PNWD-SA-9523

Millimeter-wave Advanced Imaging Technology

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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

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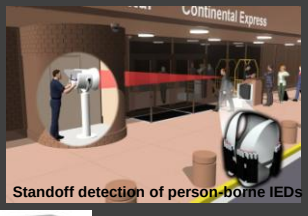
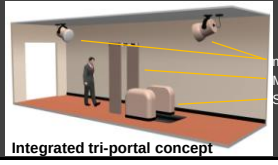
Explosives Detection Applications

Security Checkpoints



Standoff detection of person-borne IEDs



Integrated tri-portal concept

- mmWave whole-body imagers
- Metal detector
- Shoe scanner

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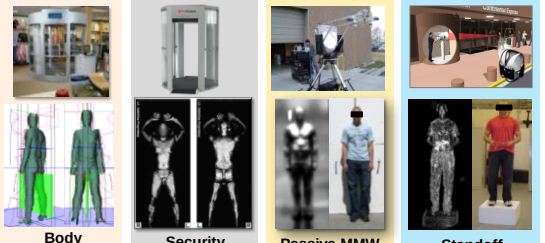
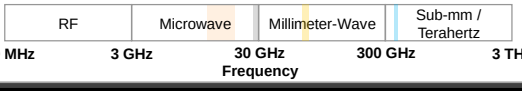
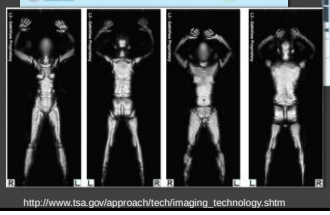
Millimeter-wave Imaging of Humans

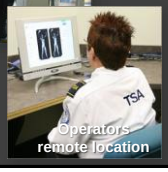


Body Measurements | **Security Screening** | **Passive MMW Security** | **Standoff Detection**



Worldwide Deployment mmW AIT





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

Holographic Imaging

How It Works

Courtesy of L-3 Communications

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

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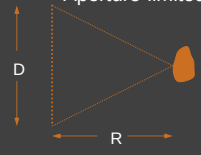
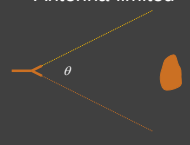
Image Resolution

- 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)

Aperture-limited



Antenna-limited



$$\delta_x = \frac{\lambda}{4\sin(\theta/2)} \approx \frac{\lambda}{2} F^{\#} \quad \text{where } F^{\#} = \frac{R}{D}$$

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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

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Millimeter-wave Safety Standards

IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields,3 kHz to 300 GHz, IEEE Std C95.1™-2005, Table 9.

Frequency Range (GHz)	RMS power density (S) (W/m^2)	Averaging time (min)
5 – 30	10	30 – 5
30 – 100	10	5 – 2.81
100 – 300	10 - 100	2.81 – 0.17

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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*
- -11.6dBm† = ~0.00007 W emitted at the array output

Distance	Power Density mmW AIT (W/m^2)	IEEE Standard (W/m^2)
0.25 m	0.000089	10
0.50 m	0.000025	10
0.75 m	0.000011	10

* http://en.wikipedia.org/wiki/Equivalent_isotropically_radiated_power
† Telephone discussion with L-3 engineer – Scott Trosper

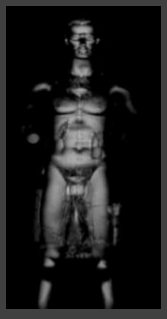
Next-generation system

L-3 (TSA)

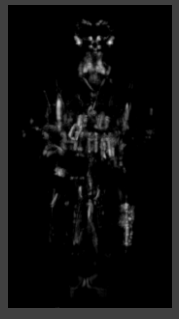
ProVision ATD (automatic target detection)
- Detects items on body
- Displays location on avatar

Addresses major TSA concern: *privacy issues!*

Future Checkpoint

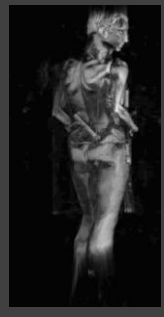


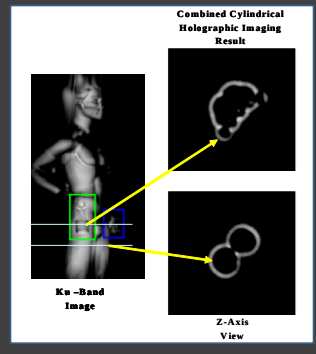
40 – 60 GHz
V=Transmit
V=Receive



40 – 60 GHz
V=Transmit
H= Receive

Combined Cylindrical Algorithm





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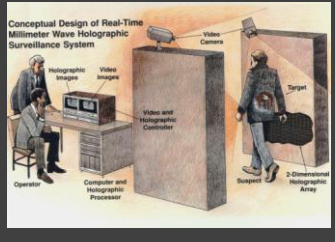
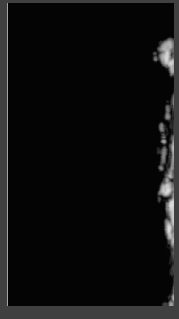
Future Walkthrough System





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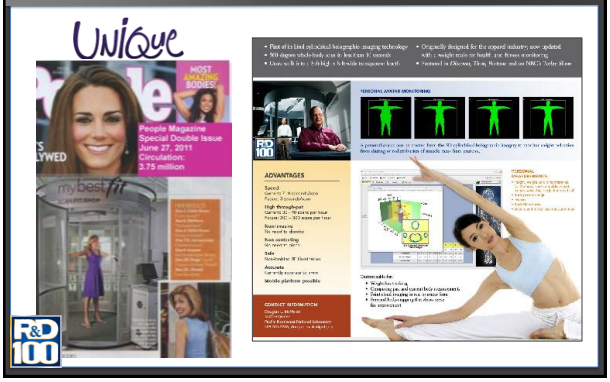
Standoff Detection

340 – 360 GHz @ 5 m

Licensed Application

Apparel, health & fitness markets



Baby Head Measurements

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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