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 (Principal Investigator)
- Rajen Sud – Systems Engineer (EE)
- John Handy – Software Engineer
- TBD – Mechanical Engineer
- Brian Sullivan – Finance
- Rich Wronski – Product Management
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 Evaluation 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
Major Components

Generator

Secondary Detectors

X-Ray Source

Shore Power

Electronic Panel
(on inside wall)

A/C

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

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**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
X-ray Backscatter Imaging

Presentation to Conductors
Peter Petrelli on
August 26, 2008

AMERICAN SCIENCE AND ENGINEERING, INC.

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:

\[ \frac{E_{\text{out}}}{E_{\text{in}}} = \frac{1}{1 + \alpha (1 - \cos \varphi)} \]

where \( \alpha = \frac{E_{\text{in}}}{m_e c^2} \)
Drugs, Explosives contain H, C, N, O etc

Objects Containing These Low Atomic Number Elements

Appear Brightly in a Backscatter Image

Backscatter Highlights Low Z Materials

Transmission Image

Backscatter Image

C4 Plastic Explosive
Body Scan 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

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**ZBY System Field of View**

- 1.5 M (5 ft.)
- 3.6 M (12 ft.)
One-sided imaging allows for simple inspections

Helicopter

X-ray backscatter strips foliage
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”
- 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

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**Long Distance Viewing (LDV) - 30 feet**

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

<table>
<thead>
<tr>
<th>Long Distance Viewing</th>
<th>Current System</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ft.</td>
<td>5 ft.</td>
</tr>
<tr>
<td>6 ft.</td>
<td>12 ft.</td>
</tr>
</tbody>
</table>
Suicide Bomber at Various Distances
Parcel IEDs and suicide vest

1" diameter pipe bombs in vest

Packs of 

5 kg explosive simulant in backpack
10 kg explosive simulant in parcel

Parcel IEDs and suicide vest @ 30'}
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
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 ANSI 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, 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 NDAs 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

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

Polarimetric MMW Radar Discrimination of Hazardous Body-Worn Targets

Carey Rappaport, NEU

BomDetect Kick-off Meeting August 16, 2006
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
  - $BW_{3\text{dB}} = \frac{\lambda}{D}$
- 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, $\frac{1}{2}$ power at the edges of the chest is $D = 100 \lambda$
- At 77 GHz, $\lambda = 3.9$ 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 $\sigma = 60 \text{ S/m}$, 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/hardware increases shrapnel yield
  - Metal is easiest to detect with electromagnetic waves
- Tubes/pipes are typical
  - Easy geometry for packing explosive
  - Fit on body effectively

Finite Difference Modeling

Air
Target
Background
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 an 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 scattering 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

<table>
<thead>
<tr>
<th>Task</th>
<th>Primary</th>
<th>Secondary</th>
<th>Secondary</th>
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</thead>
<tbody>
<tr>
<td>Identify radars to be used on the program</td>
<td>Ray</td>
<td></td>
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<tr>
<td>Obtain transmission license approvals</td>
<td>Ray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide radar specifications including available data, data output format, data rates</td>
<td>Pay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define required data output</td>
<td>PPT</td>
<td>PPT</td>
<td>Ray</td>
</tr>
<tr>
<td>Determine if available data is sufficient for gross conclusions that validate existing data</td>
<td>PPT</td>
<td>PPT</td>
<td>Ray</td>
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<tr>
<td>Determine if available data is sufficient for algorithm input</td>
<td>PPT</td>
<td>PPT</td>
<td>Ray</td>
</tr>
<tr>
<td>Determine basic modifications to radars (if needed) to provide required data output</td>
<td>PPT</td>
<td></td>
<td>Ray</td>
</tr>
<tr>
<td>Determine if modifications needed can be accomplished in Phase I</td>
<td>Ray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define data output format</td>
<td>PPT</td>
<td>PPT</td>
<td>NEU Ray</td>
</tr>
<tr>
<td>Run initial simple experiments to baseline radar performance with and without target simulations</td>
<td>PPT NEU</td>
<td>NEU</td>
<td>Ray</td>
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<tr>
<td>Re-examine results (phenomenological interpretation)</td>
<td>NEU</td>
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<tr>
<td>Develop detailed experimental testing protocol in indoor outdoor environments</td>
<td>NEU</td>
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<tr>
<td>Identify subjects, clothing, targets, innocent objects</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
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<tr>
<td>Define environmental clutter to be used</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
</tr>
<tr>
<td>Define software requirements, software data requirements specifications for operating environment for outdoor settings</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
</tr>
<tr>
<td>If different antennas required, design wider aperture lighter beam, polarization imaging</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
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<tr>
<td>Determine modifications needed to change data to pulse VV, VH and WW data</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
</tr>
<tr>
<td>Determine advantages of modifications for other polarization data</td>
<td>NEU</td>
<td>NEU</td>
<td></td>
</tr>
<tr>
<td>Define approach on changing pulse to pulse VV, VH, and other polarization data</td>
<td>NEU</td>
<td>NEU</td>
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<tr>
<td>Derive multi-polarization algorithms based on theoretical backscatter predictions</td>
<td>NEU</td>
<td>NEU</td>
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<tr>
<td>Design experiment to validate the algorithm</td>
<td>NEU</td>
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<tr>
<td>Investigate clutter reduction approaches</td>
<td>NEU</td>
<td>NEU</td>
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</table>
Radar Detection of Suicide Bomber Explosives

Carey Rappaport, NEU
Lester Kosowsky (PPT)

BomDetect Kick-off Meeting August 16, 2006

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The data subject to this restriction are contained in all the pages of the presentation
Integrated Defense Systems

Outline

• Accomplishments to Date
• Program Overview and Statement of Work
• Team and Their Tasks
Homicide Vests – Real and Surrogate

From Literature

PPT Mock-up

Carried in Explosive Surrogate

PPT

Use or disclosure of this data is subject to the restrictions on the title page of this document.
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

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

Subject at 14 meters from Radar, Reference Corner Reflector at 17 meters
Performance of Algorithm – Vest

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

Performance of our Algorithm as a function of Body Density

Note: Data unavailable for Thin 2 and Heavy with Vest

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
Polarimetric Radar Response from Single Individual Wearing Vest

As if there were 15 people in the Scene - 14 with no Vest and Thin Adult with Vest

- Scene Average - No Vest
- Thin Adult with Vest
- Thin Adult with No Vest
- Bucky Adult - No Vest
- Thin Adult - Vest

Person with vest is distinguishable in a crowd

Cumulative Radar Response and Declaration Threshold

Cumulative Data for One Second - Vertical Polarization

- Vest (A-6)
- Vest (Jeri)
- TNT (Mike)
- C-4 (Mike)
- No Vest (Jeri)
- No Vest (A-6)
- No Explosives (Mike)

Vertical polarization consistently indicates presence of vest
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

Scope

Concealed explosive indications are obtained from measurements of the millimeter wave radar returns using vertical and horizontal polarizations.
Statement of Work:
PPT Task Description

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
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 (phenomenological interpretation)

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 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 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

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.
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

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
Radar Hardware and Measurements

John Firda, Raytheon, Inc.

BomDetect Kick-off Meeting August 16, 2006

Overview

- Team
- Tasks
- Radar description
- Test area overview
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 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 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)

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
  - Several other patents
### Radar Equipment

**Raytheon**

### Radar Key Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Frequency</td>
<td>76-77 GHz</td>
</tr>
<tr>
<td>Waveform</td>
<td>FMCW</td>
</tr>
<tr>
<td>Range</td>
<td>3 – 100 meters</td>
</tr>
<tr>
<td>Range Accuracy</td>
<td>&lt; 0.5 m</td>
</tr>
<tr>
<td>Antenna</td>
<td>Electronically switched beam</td>
</tr>
<tr>
<td></td>
<td>bi-static printed-circuit array</td>
</tr>
<tr>
<td></td>
<td>(Rotman-Turner lens)</td>
</tr>
<tr>
<td>Azimuth Field of View</td>
<td>15.4 degrees</td>
</tr>
<tr>
<td></td>
<td>7 switched beams, each 2 degrees</td>
</tr>
<tr>
<td>Elevation Field of View</td>
<td>4 degrees</td>
</tr>
</tbody>
</table>
Radar Waveform

- 508 MHz
- 1.136 x 10^-5 sec
- 1.136 x 10^2 sec
- 12 x 10^-7 sec
- Beam 1
- Beam 2
- 276 MHz
- 1.304 x 10^-9 sec
- 1 MHz Sampling
- 1234 Raw Samples

Raytheon
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
Integrated Defense Systems