

# Identifying People Wearing Wires for Detonation of IEDS

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## Introduction

Our effort began with background research into the problem not from the standpoint of suicide bombing but from the direction of using radars as a detection device for humans wearing wires. The Army Research Lab's research showed ways to use radar backscatter to detect humans with weapons behind walls. We spent a lot of time developing NEC simulations for the human body and tested the radar theory. We used a GunnPlexer Doppler radar to collect experimental data from a standoff distance of approximately 50 meters of the following: human subjects, human subjects wearing a wire loop, human subjects wearing a simulated vest with wire loops. We performed numerous experiments and analyzed the data after each experimental run.

One purpose of this experimental data collection analysis was to find metrics that could be used in building models to test detection rates. We found several metrics that improved one's ability to detect person's wearing wires. The best metric was the VV/HH ratio of radar cross section. From our empirical modeling, we found that the ratio for people wearing wires was statistically different from people without wires at a level of significance  $\alpha = 0.05$ . Using that metric, we built a simulation model that generated a crowd of people and randomly picked those with wires on their person. We used our metric and a threshold value, which we determined experimentally, to distinguish the persons with wires from those without wires. The simulation picked the person with wires with a success rate of 83.4% based from running 1,000 trial runs thirty six times. The rate of false alarms, the model picking people who were not wearing wires as suspects wearing wires was about 22% of the time.

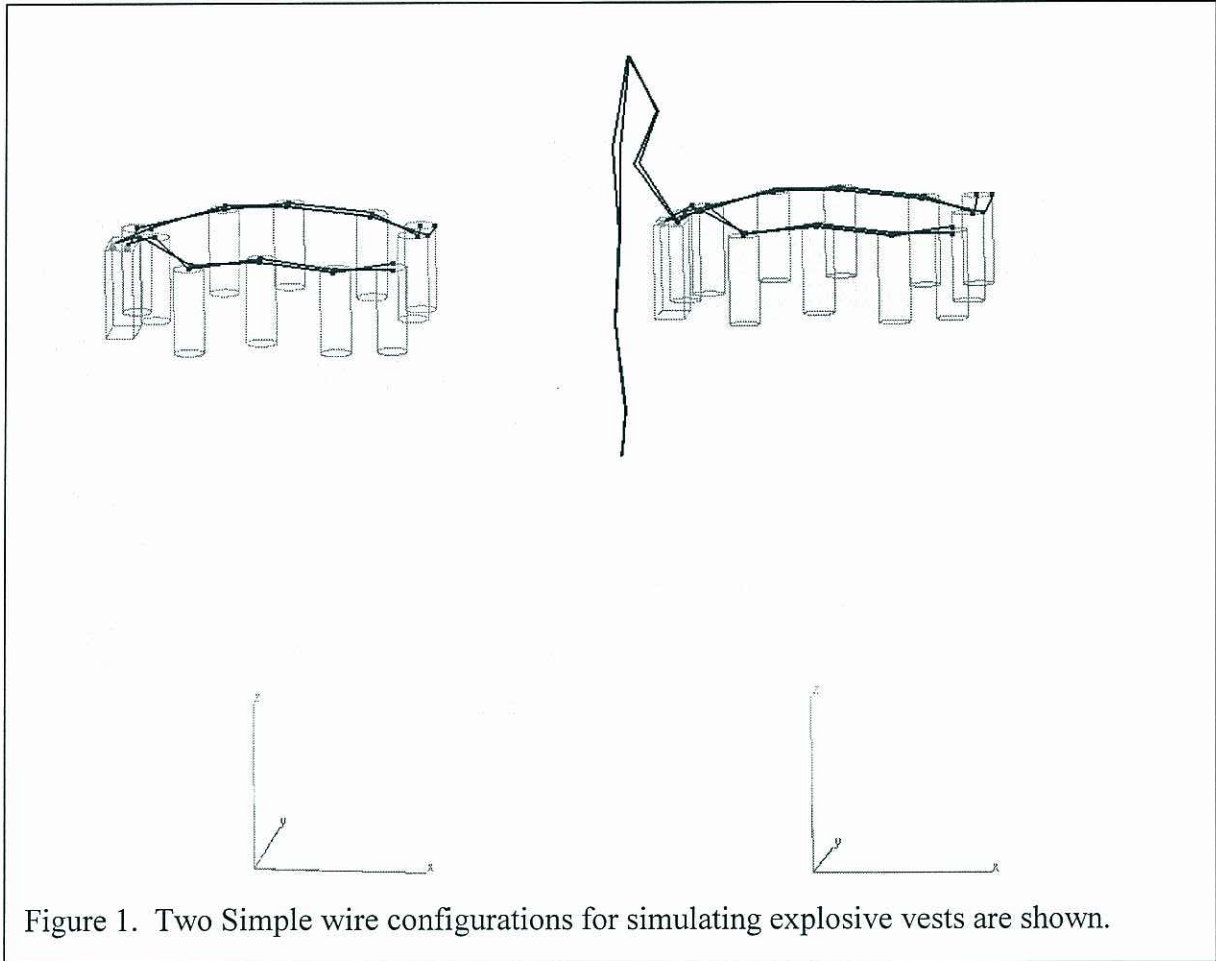
Our report shows success in finding viable metrics for detecting wires on people using radar observations. The preliminary research possible using the resources provided under this initial research project and the exciting results it produced encourages the knowledge that perhaps suicide bombers can be found prior to their detonation of their bombs.

## Methodology

We collected data of subjects both wearing wires and not wearing wires. Figure 1 displays a typical suicide vest configuration. We ran three versions of the experiments:

- Pendulum experiments with vertical wires. In these experiments we were able to characterize the experimental apparatus and calibrate in terms of a wire of known radar cross-section.

- Body experiments with subjects walking toward the radar. In these experiments a person started from a marker  $\approx 5$  m from the radar and walked to a marker about 2 m from the radar. The person was observed without wires and with several different wire configurations on their body.
- Body experiments with subjects at approximately a constant range, swaying back and forth in order to generate a Doppler signal. These experiments gave a more consistent movement and were used in addition to those above to measure the radar cross-section of a person with and without wires on their body.



### Statistical Analysis

We collected our data and display the descriptive statistics. The literature suggests This data should follow an exponential distribution. We ran a  $\chi^2$  goodness of fit test on our data sets.

Vest 1:

$$H_0 : f(x) = \frac{\lambda e^{-\lambda x}}{1 - e^{-\lambda x_0}}, 0 \leq x \leq x_0$$

$H_a$ :  $f(x)$  is not exponential

The rules for this test require at least 5 as the expected cell count so we obtain:

Interval	0-2	2-4	4-10	0-14	14-more
Observed	10	12	8	6	5
Expected	10.93338	8.065	13.578	4.15	4.957

$$\chi^2 = 5.11619$$

$$\chi^2_{.05,4} = 9.48$$

We conclude that the truncated exponential with mean 0.15209355 is a good fit.

Vest 2:

$$H_0 : f(x) = \frac{\lambda e^{-\lambda x}}{1 - e^{-\lambda x_0}}, 0 \leq x \leq x_0$$

$H_a$ :  $f(x)$  is not exponential

The rules for this test require at least 5 as the expected cell count so we obtain:

Interval	0-4	4-6	6-8	8-10	12-more
Observed	13	8	7	6	6
Expected	21.06	6.5	4.768	6.04	4.969

$$\chi^2 = 4.6898$$

$$\chi^2_{.05,4} = 9.48$$

We conclude that the truncated exponential with mean 0.156108622 is a good fit.

We also analyzed that data to see if this supports the theory of the RCS of a human being is 1 m<sup>2</sup>. We will use a simple hypothesis test.

$H_0: \mu = 1$

$H_a: \mu \neq 1$

Rejection region: reject if  $|z| \geq z_{\alpha/2}$

Using an  $\alpha$  level of 0.05,  $z_{\alpha/2} = 1.96$ . The test statistic,  $z$ , is  $z = -.3195$ .

Since .3195 is not greater than 1.96 we fail to reject the null hypothesis that the mean is not equal to 1. Therefore, we confirm the literature with our data that the RCS of a human is 1 m<sup>2</sup>.



Two key of horizontal and vertical polarization plots from previous work were analyzed and our own empirical data followed these shapes as seen in figures 2 and 3. We note that for no wires the plots are very similar and with wires the plots of the polarization are not similar.

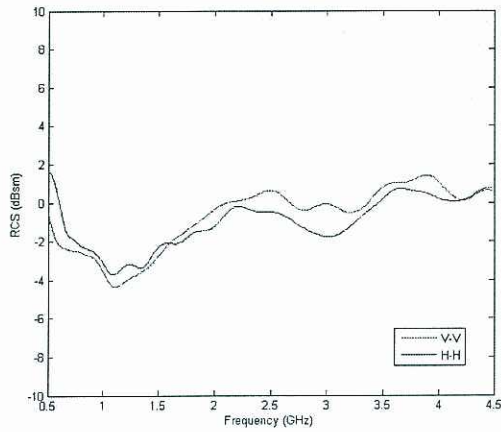


Figure 2. Human subject alone (no wires) from Dogaru (2007)

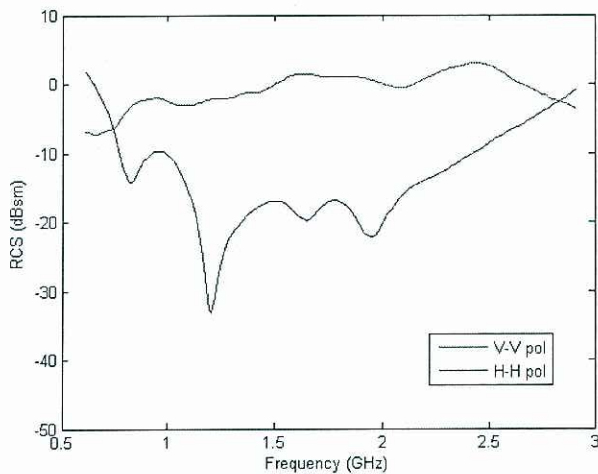


Figure 3. Human subject with 1 meter wire rod (Dogaru, 2007).

We utilized this key information to build a computer simulation model. Using the algorithm developed, we tested two metrics: polarization difference and polarization ratio. We found that polarization ratio was the more effective metric. Our model showed that using polarization ratio, we could achieve an 84% detection rate of person with wires with only a 28% false positive rate.

## Simulation Modeling Algorithm

INPUTS: N, number of runs, assumed distribution for the number of suicide bombers in a crowd, distributions for probability metric for radar detections, threshold value

OUTPUTS: the number of positive detections, the number of false detections

Step 1. Initialize all counters: detections = 0, false alarms=0, suicide bombers =0

Step 2. For  $i = 1, 2, \dots, N$  trials do

    Step 3. Generate a random number from an integer interval  $[a, b]$ .

    Step 4. Obtain an event of a suicide bomber based upon a hypothesized distribution of the number of suicide bombers in a crowd of size X. Basically if the random number  $\leq a$  then we have a suicide bomber, otherwise we do not.

    Step 5. Generate a random number from the distribution of VV-HH differences depending on whether the target is a suicide bomber with a vest and wires or not a suicide bomber. These distributions are described previously in this section.

    Step 6. Compare results from step 5 to threshold value using the following:

Target present:  $y(t) > Y \rightarrow$  correct detection

Target present:  $y(t) < Y \rightarrow$  missed detection

Target not present:  $y(t) > Y \rightarrow$  false alarm

Target not present:  $y(t) < Y \rightarrow$  no action

    Step 7. Increase Counters as necessary

Step 8. Output statistics for probabilities of detection and false positives

END

## References:

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Dogaru, T., L. Nguyen and C. Le, "Computer models of the human body signature for sensing through the wall radar applications," Tech. Rpt. ARL-TR-4290, Army Research Laboratory, 2007.

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