applies by checking one of the following boxes:

[ ] (i) Paragraph (c) applies.

[ ] (ii) Paragraph (c) does not apply and the offeror has completed the individual representations and certifications in the solicitation.

(c) The offeror has completed the annual representations and certifications electronically via the Online Representations and Certifications Application (ORCA) website at http://orca.bpn.gov. After reviewing the ORCA database information, the offeror verifies by submission of the offer that the representations and certifications currently posted electronically have been entered or updated within the last 12 months, are current, accurate, complete, and applicable to this solicitation (including the business size standard applicable to the NAICS code referenced for this solicitation), as of the date of this offer and are incorporated in this offer by reference (see FAR 4.1201); except for the changes identified below [*offeror to insert changes, identifying change by clause number, title, date*]. These amended representation(s) and/or certification(s) are also incorporated in this offer and are current, accurate, and complete as of the date of this offer.

FAR Clause	Title	Date	Change

Any changes provided by the offeror are applicable to this solicitation only, and do not result in an update to the representations and certifications posted on ORCA.

(End of Provision)

K-2: Place of Performance. (OCT 1997) 52.215-6

(a) The offeror or respondent, in the performance of any contract resulting from this solicitation, intends, ☒does not intend [*check applicable block*] to use one or more plants or facilities located at a different address from the address of the offeror or respondent as indicated in this proposal or response to request for information.
(b) If the offeror or respondent checks "intends" in paragraph (a) of this provision, it shall insert in the following spaces the required information:

Place of Performance (Street Address, City, State, County, ZIP Code)	Name and Address of Owner and Operator of the Plant or Facility if Other than Offeror or Respondent

(End of provision)

K-3: Certification of Toxic Chemical Release Reporting. (AUG 2003) 52.223-13

(a) Executive Order 13148, of April 21, 2000, Greening the Government through Leadership in Environmental Management, requires submission of this certification as a prerequisite for contract award.

(b) By signing this offer, the offeror certifies that -

(1) As the owner or operator of facilities that will be used in the performance of this contract that are subject to the filing and reporting requirements described in section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) (42 U.S.C. 11023) and section 6607 of the Pollution Prevention Act of 1990 (PPA) (42 U.S.C. 13106), the offeror will file and continue to file for such facilities for the life of the contract the Toxic Chemical Release Inventory Form (Form R) as described in sections 313(a) and (g) of EPCRA and section 6607 of PPA; or

(2) None of its owned or operated facilities to be used in the performance of this contract is subject to the Form R filing and reporting requirements because each such facility is exempt for at least one of the following reasons: [*Check each block that is applicable.*]

[X] (i) The facility does not manufacture, process, or otherwise use any toxic chemicals listed in 40 CFR 372.65;

[X] (ii) The facility does not have 10 or more full-time employees as specified in section 313(b)(1)(A) of EPCRA, 42 U.S.C. 11023(b)(1)(A);

[X] (iii) The facility does not meet the reporting thresholds of toxic chemicals established under section 313(f) of EPCRA, 42 U.S.C. 11023(f) (including the alternate thresholds at 40 CFR 372.27, provided an appropriate certification form has been filed with EPA);

[ ] (iv) The facility does not fall within the following Standard Industrial Classification (SIC) codes or their corresponding North American Industry Classification System sectors:

(A) Major group code 10 (except 1011, 1081, and 1094.

(B) Major group code 12 (except 1241).

(C) Major group codes 20 through 39.

(D) Industry code 4911, 4931, or 4939 (limited to facilities that combust coal and/or oil for the purpose of generating power for distribution in commerce).

(E) Industry code 4953 (limited to facilities regulated under the Resource Conservation and Recovery Act, Subtitle C (42 U.S.C. 6921, et seq.), 5169, 5171, or 7389 (limited to facilities primarily engaged in solvent recovery services on a contract or fee basis); or

[ ] (v) The facility is not located in the United States or its outlying areas.

(End of provision)

K-4: Cost Accounting Standards Notices and Certification. (JUN 2000) 52.230-1

Note: This notice does not apply to small businesses or foreign governments. This notice is in three parts, identified by Roman numerals I through III.

Offerors shall examine each part and provide the requested information in order to determine Cost Accounting Standards (CAS) requirements applicable to any resultant contract.

If the offeror is an educational institution, Part II does not apply unless the contemplated contract will be subject to full or modified CAS coverage pursuant to 48 CFR 9903.201-2(c)(5) or 9903.201-2(c)(6), respectively.

I. Disclosure Statement - Cost Accounting Practices and Certification

(a) Any contract in excess of $500,000 resulting from this solicitation will be subject to the requirements of the Cost Accounting Standards Board (48 CFR Chapter 99), except for those contracts which are exempt as specified in 48 CFR 9903.201-1.

(b) Any offeror submitting a proposal which, if accepted, will result in a contract subject to the requirements of 48 CFR Chapter 99 must, as a condition of contracting, submit a Disclosure Statement as required by 48 CFR 9903.202. When required, the Disclosure Statement must be submitted as a part of the offeror's proposal under this solicitation unless the offeror has already submitted a Disclosure Statement disclosing the practices used in connection with the pricing of this proposal. If an applicable Disclosure Statement has already been submitted, the offeror may satisfy the requirement for submission by providing the information requested in paragraph (c) of Part I of this provision.

Caution: In the absence of specific regulations or agreement, a practice disclosed in a Disclosure Statement shall not, by virtue of such disclosure, be deemed to be a proper, approved, or agreed-to practice for pricing proposals or accumulating and reporting contract performance cost data.

(c) Check the appropriate box below:

[ ] (1) *Certificate of Concurrent Submission of Disclosure Statement.* The offeror hereby certifies that, as a part of the offer, copies of the Disclosure Statement have been submitted as follows:

(i) Original and one copy to the cognizant Administrative Contracting Officer (ACO) or cognizant Federal agency official authorized to act in that capacity (Federal official), as applicable; and

(ii) One copy to the cognizant Federal auditor.

(Disclosure must be on Form No. CASB DS-1 or CASB DS-2, as applicable. Forms may be obtained from the cognizant ACO or Federal official and/or from the loose-leaf version of the Federal Acquisition Regulation.)

Date of Disclosure Statement: [*Name and Address of Cognizant ACO or Federal Official Where Filed:*]

The offeror further certifies that the practices used in estimating costs in pricing this proposal are consistent with the cost accounting practices disclosed in the Disclosure Statement.

[ ] (2) *Certificate of Previously Submitted Disclosure Statement.* The offeror hereby certifies that the required Disclosure Statement was filed as follows:

Date of Disclosure Statement: [ ]
Name and Address of Cognizant ACO or Federal Official Where Filed: [ ]

The offeror further certifies that the practices used in estimating costs in pricing this proposal are consistent with the cost accounting practices disclosed in the applicable Disclosure Statement.

[ ] (3) *Certificate of Monetary Exemption.* The offeror hereby certifies that the offeror, together with all divisions, subsidiaries, and affiliates under common control, did not receive net awards of negotiated prime contracts and subcontracts subject to CAS totaling $50 million or more in the cost accounting period immediately preceding the period in which this proposal was submitted. The offeror further certifies that if such status changes before an award resulting from this proposal, the offeror will advise the Contracting Officer immediately.

[ ] (4) *Certificate of Interim Exemption.* The offeror hereby certifies that (i) the offeror first exceeded the monetary exemption for disclosure, as defined in (3) of this subsection, in the cost accounting period immediately preceding the period in which this offer was submitted and (ii) in accordance with 48 CFR 9903.202-1, the offeror is not yet required to submit a Disclosure Statement. The offeror further certifies that if an award resulting from this proposal has not been made within 90 days after the end of that period, the offeror will immediately submit a revised certificate to the Contracting Officer, in the form specified under subparagraph (c)(1) or (c)(2) of Part I of this provision, as appropriate, to verify submission of a completed Disclosure Statement.

Caution: Offerors currently required to disclose because they were awarded a CAS-covered prime contract or subcontract of $50 million or more in the current cost accounting period may not claim this exemption (4). Further, the exemption applies only in connection with proposals submitted before

expiration of the 90-day period following the cost accounting period in which the monetary exemption was exceeded.

II. Cost Accounting Standards - Eligibility for Modified Contract Coverage

If the offeror is eligible to use the modified provisions of 48 CFR 9903.201-2(b) and elects to do so, the offeror shall indicate by checking the box below. Checking the box below shall mean that the resultant contract is subject to the Disclosure and Consistency of Cost Accounting Practices clause in lieu of the Cost Accounting Standards clause.

[ ] The offeror hereby claims an exemption from the Cost Accounting Standards clause under the provisions of 48 CFR 9903.201-2(b) and certifies that the offeror is eligible for use of the Disclosure and Consistency of Cost Accounting Practices clause because during the cost accounting period immediately preceding the period in which this proposal was submitted, the offeror received less than $50 million in awards of CAS-covered prime contracts and subcontracts. The offeror further certifies that if such status changes before an award resulting from this proposal, the offeror will advise the Contracting Officer immediately.

Caution: An offeror may not claim the above eligibility for modified contract coverage if this proposal is expected to result in the award of a CAS-covered contract of $50 million or more or if, during its current cost accounting period, the offeror has been awarded a single CAS-covered prime contract or subcontract of $50 million or more.

III. Additional Cost Accounting Standards Applicable to Existing Contracts

The offeror shall indicate below whether award of the contemplated contract would, in accordance with subparagraph (a)(3) of the Cost Accounting Standards clause, require a change in established cost accounting practices affecting existing contracts and subcontracts.

[ ] yes [ ] no

(End of provision)

K-5: Proposal Disclosure – Cost Accounting Practice Changes. (APR 2005) 52.230-7

The offeror shall check "yes" below if the contract award will result in a required or unilateral change in cost accounting practice, including unilateral changes requested to be desirable changes.

___ Yes
_X_ No

If the offeror checked "Yes" above, the offeror shall—

(1) Prepare the price proposal in response to the solicitation using the changed practice for the period of performance for which the practice will be used; and
(2) Submit a description of the changed cost accounting practice to the Contracting Officer and the Cognizant Federal Agency Official as pricing support for the proposal.

(End of provision)

BRENDA BRADY

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT	1. CONTRACT ID CODE	PAGE OF PAGES
		1 9

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00001	07/10/2006	RSEN-07-00073	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than item 6)	CODE
DHS/OPO/S&T/S&T		DHS/OPO/S&T/S&T	

6. ISSUED BY:
U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Branch
245 Murray Lane, SW
Building 410
Washington DC 20528

7. ADMINISTERED BY (If other than item 6):
OPO S&T Acquisition Branch

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

CODE	0014236310000	FACILITY CODE	

9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

10A. MODIFICATION OF CONTRACT/ORDER NO.
HSHQDC-07-C-00016

10B. DATED (SEE ITEM 11)
12/06/2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended. ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as extended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
Net Increase: $420,000.00
See Schedule

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	43.103(a)(3)
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

Tax ID Number: 04-1679980
DUNS Number: 001423631+0000
Division: Explosives
PPA: Explosives
Thrust Area: Explosives Detection
Program: Checkpoint Program
Project: Next Generation Passenger Checkpoint Porject
Performer: Northeast University

Description: The purpose of this effort is to excerise the second increment of Phase I of the Northeastern Award under BAA05-03 Prototypes and Technologies for Improvised Explosive
Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
	Douglas S. Roark

15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
[redacted] (Signature of person authorized to sign)	5.17.07	[redacted] (Signature of Contracting Officer)	5-17-07

NSN 7540-01-152-8070
Previous edition unusable

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Device Detection. Discount Terms: Net 30 FOB: Destination Period of Performance: 07/10/2006 to 04/07/2008 Change Item 0001 to read as follows(amount shown is the obligated amount):				
0001	PTIEDD - Phase I: BomDetec Project Including Data Deliverables Fully Funded Obligation Amount$1,711,383.00 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 04/09/2007 Delivery Location Code: DHS Department of Homeland Security 245 Murray Lane Bldg. 410 Washington DC 20528 Accounting Info: NONE000-000-RX-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 Accounting Info: NONE000-000-5X-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 Accounting Info: NONE000-000-5X-06-20-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 CLIN 0001 Total Estimated Cost: $1,687,533 CLIN 0001 Total Fixed Fee: $23,850 CLIN 0001 Total CPFF: $1,711,383 CLIN 0001 is incrementally funded in the amount of $1,305,181. This amount appears in Block 15G of the SF26 as the amount obligated with this action. Change Item 0002 to read as follows(amount shown is the obligated amount):	1	LO	1,711,383.00	0.00
0002	OPTION 1: PTIEDD - Phase II: BomDetec Project Continued ...	1	LO	1,697,743.00	0.00

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Including Data Deliverables Amount: $1,697,743.00(Option Line Item) 04/09/2007 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 365 Days After Award Delivery Location Code: DHS Department of Homeland Security 245 Murray Lane Bldg. 410 Washington DC 20528 Accounting Info: Funded: $0.00 CLIN 0002 Total Estimated Cost: $1,564,740 CLIN 0002 Total Fixed Fee: $133,003 CLIN 0002 Total CPFF: $1,697,743 Change Item 0003 to read as follows(amount shown is the obligated amount): OPTION 2: PTIEDD - Phase III: BomDetec Project Including Data Deliverables Amount: $523,332.00(Option Line Item) 04/06/2008 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 180 Days After Award Delivery Location Code: DHS Department of Homeland Security 245 Murray Lane Bldg. 410 Washington DC 20528 Accounting Info: Funded: $0.00 CLIN 0003 Total Estimated Cost: $482,334 CLIN 0003 Total Fixed Fee: $40,998 CLIN 0003 Total CPFF: $523,332 If and to the extent that all options are exercised: Add Item 0004 as follows: Continued ...				
0003		1	LO	523,332.00	0.00

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
0004	Funding for the second increment for Phase I Obligated Amount: $420,000.00 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Delivery: 04/09/2008 Delivery Location Code: S&T MURRAY LANE DHS S&T 245 Murray Lane Building 410 Washington DC 20528 Amount: $420,000.00 Accounting Info: NONE000-000-7X-33-02-03-0001-01-00-0000-00-00-00-0 0-GE-AP-25-50-000000 Funded: $420,000.00				420,000.00

Statement of Work for Northeastern University

U.S. Department of Homeland Security
Science and Technology Directorate
Explosives Division

RSEN-07-00073

I. Background

The U.S. Department of Homeland Security (DHS) is committed to using cutting-edge technologies and scientific talent in its quest to make America safer. The DHS Directorate of Science and Technology (S&T) is tasked with researching and organizing the scientific, engineering, and technological resources of the United States and leveraging these existing resources into technological tools to help protect the homeland. The Suicide Borne IED program supports this effort by focusing on protecting the homeland from the threat of explosives through detection. Solutions targeted are either near-term or more in-depth for suicide bomb and/or leave-behind bomb detection.

II. Scope of Work

The purpose of this SOW is to exercise the second increment for Phase I of the Northeastern Award under BAA05-03 Prototypes and Technologies for Improvised Explosives Device Detection. The remaining $420K will be funded in FY07. The core deliverable for the remainder of this Phase will be a summary report to include potential technological issues related to the integration of multiple technologies.

	Item	Time After Award
1.	Monthly Technical Progress and Cost Reports	Monthly
2.	Report on Laboratory and Field Evaluation Criteria	Thirty (30) Weeks
3.	Report on Laboratory and Field Evaluation Results for each sensor	Thirty-four (34) Weeks
4.	Independent Review Board Report on the use of Human Test Subjects	Thirty (30) days prior to testing
5.	System Configuration concept	Thirty-six (36) Weeks
6.	Preliminary Design Review (PDR) with Detailed Summary Report	Thirty-six (36) Weeks
7.	Final Report Phase I	Nine (9) Months

Northeastern University has completed items 2.1, 2.2, 4.1 and 4.3 as numbered in the Contract Section C1: Statement of work and will perform the remaining tasks described below with the additional $420K.

1) Intelligent Video:
   a. Test and analyze the performance of the Intelligent Video
   b. Test the software System architecture, and integration
   c. Test and evaluate visualization front end, policy engine
   d. Develop system configuration Concept (w/team)
   e. Write Preliminary Design Review (Intelligent Video, software integration) (PDT)
   f. Write Phase I Final Report (Intelligent Video, and software integration)

2) Radar:
   a. Design experiments to validate the algorithms
   b. Investigate clutter reduction approaches
   c. Develop system configuration Concept (w/team)
   d. Write Preliminary Design Review (radar sensor) (PDR)
   e. Write Phase I Final Report (radar sensor)

3) X-Ray:
   a. Develop System Configuration Concept (w/team)
   b. Write Preliminary Design Review (X-ray sensor, hardware integration) (PDR)
   c. Write Phase I Pinal Report (X-ray sensor, hardware integration)

4) Terahertz:
   a. Develop system Configuration Concept
   b. Write Preliminary Design review (THz sensor) (PDR)
   c. Write Phase I Final Report (THz sensor)

5) Suicide bomber Test subject:

6) Hardware and software Integration:

7) Program Management:
   a. System Configuration Concept
   b. Preliminary Design Review (PDR)
   c. Phase I Final Report

III. Other Contract Details

1. **Period of Performance.** The period of performance for this SOW will continue from the contract award date to 9 April 2007. DHS may give subsequent extension notices to Northeastern University in writing for further performance in accordance with the terms of this SOW.

   Travel. The DHS Explosives Division Director and the DHS S&T Special Assistant for International Policy must approve all foreign travel in advance.

2. **DHS-Furnished Information.**

   a. DHS will provide certain DHS information, materials, and forms unique to DHS to Northeastern University to support certain tasks under this SOW.

   b. The DHS S&T Technical Representative identified in this SOW will be the point of contact (POC) for identification of any required information to be supplied by DHS.

   c. Northeastern University will prepare any documentation according to the guidelines provided by DHS.

3. **DHS-Furnished Facilities, Supplies, and Services.** If work at DHS-provided facilities is necessary for the services being performed under this SOW, such facilities will be provided at S&T's office in Washington, D.C. Parking facilities are not provided, however several commercial parking facilities are located near S&T's office. Basic facilities such as work space and associated operating requirements (e.g., phones, desks, utilities, desktop computers, and consumable and general purpose office supplies) will be provided to Northeastern University personnel working in S&T's office.

4. **Place of Performance.** Northeastern University will perform the work under this SOW at Northeastern University or the facility of one of the subcontractors.

5. **DHS-Furnished Property.** DHS property will not be provided to Northeastern University unless otherwise agreed in a task order issued under this SOW. In such instances, DHS will maintain property records.

   Before purchasing any individual item equal to or exceeding $50,000 that is required to support technical tasks performed pursuant to this SOW, Northeastern University shall obtain the DHS S&T Technical Representative's prior written consent. The DHS S&T Technical Representative may lower or raise the aforementioned $50,000 threshold at his/her discretion and on written notice to Northeastern University. If the DHS S&T Technical Representative consents to such purchase, such item shall become the property of DHS. Northeastern University will maintain any such items according to currently existing property accountability procedures. The DHS S&T Technical Representative will determine the final disposition of any such items.

6. **Deliverables.** Northeastern University will provide all deliverables identified in this SOW directly to the DHS S&T Technical Representative with a copy of the transmittal letter to the Contracting Officer.

7. **Program Status Report.** Northeastern University will deliver a monthly program status report to the DHS S&T Technical Representative and DHS S&T Resource Manager containing metrics pertaining to financial, schedule, and scope information, risk information, and performance assessment information of all work performed hereunder.

8. **Cost Summary.** DHS will provide funding to Northeastern University in accordance with DHS's appropriations and available funds pursuant to the allocation outlined below:

Budget Summary*						
Task	Labor	Materials and Supplies	Capital Equipment	Travel	Other Direct Costs	Total
Complete Phase I	$265,000	$10,000	$100,000	$10,000	$35,000	$420,000
Totals	$265,000	$10,000	$100,000	$10,000	$35,000	**$420,000**

**Figures extracted from NRL's Phase II Proposal Cost Summary*

9. **Security Requirements.**

   a. All work performed under this SOW is unclassified unless otherwise specified by DHS.

   b. If classified work is required under this SOW, DHS will provide specific guidance to Northeastern University as to which work will be conducted in a classified manner and at which classification level. If such DHS-guidance conflicts with applicable DOE guidelines, Northeastern University will adhere to the applicable DOE guidelines. Northeastern University will also adhere to other applicable Government orders, guides, and directives pertaining to classified or confidential work. This SOW may require access to information at the FOUO level.

   c. The Contractor shall closely coordinate with the COTR regarding any proposed scientific, technical or professional publication of the results of the work performed or any data developed under this contract. The Contractor shall provide the COTR an opportunity to review any proposed manuscripts describing, in whole or in part, the results of the work performed or any data developed under this contract at least 45 days prior to publication. The COTR will review the proposed publication and provide comments. A response shall be provided to the Contractor within 45 days; otherwise, the Contractor may assume that the COTR has no comments. The Contractor agrees to address any concerns or issues identified by the COTR prior to publication.

IV. Points of Contact

Northeastern University Points of Contact (POCs) are as follows:

- Technical POC(s) – John Beatty
  Northeastern University
  360 Huntington Avenue
  251 RI
  Boston, MA 02115-5000
  [redacted]

- Financial POC(s) – Paul Powell
  Northeastern University
  360 Huntington Avenue
  251 RI
  Boston, MA 02115-5000
  [redacted]

The DHS POCs are as follows:

- DHS S&T Technical Representative – Mike Shepard
  Department of Homeland Security
  Science and Technology
  Directorate/Explosives Division, Mike Shepard
  Washington, DC 20528
  [redacted]

- Resource Manager – Shaun MacKeever
  Contractor in support of the
  Department of Homeland Security
  Science and Technology Directorate/Explosives Division,
  Washington, DC 20528
  [redacted]

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT	1. CONTRACT ID.	PAGE OF PAGES
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2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00002	07/02/2008	RSEN-08-00093	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than item 6)	CODE
DHS/OPO/S&T/S&T		DHS/OPO/S&T/S&T	

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Branch
245 Murray Lane, SW
Building 410
Washington DC 20528

OPO S&T Acquisition Branch

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

(x) 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

x 10A. MODIFICATION OF CONTRACT/ORDER NO.
HSHQDC-07-C-00016

10B. DATED (SEE ITEM 11)
12/06/2006

CODE 0014236310000 FACILITY CODE

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
See Schedule

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	43.103(a)(3)
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

DUNS Number: 001423631+0000
Division: Explosives
PPA: Explosives
Thrust Area: Explosives Detection
Program: Checkpoint Program
Project: Next Generation Passenger Checkpoint Porject
Performer: Northeastern University

The purpose of this modification is to extend the Period of Performance through 10/31/2008 at no cost to the Government and include revised Statement of Work with updated delivery date for Final Report Phase I. All other terms and conditions remain

Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)		16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)	
[redacted]		Aaron H. Ford	
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
Maureen A. Joyce Director, Div. of Sponsored (Signature of person authorized to sign)	7.24.08	[redacted] (Signature of Contracting Officer)	8/5/08

NSN 7540-01-152-8070 Project Administration
Previous edition unusable

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

CONTINUATION SHEET	REFERENCE OF DOCUMENT BEING CONTINUED HSHQDC-07-C-00016/P00002	PAGE 2 OF 8

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	unchanged and in full force and effect. Period of Performance: 07/10/2006 to 10/31/2008				

Statement of Work for Northeastern University

U.S. Department of Homeland Security
Science and Technology Directorate
Explosives Division

PR# RSEN-08-00093

I. Background

The U.S. Department of Homeland Security (DHS) is committed to using cutting-edge technologies and scientific talent in its quest to make America safer. The DHS Directorate of Science and Technology (S&T) is tasked with researching and organizing the scientific, engineering, and technological resources of the United States and leveraging these existing resources into technological tools to help protect the homeland. The Suicide Borne IED program supports this effort by focusing on protecting the homeland from the threat of explosives through detection. Solutions targeted are either near-term or more in-depth for suicide bomb and/or leave-behind bomb detection.

II. Scope of Work

The purpose of this SOW is to extend the period of performance, at no cost to the government, to allow time to complete originally contracted efforts. The core deliverable for this modification will be -the Phase I final report, including a discussion of potential technological issues related to the integration of multiple technologies. Recent results from this program are significantly more complex than originally thought. Further development of the wide aperture antenna array concept, developed earlier in this phase, is needed to clarify the performance of radar in this multi-sensor system. Supporting tasks are highlighted below under "2. Radar". These tasks fall within the scope of the original contract.

	Item	Time After Award
1.	Monthly Technical Progress and Cost Reports	Monthly
2.	Report on Laboratory and Field Evaluation Criteria	Thirty (30) Weeks
3.	Report on Laboratory and Field Evaluation Results for each sensor	Thirty-four (34) Weeks
4.	Independent Review Board Report on the use of Human Test Subjects	Thirty (30) days prior to testing
5.	System Configuration concept	Thirty-six (36) Weeks
6.	Preliminary Design Review (PDR) with Detailed Summary Report	Thirty-six (36) Weeks
7.	Final Report Phase I	**October 31, 2008**

Northeastern University has completed items 2.1, 2.2, 4.1 and 4.3 as numbered in the Contract Section C1: Statement of work and will perform the remaining tasks described below with the additional $420K.

1) Intelligent Video:
   a. Test and analyze the performance of the Intelligent Video
   b. Test the software System architecture, and integration
   c. Test and evaluate visualization front end, policy engine
   d. Develop system configuration Concept (w/team)
   e. Write Preliminary Design Review (Intelligent Video, software integration) (PDT)
   f. Write Phase I Final Report (Intelligent Video, and software integration)

2) Radar:
   a. Design experiments to validate the algorithms
   b. Investigate clutter reduction approaches
   c. Develop system configuration Concept (w/team)
   d. Write Preliminary Design Review (radar sensor) (PDR)
   e. Based on the existing wide aperture antenna array, establish specifications and design a single multi-monostatic mm-wave element of the full array.
   f. Design and fabricate or purchase a standard gain feed and a reflector antenna for radar.
   g. Build the radar element by combining source, antennas, and drive electronics.
   h. Fabricate an adjustable support structure for mounting and repositioning the single element to simulate a full array of stationary elements.
   i. Test the array antenna mm-wave radar element indoors in a large W-band rated anechoic chamber. Compare with modeled results.
   j. Write Phase I Final Report (radar sensor)

3) X-Ray:
   a. Develop System Configuration Concept (w/team)
   b. Write Preliminary Design Review (X-ray sensor, hardware integration) (PDR)
   c. Write Phase I Pinal Report (X-ray sensor, hardware integration)

4) Terahertz:
   a. Develop system Configuration Concept
   b. Write Preliminary Design review (THz sensor) (PDR)
   c. Write Phase I Final Report (THz sensor)

5) Suicide bomber Test subject:

6) Hardware and software Integration:

7) Program Management:
   a. System Configuration Concept
   b. Preliminary Design Review (PDR)
   c. Phase I Final Report

III. Other Contract Details

1. **Period of Performance.** The period of performance for this SOW will continue from the contract award date to 9 April 2008 to October 31, 2008. DHS may give subsequent extension notices to Northeastern University in writing for further performance in accordance with the terms of this SOW.

2. **Travel.** Travel may be required in the performance of the tasks described herein. S&T anticipates that travel will be limited to the continental United States. The DHS S&T Technical Representative and the DHS S&T Special Assistant for International Policy must approve all foreign travel in advance. Travel Costs incurred in association with the execution of the tasks described in this SOW will be reimbursed in accordance with the travel reimbursement policy set forth in the prime contract between DHS and Northeastern University for research, testing, evaluation, and/or development activities.

3. **DHS-Furnished Information.**

   DHS will provide certain DHS information, materials, and forms unique to DHS to Northeastern University to support certain tasks under this SOW.

   The DHS S&T Technical Representative identified in this SOW will be the point of contact (POC) for identification of any required information to be supplied by DHS.

   Northeastern University will prepare any documentation according to the guidelines provided by DHS.

4. **DHS-Furnished Facilities, Supplies, and Services.** If work at DHS-provided facilities is necessary for the services being performed under this SOW, such facilities will be provided at S&T's office in Washington, D.C. Parking facilities are not provided, however several commercial parking facilities are located near S&T's office. Basic facilities such as work space and associated operating requirements (e.g., phones, desks, utilities, desktop computers, and consumable and general purpose office supplies) will be provided to Northeastern University personnel working in S&T's office.

5. **Place of Performance.** Northeastern University will perform the work under this SOW at Northeastern University or the facility of one of the subcontractors.

6. **DHS-Furnished Property.** DHS property will not be provided to Northeastern University unless otherwise agreed in a task order issued under this SOW. In such instances, DHS will maintain property records.

Before purchasing any individual item equal to or exceeding $50,000 that is required to support technical tasks performed pursuant to this SOW, Northeastern University shall obtain the DHS S&T Technical Representative's prior written consent. The DHS S&T Technical Representative may lower or raise the aforementioned $50,000 threshold at his/her discretion and on written notice to Northeastern University. If the DHS S&T Technical Representative consents to such purchase, such item shall become the property of DHS. Northeastern University will maintain any such items according to currently existing property accountability procedures. The DHS S&T Technical Representative will determine the final disposition of any such items.

7. **Deliverables**. Northeastern University will provide all deliverables identified in this SOW directly to the DHS S&T Technical Representative with a copy of the transmittal letter to the Contracting Officer.

   Acceptance Criteria. Deliverables shall be subject to testing, review, and acceptance by DHS to verify that each deliverable satisfies DHS's applicable acceptance criteria. "Acceptance Criteria" mean the criteria developed by DHS to determine whether a deliverable is ready for acceptance by DHS and may include, without limitation, requirements that the applicable deliverable: (i) has been completed and delivered/achieved according to this SOW; (ii) meets or exceeds the identified requirements in this SOW, including but not limited to technical specifications and performance standards; and (iii) complies with such other criteria as may be developed and agreed on by DHS and Northeastern University. Deliverables for which DHS wishes to develop Acceptance Criteria will be identified by DHS, in writing, prior to initiation of any work on such deliverables. DHS and Northeastern University will agree in writing on the Acceptance Criteria associated with such deliverables.

   Correction of Nonconformities. If a deliverable fails to meet the relevant Acceptance Criteria (each such failure or deficiency is referred to as a "Nonconformity"), DHS will provide written notification to Northeastern University of such failure. Upon receiving such notice, Northeastern University will inform DHS in writing of the costs associated with correction and proposed actions to correct. Corrective actions will not be undertaken until additional funding has been received as well as clear written guidance as to what actions are authorized. The corrected Nonconformity will be redelivered to DHS, which will then confirm in writing whether the redelivered deliverable conforms to and satisfies the applicable Acceptance Criteria. The process described in this Section may be repeated as necessary until all Nonconformities are corrected and the deliverable conforms to and satisfies its Acceptance Criteria or until either party reasonably determines that continued efforts would be unsuccessful. DHS will cover all expenses associated with these corrective activities.

8. **Program Status Report**. Northeastern University will deliver a monthly program status report to the DHS S&T Technical Representative, DHS S&T Business Operations Manager, and DHS S&T Resource Manager containing metrics pertaining to financial,

schedule, and scope information, risk information, and performance assessment information of all work performed hereunder.

9. **Cost Summary.** DHS will provide funding to Northeastern University in accordance with DHS's appropriations and available funds. Requested funding amount is $420,000.

10. **Security Requirements.**

    a. All work performed under this SOW is unclassified unless otherwise specified by DHS.

    b. If classified work is required under this SOW, DHS will provide specific guidance to Northeastern University as to which work will be conducted in a classified manner and at which classification level. If such DHS-guidance conflicts with applicable DOE guidelines, Northeastern University will adhere to the applicable DOE guidelines. Northeastern University will also adhere to other applicable Government orders, guides, and directives pertaining to classified or confidential work. This SOW may require access to information at the FOUO level.

    c. The Contractor shall closely coordinate with the COTR regarding any proposed scientific, technical or professional publication of the results of the work performed or any data developed under this contract. The Contractor shall provide the COTR an opportunity to review any proposed manuscripts describing, in whole or in part, the results of the work performed or any data developed under this contract at least 45 days prior to publication. The COTR will review the proposed publication and provide comments. A response shall be provided to the Contractor within 45 days; otherwise, the Contractor may assume that the COTR has no comments. The Contractor agrees to address any concerns or issues identified by the COTR prior to publication.

IV. Points of Contact

Northeastern University Points of Contact (POCs) are as follows:

Technical POC(s):
John Beatty
Northeastern University
360 Huntington Avenue
251 RI
Boston, MA 02115-5000
Tel: [redacted]

Financial POC(s):

Paul Powell
Northeastern University
360 Huntington Avenue
251 RI
Boston, MA 02115-5000
Tel: [redacted]

Northeastern University may change the individual designated as a POC upon notice to DHS S&T of such change.

The DHS POCs are as follows:

DHS S&T Technical Representative:
Mike Shepard
Department of Homeland Security
Science and Technology
Directorate/Explosives Division/ATTN: Mike Shepard
Washington, DC 20528
Tel: [redacted]

DHS S&T Business Operations Manager:
Wallicia Tapscott
Explosives Division
Science and Technology Directorate
Department of Homeland Security
Washington, DC 20582
Tel: [redacted]
Fax: 202-254-5393
[redacted]

DHS Financial Analysis:
Shaun MacKeever
Contractor in support of the
Department of Homeland Security
Science and Technology Directorate
Explosives Division
Washington, DC 20528
Tel: [redacted]

DHS S&T may change the individual designated as a POC upon notice to Northeastern University of such change.

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1 CONTRACT ID CODE	PAGE OF PAGES
	1 of 6

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4 REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00003	09/10/2008	RSTR-08-00071	

6. ISSUED BY	CODE	7 ADMINISTERED BY (If other than item 6)	CODE
DHS/OPO/S&T/S&T		DHS/OPO/S&T/S&T	

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Branch
245 Murray Lane, SW
Building 410
Washington DC 20528

OPO S&T Acquisition Branch

8 NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

CODE	FACILITY CODE
0014236310000	

(x) 9A. AMENDMENT OF SOLICITATION NO

9B. DATED (SEE ITEM 11)

x 10A. MODIFICATION OF CONTRACT/ORDER NO
HSHQDC-07-C-00016

10B. DATED (SEE ITEM 11)
12/06/2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of the amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12 ACCOUNTING AND APPROPRIATION DATA (If required) Net Increase: $12,000.00
NONE000-000-9X-39-02-01-001-01-00-0000-00-00-00-00-GE-OE-25-50-000000

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	43.103(a)(3)
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

DUNS Number: 001423631+0000
Delivery: 365 Days After Award
Discount Terms:
Net 30
Delivery Location Code: S&T MURRAY LANE
DHS S&T
245 Murray Lane
Building 410
Washington DC 20528

FOB: Destination
Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A NAME AND TITLE OF SIGNER (Type or print)	16A NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
Maureen A. Joyce Director, Div. of Sponsored Project Admin.	Albert Dainton
15B CONTRACTOR/OFFEROR [redacted] (Signature of person authorized to sign)	15C. DATE SIGNED 9.11.08
16B. UNITED STATES OF AMERICA [redacted] (Signature of Contracting Officer)	16C. DATE SIGNED 9/24/08

NSN 7540-01-152-8070
Previous edition unusable

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

CONTINUATION SHEET	REFERENCE NO. OF DOCUMENT BEING CONTINUED HSHQDC-07-C-00016/P00003	PAGE 2 OF 6

NAME OF OFFEROR OR CONTRACTOR

NORTHEASTERN UNIVERSITY

ITEM NO (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Period of Performance: 07/10/2006 to 10/31/2008 Add Item 0005 as follows:				
0005	The purpose of this modification is to incorporate an additional tasking into the contract's Statement of Work (see Attachment 1.) Obligated Amount: $12,000.00				12,000.00

Statement of Work for Northeastern University
Contract HSHQDC-07-C-00016

Support for NATO SET Panel 124

Directorate of Science and Technology
U.S. Department of Homeland Security
International Programs Division

I. Background

The U.S. Department of Homeland Security (DHS) is committed to using cutting-edge technologies and scientific talent in its quest to make America safer. The DHS Directorate of Science and Technology (S&T) is tasked with researching and organizing the scientific, engineering, and technological resources of the United States and the international community and leveraging these existing resources into technological tools to help protect the homeland. The International Programs Division (IND) at DHS S&T was established in accordance with the Implementing Recommendations of the 9/11 Commission Act of 2007 (codified as amended at 6 U.S.C. 317), indicating DHS priority. The responsibilities of IND is to facilitate the matching of US entities engaged in homeland security research with foreign counterparts so that they may partner in cooperative research activities.

IND, in conjunction with DHS S&T's Counter-IED Detection Program, seeks to continue efforts to develop Terahertz wave based sensing technologies for standoff explosives detection. These efforts have been initiated by Northeastern University and its performer, Rensselaer Polytechnic University (Contract HSHQDC-07-C-00016). This task will provide the Government with the capacity to further develop THz technology and to support NATO field tests of such technology. The output– a report of these efforts and a report on the NATO meeting–will build capacity for international operational cooperation in the area counter-IED detection.

II. Scope of Work

Northeastern University and its performer will continue the development of Terahertz wave based sensing technologies for standoff explosives detection. In addition to the tasks already prescribed in the aforementioned contract, the performer will also help organize and then participate in the 4th NATO SET Panel 124 business meeting to be held at The Hague, Netherlands in late October 2008. The performer will present their result in the meeting (pre-approval might be required by DHS).

Upon completion of this international meeting, the performer shall deliver a report documenting the results of the NATO meeting. A final report shall be submitted to DHS S&T documenting

the efforts to develop THz technology, field tests of such technology and technical recommendations on the state-of-the-art in Terahertz based explosives detection.

III. Other Contract Details

1. **Period of Performance**. The period of performance for this SOW is for a period of twelve months from the date of award. DHS may give subsequent extension notices to Northeastern University in writing for further performance in accordance with the terms of this SOW.

2. **Travel**. Travel to a NATO meeting in Europe is anticipated.

3. **DHS-Furnished Information**.

   a. DHS will provide certain DHS information, materials, and forms unique to DHS to Northeaster to support certain tasks under this SOW.

   b. The DHS S&T Technical Representative identified in this SOW will be the point of contact (POC) for identification of any required information to be supplied by DHS.

4. **Place of Performance**. Northeastern University will perform the work under this SOW at their location in Boston, Massachusetts and at Rensselaer Polytechnic University in Troy, NY.

5. **Deliverables**. Northeastern University will provide all deliverables identified in this SOW to the DHS S&T Technical Representative with a copy of the transmittal letter to the Contracting Officer.

6. **Program Status Report.** Northeastern University will deliver a final Program Status Report in accordance with the Parties mutually agreed format and content requirements to the DHS Technical Representative and DHS Resource Manager. Among other things, the report shall include financial, schedule, and scope information, and an assessment of performance for all work performed under this SOW.

Funding Requirements. DHS will provide funding to Northeastern University in accordance with DHS's appropriations and available funds pursuant to the allocation as outlined below:

$12,000 Support for NATO SET Panel 124

7. **Security Requirements**.
   a. All work performed under this SOW is unclassified unless otherwise specified by DHS.

   b. If classified work is required under this SOW, DHS will provide specific guidance to Northeastern University as to which work will be conducted in a classified manner and at

which classification level. Northeastern University will also adhere to other applicable Government orders, guides, and directives pertaining to classified or confidential work. This SOW may require access to information at the Secret level and with the Restricted Data category.

IV. Points of Contact

Northeastern University Points of Contact (POCs) are as follows:

Technical Representative
Prof. X.-C. Zhang
Center for Terahertz Science and Technology
Rensselaer Polytechnic Institute
Phone: [redacted], email: [redacted]

Financial Representative
John Beaty
Northeastern University
320 Huntington Avenue
Stearns Center, Suite 302
Boston, Massachusetts 02115
Cell: [redacted], Phone: [redacted]
Fax: (617) 373-8627, [redacted]

Northeastern University may change the individual designated as a POC upon notice to DHS S&T of such change.

The DHS S&T POCs are as follows:

Technical Representative
Penny Satches-Brohs
Deputy Director
International Programs Division
Science and Technology Directorate
U.S Department of Homeland Security
[redacted]
Washington, DC 20005
Phone: [redacted]
E-Mail: [redacted]

Financial Representative
Ms. Stephanie Howlett
International Programs Division
Science and Technology Directorate

U.S Department of Homeland Security
[redacted]
Washington, DC 20005
Phone: [redacted]
E-Mail: [redacted]

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT	1. CONTRACT ID CODE	PAGE OF PAGES
		1 13

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00004	See Block 16C	RSEN-09-00040	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
DHS/OPO/S&T/EXBOR		DHS/OPO/S&T/EXBOR	

6. ISSUED BY:
U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

7. ADMINISTERED BY (If other than Item 6):
U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

CODE	FACILITY CODE
001423631000	

9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

X 10A. MODIFICATION OF CONTRACT/ORDER NO.
HSHQDC-07-C-00016

10B. DATED (SEE ITEM 13)
12/06/2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
See Schedule

Net Increase: $549,918.00

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	FAR 52.243-2 Alt V Changes - Cost Reimbursement - Alternate V
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

DUNS Number: 001423631+0000

The purpose of this modification to contract HSHQDC-07-C-00016 is to increase the ceiling for CLIN 0001 by $143,716.00 for a new total of $1,855,099, add additional funding of $549,918.00 to CLIN 0001 to continue Phase I of the original contract in accordance with the attached Statement of Work (SOW), extend the period of performance of the contract through 30 September 2010, and update the invoicing instructions as follows:

Invoicing instructions previously provided in clause G-7, Invoicing Instructions, are revised as follows: Invoices may be e-mailed to SAT.Invoice.Consolidation@dhs.gov, or mailed to:
DHS ICE
Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
Lawrence W. Barnett, Acting Director Div. of Sponsored Project Admin	Joseph F. Wolfinger
15B. CONTRACTOR/OFFEROR [redacted]	15C. DATE SIGNED: 4/29/09
16B. UNITED STATES OF AMERICA [redacted]	16C. DATE SIGNED: 5-4-2009

NSN 7540-01-152-8070
Previous edition unusable

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Burlington Finance Center P.O. Box 1000 Attn: S&T Explosives Division Williston, VT 05495-1000 Delivery: 09/30/2010 Discount Terms: Net 30 Delivery Location Code: DHS Department of Homeland Security 245 Murray Lane Bldg. 410 Washington DC 20528 FOB: Destination Period of Performance: 07/10/2006 to 09/30/2010 Change Item 0001 to read as follows(amount shown is the obligated amount):				
0001	PTIEDD - Phase I: BomDetec Project Including Data Deliverables Fully Funded Obligation Amount$1,855,099.00 Product/Service Code: R425 Product/Service Description: ENGINEERING & TECHNICAL SERVICES Accounting Info: NONE000-000-RX-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 Accounting Info: NONE000-000-5X-06-10-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 Accounting Info: NONE000-000-5X-06-20-DC-005-06-01-0000-00-00-00-00-GE-DL-25-50-00000 Funded: $0.00 Accounting Info: NONE000-000-9X-33-06-03-006-01-00-0000-00-00-00-00-GE-OR-25-50-000000 Funded: $549,918.00 CLIN 0001 is now fully funded in the amount of $1,855,099.00.	1	LO	1,855,099.00	549,918.00

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE OF PAGES
	1 2

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00005	See Block 16C	RSEN-10-00009	

6. ISSUED BY CODE DHS/OPO/S&T/FXBOR

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

7. ADMINISTERED BY (If other than Item 6) CODE DHS/OPO/S&T/FXBOR

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

CODE 0014236310000 FACILITY CODE

(x) 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

x 10A. MODIFICATION OF CONTRACT/ORDER NO. HSHQDC-07-C-00016

10B. DATED (SEE ITEM 13) 12/06/2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
See Schedule

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
X	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: FAR 52.243-2 Alt V, Changes - Cost Reimbursement (Aug 1987) - Alternate V (Apr 1984)
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor [x] is not. ☐ is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

DUNS Number: 001423631+0000
Division: Explosives
PPA: Counter IED
Thrust: Detect
Program: PBIED- Transition Projects
Project: Intelligent Pedestrian Surveillance Platform
Performer: Northeastern University
Appropriation Year: FY09 (9X Funds)
Budget Authority: No-Year R&D Funds
Project Manager: Tom Coty
Lead Support Staff: N/A
Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
	Duane Schatz

15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
_____ (Signature of person authorized to sign)		[redacted] (Signature of Contracting Officer)	11/30/2009

NSN 7540-01-152-8070
Previous edition unusable

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	ALC: 70-08-1513 APPS: 70X0800 The purpose of this modification to contract HSHQDC-07-C-00016 is to change the current Contracting Officer's Technical Representative (COTR) from Mike Shepard to Tom Coty. Contract clause G2: CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE (COTR) is deleted in its entirety and replaced with the following: Thomas P. Coty Department of Homeland Security ATTN: Science and Technology Directorate Explosives Division 245 Murray Lane Washington, DC 20528 Tel: [redacted] Fax: 202-254-5398 [redacted] The above contact information also replaces Mike Shepard's contact information in Section IV, Points of Contact, in the Statement of Work (SOW). All other terms and conditions of the contract remain unchanged. Period of Performance: 07/10/2006 to 09/30/2010				

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE OF PAGES
	1 | 3

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
P00006	See Block 16C	RSTR-10-00066	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
DHS/OPO/S&T/RSRCH		DHS/OPO/S&T/RSRCH

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

U.S. Dept. of Homeland Security
Office of Procurement Operations
S&T Acquisition Division
245 Murray Lane, SW
Building 410
Washington DC 20528

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

NORTHEASTERN UNIVERSITY
360 HUNTINGTON AVENUE
251 RI
BOSTON MA 021155000

	9A. AMENDMENT OF SOLICITATION NO.
(x)	
	9B. DATED (SEE ITEM 11)
X	10A. MODIFICATION OF CONTRACT/ORDER NO. HSHQDC-07-C-00016
	10B. DATED (SEE ITEM 13) 12/06/2006

CODE	0014236310000	FACILITY CODE	

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as extended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required) Net Decrease: -$12,000.00
NONE000-000-8X-39-02-01-001-01-00-0000-00-00-00-00-GE-OE-25-50-000000

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	
	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	FAR 43.103 Mutual Agreements of Both Parties
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not. ☒ is required to sign this document and return 1 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

DUNS Number: 001423631+0000
ALC: 70-08-1513
APPS: 70X0800

Division: Explosives
PPA: Counter IED
Thrust: Detect
Program: PBIED- Transition Projects
Project: Intelligent Pedestrian Surveillance Platform
Performer: Northeastern University

Continued ...

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
[redacted]	Kevin Dillon
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED
(Signature of person authorized to sign)	10-19-10
16B. UNITED STATES OF AMERICA [redacted] (Signature of Contracting Officer)	16C. DATE SIGNED 10/19/10

NSN 7540-01-152-8070
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Prescribed by GSA
FAR (48 CFR) 53.243

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Project Manager: Tom Coty The purpose of this modification is to de-obligate funds from subject Inter-Agency Agreement (IAA). The modification hereby de-obligates funds in the amount of -$12,000.00 from subject Inter-Agency Agreement (IAA). The funding amount hereby decreases -$12,000.00 from [redacted]. The Invoice Address for the subject contract is hereby replaced with the following address: DHS ICE Burlington Finance Center P.O. Box 1000 ATTN: S&T Division Williston, VT 05495-1000 Invoices may be sent by mail to the above-specified address or they may be submitted by e-mail to: SAT.Invoice.Consolidation@dhs.gov Point of Contact for Return of Executed Document: The Point of Contact for the return of the executed agreement is: Renee J. Bayton, Contract Specialist, E-mail: [redacted] DO/DPAS Rating: NONE Delivery: 365 Days After Award Discount Terms: Net 30 Delivery Location Code: S&T MURRAY LANE DHS S&T 245 Murray Lane Building 410 Washington DC 20528 FOB: Destination Period of Performance: 07/10/2006 to 09/30/2010 Continued ...				

NAME OF OFFEROR OR CONTRACTOR
NORTHEASTERN UNIVERSITY

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
	Change Item 0005 to read as follows(amount shown is the obligated amount):				
0005	De-obligation of the remaining balance Obligated Amount: -$12,000.00				-12,000.00