Outline

- Introduction
- Background on Millimeter-wave Imaging of Humans
- Millimeter-wave Security Scanner
- Millimeter-wave Safety Standards
- Future Checkpoint Improvements
- Standoff Detection
- Health Applications
- Conclusions

Explosives Detection Applications

- Security Checkpoints
- Standoff detection of person-borne IEDs
- Explosives Detection Applications

Millimeter-wave Imaging of Humans

- Body Measurements
- Security Screening
- Passive MMW Security
- Standoff Detection

<table>
<thead>
<tr>
<th>Frequency</th>
<th>RF</th>
<th>Microwave</th>
<th>Millimeter-Wave</th>
<th>Sub-mm / THz</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 GHz</td>
<td></td>
<td></td>
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<tr>
<td>30 GHz</td>
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<tr>
<td>300 GHz</td>
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<tr>
<td>3 THz</td>
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</tbody>
</table>
Worldwide Deployment mmW AIT

L-3 ProVision®
Active Millimeter Wave Portal
- Walk-through – stop 2 seconds
- Detects metals, and non-metals
  - Metals, ceramics, wood, plastic, etc.
  - Liquids and gels
  - Paper and coin currency
- Safe radio waves
  - Max. Peak EIRP: -11.6 dBM
  - 10,000 times lower power than a phone
- Fast: 200 – 400 people per hour
- Operational Frequency: 24.25 – 30 GHz
- Two Vertical Antenna Arrays
  - 384 elements per array (2 x 192)
  - One for front, one for back

Image Resolution
- Image resolution is determined by the wavelength and the angular extent of the illumination
- The angular extent can be limited by the size of the aperture (aperture limited), or by the beamwidth of the antenna (antenna limited)

\[ \delta_x = \frac{\lambda}{4 \sin(\theta / 2)} = \frac{\lambda}{2 \#} \]

where \( \# = \frac{R}{D} \)

Holographic Imaging
How It Works

L-3 ProVision

Operators at remote location

http://www.tsa.gov/approach/imaging_technology.shtm

Courtesy of L-3 Communications
Range Resolution

- Range resolution is determined by the bandwidth of the system

\[ \delta_r = \frac{c}{2B} \]

- For example, a bandwidth of 10 GHz (e.g., 90-100 GHz operation) results in a range resolution of 1.5 cm

Millimeter-wave Safety Standards


<table>
<thead>
<tr>
<th>Frequency Range (GHz)</th>
<th>RMS power density (S) (W/m²)</th>
<th>Averaging time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 – 30</td>
<td>10</td>
<td>30 – 5</td>
</tr>
<tr>
<td>30 – 100</td>
<td>10</td>
<td>5 – 2.81</td>
</tr>
<tr>
<td>100 – 300</td>
<td>10 - 100</td>
<td>2.81 – 0.17</td>
</tr>
</tbody>
</table>

Equivalent Isotropically Radiated Power

- EIRP is the amount of power that a theoretical isotropic antenna would emit to produce the peak power density observed in the direction of the maximum antenna gain

\[-11.6\text{dBm} \approx 0.00007 \text{ W emitted at the array output}\]

<table>
<thead>
<tr>
<th>Distance</th>
<th>Power Density AIT (W/m²)</th>
<th>mmW AIT (W/m²)</th>
<th>IEEE Standard (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 m</td>
<td>0.000089</td>
<td>0.000089</td>
<td>10</td>
</tr>
<tr>
<td>0.50 m</td>
<td>0.000025</td>
<td>0.000025</td>
<td>10</td>
</tr>
<tr>
<td>0.75 m</td>
<td>0.000011</td>
<td>0.000011</td>
<td>10</td>
</tr>
</tbody>
</table>

Next-generation system

L-3 (TSA)

ProVision ATD (automatic target detection)
- Detects items on body
- Displays location on avatar

Addresses major TSA concern: privacy issues!
Future Checkpoint

40 – 60 GHz
V=Transmit
V=Receive

Combined Cylindrical Algorithm

Combined Cylindrical Holographic Imaging Result

Z-Axis View

Future Walkthrough System

Combined Cylindrical Holographic Imaging Result

Z-Axis View

Standoff Detection

340 – 360 GHz @ 5 m
Conclusions

- Millimeter-wave technology is suitable for detecting person-borne threats concealed in clothing
- Commercial available millimeter-wave imaging technology is well below recognized health safety standards
- Next generation mmW AIT will improve detection and privacy
- Submillimeter-wave technology ideal for standoff weapons detection
- Security body scanner technology adapted to apparel, health, and fitness markets

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Questions?

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