

Strategic Study *Workshop Series*

Algorithm Development for Security Applications

*April 2010 Workshop
Final Report*



Awareness and Localization of Explosives-Related Threats
A Department of Homeland Security Center of Excellence



Northeastern University

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1. Disclaimers

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This document summarizes a workshop at which a number of people participated and some made presentations. The views in this summary are those of the organizing committee and do not necessarily reflect the views of all the participants. All errors and omissions are the sole responsibility of the organizing committee.

This material is based upon work supported by the U.S. Department of Homeland Security under Award Number 2008-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security.

2. Executive Summary¹

A workshop was conducted on April 27-28, 2010, at Northeastern University in Boston, Massachusetts, to discuss the development of advanced algorithms for advanced imaging technology, which is also known as whole body imaging. The emphasis was on the development of advanced algorithms by third parties, which include people from academia and industry other than the incumbent vendors. A number of areas were identified where third parties could contribute. However, a number of operational issues will have to be addressed before the third parties can fully participate in the development of advanced algorithms.

¹ This report is available as a hardcopy, on the Internet and on a CD. Please contact ALERT at Northeastern University (alert-info@ece.neu.edu) for access to these three formats.

3. Introduction

The US Department of Homeland Security (DHS²) Science & Technology Directorate (S&T), in coordination with the Transportation Security Administration (TSA), has identified requirements for future scanners for detecting explosives that include a larger number of threat categories, higher probability of detection per category, lower false alarm rates and lower operating costs. One tactic that DHS is pursuing to achieve these requirements is to create an environment in which the capabilities of the established scanner vendors could be enhanced or augmented by third-party algorithm development. A third-party developer in this context refers to academics, subject matter experts (SME), small companies and organizations other than the established scanner vendors. DHS is particularly interested in adopting the model that has been used very successfully by the medical imaging industry, in which university researchers develop algorithms that are eventually deployed in commercial medical imaging equipment.³ This model has improved the ability of the end user (i.e. radiologist) to identify, locate and treat potential cancerous abnormalities.

One tactic that DHS is using to stimulate academic and industrial third-party algorithm development is to sponsor workshops addressing the research opportunities that may enable the development of next-generation algorithms for homeland security applications. The first such workshop, entitled “Algorithm Development for Security Applications (ADSA) Workshop,” was held at Northeastern University (NEU) on April 23-24, 2009.⁴ The workshop was led by Professor Michael B. Silevitch (NEU) as part of the DHS Center of Excellence (COE) for Awareness and Localization of Explosives-Related Threats (ALERT⁵).

The main recommendation of the first workshop was to establish grand challenges for different aspects of threat detection and different screening

² Acronyms are defined in Section 14.

³ When we speak of an algorithm, we are talking about the mathematical steps. The actual implementation is usually in a general purpose computer.

⁴ Final Report, Algorithm Development for Security Applications Workshop, Northeastern University, April 23-24, 2009.

⁵ ALERT in this work plan refers to the COE at NEU.

modalities. The aspects of threat detection include (1) reconstruction and processing of sensor data, (2) image segmentation, (3) automated threat detection and (4) improved operator performance. The screening modalities include x-ray computed tomography (CT) for checked and carry-on baggage, advanced imaging technology, cargo inspection, and stand-off detection.

It was further recommended at the first ADSA workshop that the first grand challenge should develop advanced segmentation algorithms from volumetric (CT) data for the purpose of enhancing ATR algorithms for Explosives Detection Systems and for CT-based checked baggage scanners for the check-point. Three sets of volumetric data corresponding to scans of baggage containing known objects will be created. The three sets are designated as training, test and validation sets. The selected grand challenge participants will develop algorithms to segment the objects based on the training set and report their results on the test set. The algorithms will be independently graded by ALERT and LLNL on the validation dataset, which will not be provided to the participants. ALERT, in cooperation with LLNL and DHS, developed a plan for the grand challenge for image segmentation. The first phase of this grand challenge entails development, coordination and distribution of essential technical information and materials into the public domain: data sets, sensor descriptions and acceptance criteria. A copy of this plan can be found in the final report for the first ADSA workshop.

A second ADSA workshop was held at NEU on October 7-8, 2009, under the direction of Professor Silevitch, Harry Martz (LLNL) and Carl Crawford (Csuptwo). The purpose of the second workshop was to discuss the efforts necessary to continue investigation and development of third-party algorithms and in particular how to implement a grand challenge for segmenting objects from volumetric CT data. In essence, the purpose of the second workshop was to review the plan for the CT segmentation grand challenge. The objectives the workshop were delineated by the following statement from Doug Bauer (DHS S&T):

“Our overarching goal is to protect the American people better in travel environments against an evolving, dynamic range of threats. We need the best hardware and best algorithm development. We think that the medical field can help provide a framework for us and we brought you together for a multidisciplinary approach. How do we preserve openness to innovation? How do we meet the near-term requirements of DHS without forsaking academic research?

A third ADSA workshop was held at NEU on April 27-28, 2010, under the direction of Professor Silevitch, Carey Rappaport (NEU) and Carl Crawford (Csuptwo). The purpose of the third workshop was to discuss how third parties could participate in the development of algorithms for advanced imaging technology, which is also known as whole body imaging.

The format of the workshop was as follows:

1. Review existing technologies and general TSA concept of operations
2. Identify areas where advanced algorithms are required
3. Identify efforts in which third parties could play a role in these improvements
4. Establish a roadmap for going forward

The following technologies were addressed:

1. Millimeter-wave scattering (MMW)
2. X-ray backscatter (XBS)
3. X-ray transmission (TRX)
4. Infrared sensing (IR)
5. THz imaging and spectroscopy (THZ)
6. Nuclear Quadrupole resonance (NQR)
7. Nuclear Magnetic Resonance / Magnetic Resonance Imaging (NMR/NMI)
8. Acoustic

The following applications for advanced algorithms were addressed:

1. Concept of operations for using sensors
2. Modeling of sensors, probe interactions with targets, and clutter sources
3. Reconstruction algorithms
4. Automated threat recognition (ATR)
5. Sensor and data fusion of multi-sensor systems, including adaptive processing
6. Advanced display including privacy filters

The participants were asked to fill out a questionnaire that asked the following questions:

1. What opportunities are there for developing advanced algorithms for the following topics? (Include in your answer modality, application and algorithmic needs).
 - a. Concept of operations for using sensors
 - b. Modeling of sensors, probe interactions with targets, and clutter sources

- c. Reconstruction algorithms
 - d. Automated threat recognition (ATR)
 - e. Sensor and data fusion of multi-sensor systems, including adaptive processing
 - f. Advanced display including privacy filters
 - g. Other
2. What information and material would you need develop advanced algorithms for AIT?
 3. What issues would be barriers for you participating?
 4. What did you like about this workshop?
 5. What would you like to see changed for future workshops?
 6. What topics would you like to see addressed in future workshops?

The purpose of this report is to present the findings from the third workshop.

4. Report Organization

The remainder of this report is organized as indicated in the following table.

Sec.	Title	Contents and Notes
<i>Report Body</i>		
5	Findings and recommendations	Presents findings and recommendations from the workshop.
6	Future efforts	Presents recommendations for projects to implement the ideas generated at this workshop.
7	Lessons learned	A list of topics that could have been implemented better or differently, and recommendations for improvement for future workshops.
8	Notes	Miscellaneous notes about the workshop and this report.
9	Acknowledgements	Identifies people and organizations that were instrumental to implementing this workshop.
<i>Appendices</i>		
10	Agenda	Agenda for the workshop
11	Planning committee	List of people who organized the workshop.
12	Invitation	Invitation sent to people to participate.
13	Speaker Assignment	Instructions given to speakers at the workshop.
14	Acronyms	A glossary of acronyms and terms used in this report and the presentations.
15	Attendee list	A list of people who attended the workshop.
16	Biographies	Biographies of the people who attended the workshop.

- | | | |
|----|---------------------------|--|
| 17 | Questionnaire and replies | A list of questions provided to the participants and their replies provided after the workshop |
| 18 | Minutes | Minutes taken during the workshop. |
| 19 | Presentations | Slides that were used by the presenters in the workshop. |

5. Findings and Recommendations

The main outcomes of the workshop are organized below as answers to the questions that were posed in the questionnaire. The sections and subsections below correspond to the list of questions.

5.1 Opportunities for developing advanced algorithms

Concept of operations for using sensors

1. One scanning technology alone will not satisfy all of the TSA requirements. Therefore, a system of systems, which is also known as a fused system, will be required. Examples of fused systems included the following.
 - a. Using video to locate certain parts of a passenger and then dwell longer on these parts to obtain lower noise, higher resolution or additional views.
 - b. Using IR or THZ to do secondary (Level 2) screening.
 - c. Using NMR, MRI or NQR to inspect body cavities.
 - d. Using other technologies to obtain range information.
 - e. Metal detectors are useful to assure passenger compliance with rules for divestiture.
2. TSA should increase its purchase price for AIT so that additional hardware and software could be deployed. The following are examples where increased price may lead to increased performance.
 - a. Deployment of additional antennas for MMW in order to provide better images of certain locations on a passenger.
 - b. Deployment of additional x-ray sources and detectors for XBS in order to provide better images of certain locations on a passenger. These detectors could also be used to generate low-dose transmission images that could detect anomalies in orifices.
 - c. Advanced reconstruction algorithms could be deployed for MMW to reduce multi-path artifacts and to provide high resolution images from multiple views.
3. Application programming interfaces (API) should be developed so that systems can be interconnected.
4. DICOS should be extended to handle AIT so that images and the results of ATR can be shared between systems.
5. Simulations should be performed to optimize posing to maximize detection.

Modeling of sensors, probe interactions with targets, and clutter sources

Simulation software should be developed for all modalities. This software may resolve some issues with vendors and the TSA not being able to distribute images because of proprietary and security issues. The software may also provide the justification necessary for DHS to fund research activities and to increase the purchase price of scanners.

Reconstruction algorithms

Better reconstruction for MMW should be pursued. The reduction of multi-path artifacts and hyper-resolution should be investigated.

Automated threat recognition (ATR)

1. ATR could be developed for all modalities. There is a need to distribute requirement specifications to the developers in advance; however this may be difficult because these requirements are usually classified.
2. Models of humans developed for medical imaging could be deformed to match AIT images. The underlining human structure could be removed resulting in images containing only anomalies.
3. Depth information would improve performance.
4. ATR for AIT would benefit from having access to the complex-pairs that result from reconstruction from MMW systems.

Sensor and data fusion of multi-sensor systems, including adaptive processing

See bullet above entitled "Concept of operations for using sensors."

Advanced display including privacy filters

Algorithms are required to combine images and other forms of data at a common workstation that may be part of an integrated checkpoint.

Other

Models for predicting radiation exposure should be developed.

5.2 Information and material needed to develop advanced algorithms

1. Funding.

2. Requirement specifications for ATR and concepts of operation.
3. Access to SSI and classified information.
4. Rights to publish, obtain IP and commercialize.
5. Images and raw data.
6. Problem statements from vendors or government that include an honest assessment of the limitations of these technologies.

5.3 Barriers to participation

1. Lack of images and raw data. This may be mitigated by having national labs or academia using legacy systems or building their own. A MMW system may be built from components supplied by Radio Physics Solutions.
2. Lack of cooperation from incumbent vendors. This may be mitigated by showing how the vendors would benefit from the participation of third parties.
3. Lack of funding. DHS needs to find ways to fund third parties. Using ALERT as an intermediary is one way. A number of participants volunteered to share their experience working with NIH and NSF to help DHS to set up funding vehicles and review boards.
4. Lack of specifications. DHS should find ways to partition problems into non-classified pieces. DHS should set different standards, if necessary, for the following aspects of involving third parties.
 - a. Type: Academia, national labs, other industry
 - b. Location: US, non-US (friendly and non-friendly nation)
 - c. Data source: Certified equipment, predicate system, computer simulations
 - d. Data provider: TSA, academia, vendor
 - e. Algorithm use: commercial, public domain, publication
 - f. Funding source: DHS/TSA, incumbent vendor
5. Lack of roadmaps for developing and deploying new algorithms and equipment.

5.4 Positives about this workshop

1. Interactions between various groups and individuals.
2. Tutorials.
3. Description of the Sandia database.

5.5 Changes for future workshops

1. Prevent presenters from being cut short or cut off.

2. Breakout sessions.
3. More technical presentations.

6. Future Efforts

This section contains recommendations for future efforts to increase the involvement of 3rd parties in the development of advanced algorithms for security applications⁶.

1. The following issues related to adoption of algorithms should be addressed in future workshops:
 - a. Royalty payments.
 - b. IP ownership.
 - c. Implementation issues such as coding standards, operating environment, exception handling, specification maintenance.
 - d. Accessing and/or generating classified or SSI data.
2. Have workshops on the following topics:
 - a. Grand challenges
 - b. Stand-off detection
 - c. Automated threat detection
 - d. Image reconstruction
 - e. Cargo screening
 - f. Whole body imaging (advanced imaging technology, AIT)
 - g. Sensor fusion
 - h. Sensor simulation
 - i. Human factors
 - j. How to fund participants
 - k. Showing that incumbent vendors benefit from the involvement of third parties
 - l. Ongoing conversations about AIT
 - m. Discussions of the Sandia database
 - n. Discussions of ATR
 - o. A closed meeting for people with access to SSI or classified information
3. Have grand challenges for the following topics:
 - a. X-ray CT
 - i. Image segmentation
 - ii. Image reconstruction
 - iii. Automated threat detection
 - iv. Sensor modeling

⁶ Some of these recommendations are from the final report for ADSA01 with minor modifications.

- b. WBI/AIT
 - i. Sensor modeling
 - ii. Threat detection
 - iii. Sensor fusion
- c. Human operator performance
 - i. PD versus PFA
 - ii. Effect of TIP
- 4. Publicize grand challenges at conferences and workshops, through announcements in journals, and via word of mouth.
- 5. Create a website where information and material about threat detection can be exchanged. Use RSS or equivalent to alert people about new content.
- 6. Establish a method to seed and reward people for developing advanced algorithms.
- 7. Find ways to create a feedback loop from the field performance of scanners back to researchers. In particular, disseminate lists of problem misses and sources of false alarms.
- 8. Create a bibliography of applicable literature and abstract the materials.

7. Lessons Learned and Mitigation

Lessons Learned	Mitigation
The agenda, as prospectively written, did not provide enough time for discussion and statements from the participants.	Increase the length of the workshop, allow more time for round-the-room sessions and discussions.
Many of the presentations were pre-empted by discussion. The net effect was positive.	Allow more time for discussions. Distribute the presentations in advance of the workshop.
Having 3 rd parties present technologies allows the discussion of problems with the technologies.	Continue with 3 rd parties making presentations.
Participants need more background information.	Distribute patents and reprints before the meeting.
There was too much discussion about what topics were classified, SSI or proprietary.	Need to resolve these issues outside of the workshop. Discussions after the workshop indicated that there are clear guidelines from DHS on these subjects and that the guidelines should be followed.
Still not enough images were shown, especially of problem cases.	Show more images.
Scope of project not always clear.	Present objective statement at beginning.

Lessons Learned**Mitigation**

Some of the presentations were too long and/or the scope was not correct. Some of the presenters were asked to cut short their presentations.

Spend more time in advance of the workshop discussing presentations with presenters. The moderator apologizes to the presenters who he cut short or off.

It was difficult for people in the back of the room to hear the presenters and it was difficult for everyone in the room to hear questions from participants. These problems were related to the number of participants and the shape of the room.

Reduce the number of participants for future meetings. Do not use long and narrow rooms.

More discussions on human factors and concept of operations should have been given at the beginning of the workshop.

Make these changes.

8. Notes

This section contains miscellaneous notes about the workshop itself and the final report.

1. The final report will be distributed as a hardcopy, via the Internet and a CD, subject to approval from DHS.
2. The timing in the agenda was only loosely followed because of the amount of discussion that took place during the presentations.
3. Some of the questionnaires were transcribed from handwritten versions. Errors in these questionnaires are due to the editors of this report and not due to the authors of the questionnaires.

9. Acknowledgements

The planning committee would like to thank the following people and organizations for their involvement in the workshop.

1. DHS S&T for funding ALERT and sponsoring the workshop.
2. Doug Bauer, DHS, and George Zarur, TSA, for their vision to involve 3rd parties in the development of technologies for security applications.
3. Suriyun Whitehead for coordinating the participation of DHS and TSA.
4. Northeastern University for hosting the workshop.
5. Mariah Nobrega and Rachel Harger for handling logistics before and during the workshop.
6. Brian Loughlin and Rachel Harger for providing audio-visual assistance.
7. Rachel Harger for assembling and editing the final report.
8. Brian Loughlin and Rachel Harger for taking the minutes during the workshop.
9. Michael Silevitch and John Beaty for reviewing the final report.
10. Cynthia and Alex (NEU students) for transcribing the questionnaires.

The workshop would not have been a success without the participants and the speakers. The technical content of this report is due mostly to them. We extend our heartfelt thanks to them for their contributions.

10. Agenda*Tuesday, April 27, 2010*

- | | |
|-----------------|---|
| 8:00 AM | Registration/Continental Breakfast (318 Curry Student Center) |
| 9:00 AM | Call to Order <ul style="list-style-type: none"> • Carl Crawford, Csuptwo |
| 9:10 AM | Welcoming remarks <ul style="list-style-type: none"> • Michael Silevitch, Northeastern University/ALERT • Doug Bauer, Department of Homeland Security • Carey Rappaport, Northeastern University/ALERT |
| 9:30 AM | Workshop overview <ul style="list-style-type: none"> • Carl Crawford, Csuptwo |
| 10:15 AM | Technology overview – millimeter wave, x-ray backscatter, infrared, magnetic resonance, quadrupole resonance, terahertz <ul style="list-style-type: none"> • Tim White, Pacific Northwest National Laboratory |
| 11:15 AM | Discussion – initial comments from all participants |
| 12:15 PM | Technology details
<i>Millimeter Wave</i> <ul style="list-style-type: none"> • David Sheen, Pacific Northwest National Laboratory |
| 1:15 PM | Commercial products and algorithmic needs <ul style="list-style-type: none"> • Millimeter wave <ul style="list-style-type: none"> ○ Michael Fleisher, L-3 Communications • X-ray backscatter |

- Markus Schiefele, American Science and Engineering
- Millimeter wave
 - Pia Dreiseitel, Smiths Detection
- X-ray backscatter
 - Gerard Hanley, Rapiscan
- Millimeter wave
 - Iztok Koren, Brijot

4:30 PM The integrated check point

- Ted Grant, Department of Homeland Security
- Michael Barrientos, Department of Homeland Security

5:30 PM Social period

- Sponsored by Csuptwo, LLC

6:30 PM Working dinner

- CT segmentation grand challenge (ADSA02) update
 - Carl Crawford, Csuptwo
- Human factors for AIT
 - Jeremy Wolfe, Harvard Medical School

8:00 PM Adjourn

Wednesday, April 28, 2010

7:00 AM Continental breakfast**8:00 AM Emerging Technologies**

- Terahertz
 - Masashi Yamaguchi, Rensselaer Polytechnic Institute
- Fused technologies
 - Richard Bijjani, Reveal Imaging
- Infrared
 - Mike Watkins, Pacific Northwest National Laboratory
- Quadruple resonance
 - Chris Crowley, Morpho Detection

10:00 AM Automated threat detection and video surveillance

- ATR for millimeter wave
 - David Sheen, Pacific Northwest National Laboratory
- ATR for millimeter wave and x-ray backscatter
 - Thomas Sebastian, GE Global Research Center
- Video tracking of divested objects
 - Visvanathan Ramesh, Siemens Corporate Research
- Database for ATR development
 - Jeff Jortner, Sandia National Laboratory

12:00 PM Algorithmic Needs – Discussion and Prioritization

- Concept of operations for using sensors
 - Lauren Porr, Department of Homeland Security
- Modeling of sensors, probe interactions with targets, and clutter sources

- Carey Rappaport, Northeastern University/ALERT
- Reconstruction algorithms
 - Eric Miller, Tufts University
- Automated threat recognition (ATR)
 - Jeff Jortner, Sandia National Laboratory
- Sensor and data fusion of multi-sensor systems, including adaptive processing
 - David Castañón, Boston University
- Advanced display including privacy filters
 - Rick Moore, Massachusetts General Hospital

2:30 PM Around the room

3:45 PM Closing remarks

- Carey Rappaport, Northeastern University/ALERT
- Doug Bauer, Department of Homeland Security
- Michael Silevitch, Northeastern University/ALERT

4:00 PM Adjourn

11. Appendix: Planning Committee

The planning committee for the workshop consisted of the following people:

1. Michael Silevitch, Northeastern University
2. Carey Rappaport, Northeastern University
3. David Castañón, Boston University
4. Horst Wittmann, Northeastern University
5. John Beaty, Northeastern University
6. Carl Crawford, Csuptwo

The final report was edited by:

1. Carl Crawford, Csuptwo
2. Rachel Harger, Northeastern University
3. Mariah Nobrega, Northeastern University

Logistics for the workshop were handled by:

1. Rachel Harger, Northeastern University
2. Mariah Nobrega, Northeastern University

12. Appendix: Invitation

I am soliciting your participation in a workshop on advanced algorithm development for Advanced Imaging Technology (AIT), the DHS standard name for Whole Body Imaging (WBI) Technology. The primary objective of the workshop is to find ways to involve third parties in the development of both near-term and revolutionary improvements to existing AIT equipment. Algorithms developed by the third parties would be designed to augment the capabilities and capacities of the existing vendors of AIT equipment. The workshop will take place at Northeastern University (NEU) in Boston on April 27th and 28th, 2010.

The workshop is being led by Professor Carey Rappaport (NEU) and is sponsored by the DHS S&T Explosives Center of Excellence, "Awareness and Localization of Explosives-Related Threats" (ALERT, www.northeastern.edu/alert). I am helping Dr. Rappaport coordinate the workshop invitations and presentations.

The provisional format of the workshop is as follows.

1. Review existing technologies and general TSA concept of operations
2. Identify areas where advanced algorithms are required
3. Identify efforts in which third parties could play a role in these improvements
4. Convene in-depth breakout discussion sessions to determine and detail top-ranked projects
5. Present results of breakout sessions
6. Establish a roadmap for going forward

The following technologies will be addressed:

1. Millimeter-wave scattering
2. X-ray backscatter
3. X-ray transmission
4. Infrared sensing
5. THz imaging and spectroscopy
6. Nuclear Quadrupole Imaging
7. Nuclear Magnetic Resonance / Magnetic Resonance Imaging
8. Acoustic

While focus will be on technologies at a portal at a check-point, standoff technologies will also be considered.

The following applications for advanced algorithms will be addressed:

1. Concept of operations for using sensors
2. Modeling of sensors, probe interactions with targets, and clutter sources
3. Reconstruction algorithms
4. Automated threat recognition (ATR)
5. Sensor and data fusion of multi-sensor systems, including adaptive processing

A provisional agenda is enclosed.

The deliverable from the workshop will be a report to DHS recommending opportunities for funding research by third parties for further development of AIT algorithms.

Approximately fifty people are expected to attend the workshop from the following groups:

1. Government (DHS S&T, TSA, TSL, DoD)
2. DoE National Labs
3. AIT system vendors
4. Academia
5. Other Industry (3rd parties algorithm developers)

The format of the workshop will provide many opportunities for discussion. All participants should come prepared to participate in these discussions.

Please let me know if you are interested in attending the workshop. In addition, please provide answers to the following questions.

1. Are revisions to the agenda required? For example, are the lists of technologies and areas for development complete, and is the format of the workshop satisfactory?
2. Are there other experts you might recommend attend?
3. Are you willing to present? If so, on what topic?

I have enclosed an MS Word version of this email in case you want comment using the "Track Changes" feature in MS Word.

If possible, we would like to limit participation to one to two people per company. In some cases we can accommodate additional people from a company. Please let me know who from your company you want to send to the workshop we can discuss how many slots will be available for your company.

We will be paying travel expenses for people coming from academia.

Please feel free to contact me (see below for contact information) or Carey Rappaport (rappaport@neu.edu or 617-373-2043) on all matters related to the workshop.

Thank you for your consideration of the workshop and we look forward to your participation.

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13. Appendix: Speaker assignments

Thank you for agreeing to present at the workshop.

Focus your presentation discussion on the following opportunities for advanced algorithm development:

1. Concept of operations for using sensors
2. Modeling of sensors, probe interactions with targets, and clutter sources
3. Reconstruction algorithms
4. Automated threat recognition (ATR)
5. Sensor and data fusion of multi-sensor systems, including adaptive processing
6. Advanced display including privacy filters

Present many pictures and diagrams. The feedback from previous workshops is that we need to show more images.

If you are from industry, present your offerings in AIT, which means showing block diagrams, pictures of the scanners, and some sample images.

Please plan on speaking for 30 minutes including time for taking questions and answers. Participants will be encouraged to ask questions during your presentation.

Bring your presentation on a USB memory stick in PowerPoint (PPT) or PDF. A PC will be provided with PowerPoint version 2007 and Adobe Acrobat.

Do not present any SSI or classified information.

It is our intent to put your presentation into the public domain. However, you will be allowed to redact some or all of your slides after you give your presentation.

Again, thank you for agreeing to present.

14. Appendix: Acronyms⁷

Term	Definition
AAPM	American Association of Physicists in Medicine
ADSA	Algorithm Development for Security Applications
ADSA01	First ADSA workshop held in April 2009 on the check-point application
ADSA02	Second ADSA workshop held in October 2009 on the grand challenge for CT segmentation
AIT	Advanced imaging technology. Technology for find objects of interest on passengers. WBI is a deprecated synonym.
ALERT	Awareness and Localization of Explosives-Related Threats, A Department of Homeland Security Center of Excellence co-led by NEU
ASTM	American Society for Testing and Materials
AT	Advanced technology
ATD	Automated threat detection
ATR	Automated threat resolution; a synonym of ATD.
BAA	Broad agency announcement
BHS	Baggage handling system
BIR	Baggage inspection room
BLS	Bottled Liquids Scanners
BPSS	Boarding Pass Scanning Systems
BU	Boston University
CAD	Computer aided or assisted detection
Cambria	TSA procurement program for next-generation check-point scanners
CAPPS	Computer Assisted Passenger Prescreening System
CAT	Credential Authentication Technology
CENSSIS	A National Science Foundation Engineering Research Center headquartered at NEU
CERT	Certification testing at the TSL
CIA	Central Intelligence Agency
COE	Center of excellence, a DHS designation
CONOP	Concept of operations

⁷ Some of these acronyms are neither defined or used in the body of this report.

Term	Definition
COP	Concept of Operation
CPI	Cast & Prosthesis Imagers
CRT	Certification readiness testing
CT	Computed tomography
CTsegGC	CT segmentation grand challenge; in places “GC” is deleted from this acronym,
CTreconGC	CT reconstruction grand challenge; in places “GC” is deleted from this acronym,
DAS	Data acquisition system
DHS	Department of Homeland Security
DHS S&T	DHS Science & Technology division
DICOM	Digital Imaging and Communications in Medicine; http://medical.nema.org
DICOS	Digital Imaging and Communications in Security. NEMA standard for image format for security; NEMA IIC Industrial Imaging and Communications Technical Committee.
DOD	Department of Defense
DOD	Department of Defense
DR	Digital radiology
EDS	Explosive detection scanner that passes TSL’s CERT.
ETD	Explosive trace detection
FA	False alarm
FAA	Federal Aviation Administration
FAT	Factory acceptance testing
FBI	Federal Bureau of Intelligence
FOUO	For official use only
FOV	Field of view
GC	Grand challenge
HME	Homemade explosive
HMS	Harvard Medical School
HVPS	High voltage power supply
IED	Improvised explosive device
IEEE	Institute of electrical and electronic engineers
IGT	Image guided therapy
IHE	Integrating the Healthcare Enterprise
INL	Idaho National Laboratory
IQ	Image quality
JND	Just noticeable difference

Term	Definition
L-3	L-3 Communications
LAC	Linear Attenuation Coefficient
LLNL	Lawrence Livermore National Laboratory
LS	Line scanners (projection scanners)
Manhattan II	TSA procurement program for next-generation EDS
MC	Monte Carlo [modeling]
MIC	Medical Imaging Conference (IEEE)
MMW	Millimeter wave
MRI	Magnetic resonance imaging
MV	Multiple view
NDA	Non-disclosure agreement
NDE	Non-destructive evaluation
NEMA	National Electrical Manufacturers Association
NEU	Northeastern University
NIST	National Institute of Standards and Technology
NQR	Nuclear Quadrupole Resonance
OOI	Object of interest
ONR	Office of Naval Research
OSARP	On screen alarm resolution protocol/process
OSR	On screen resolution
PD	Probability of detection
PET	Positron emission tomography
PFA	Probability of false alarm
PPV	Positive predictive value
QR	Quadrupole resonance
RED	Remote explosive detection (stand-off)
RFI	Request for information
ROC	Receiver operator characteristic
RPI	Rensselaer Polytechnic Institute
RSNA	Radiology Society of North America
SAT	Site acceptance testing
SBIR	Small business innovation research
SCS	Standard Communication in Security
Sensitivity	Probability of true positive
SOC	Stream of commerce
SOP	Standard operating procedure
Specificity	1 – probability of false positive
SPECT	Single photon emission computed tomography

Term	Definition
SPIE	International society for optics and photonics
SSD	Security system developer. Vendor of complete security device such as L-3, Reveal, Analogic or Morpho Detection
SSI	Sensitive security information
STIP	Security Technology Integrated Program
TBD	To be determined
THZ	Tera-Hertz imaging
TIP	Threat image projection
TMI	Transactions on Medical Imaging. An IEEE journal publication.
TQ	Threat quantity; minimum mass required for detection. Value(s) is classified.
TRX	TIP-ready x-ray line scanners
TSA	Transportation Security Administration
TSL	Transportation Security Lab, Atlantic City, NJ
TSO	Transportation security officer; scanner operator
WBI	Whole body imaging; a deprecated term for AIT
XBS	X-ray back scatter
XRD	X-ray diffraction

15. Appendix: Attendee List⁸

Name	Affiliation
Omar Al-Kofahi	American Science and Engineering
Claus Bahlmann	Siemens Corporate Research
Naveen Bansal	Marquette University
Michael Barrientos	Department of Homeland Security
Doug Bauer	Department of Homeland Security
John Beaty	Northeastern University
Richard Bijjani	Reveal Imaging
Christopher Boehnen	Oak Ridge National Laboratory
Charles Bouman	Purdue University
Doug Boyd	Telesecurity Sciences
Mark Carlotto	General Dynamics
Gary Carter	Department of Homeland Security
David Castañón	Boston University
John Chang	Lawrence Livermore National Laboratory
Carl Crawford	Csuptwo
Chris Crowley	Morpho Detection
Bob Daly	Brijot
Bryan Donaldson	Intelliscience
Pia Dreiseitel	Smiths Detection
Limor Eger	Boston University
Xin Feng	Marquette University
Justin Fernandes	Northeastern University
Michael Fleisher	L-3 Communications
David Getty	Harvard Medical School
Galia Ghazi	Northeastern University
Steve Godbout	Optosecurity
Ted Grant	Department of Homeland Security
Grant Gullberg	Lawrence Berkeley National Laboratory
Gerard Hanley	Rapiscan
Jeff Jortner	Sandia National Lab
Seemen Karimi	Northeastern University
W. Clem Karl	Boston University
Tracy Kennedy	General Dynamics
Ron Kikinis	Harvard Medical School

⁸ This list comprises all attendees at the workshop, both professional participants and students. Students are omitted from the following Participant Biographies section.

Iztok Koren	Brijot
Patrick La Riviere	University of Chicago
Jose Martinez	Northeastern University
Eric Miller	Tufts University
Perhaad Mistry	Northeastern University
Rick Moore	Massachusetts General Hospital
Richard Moro	Raytheon
Richard Obermeier	Northeastern University
Xiaochuan Pan	University of Chicago
Laura Parker	Department of Homeland Security
Doug Pearl	Insight Consulting
Luc Perron	Optosecurity
Homer Pien	Massachusetts General Hospital
Lauren Porr	Department of Homeland Security
Fernando Quivira	Northeastern University
Tom Ramsay	Guardian Technologies
Visvanathan Ramesh	Siemens Corporate Research
Carey Rappaport	Northeastern University
Erick Rekstad	Transportation Security Administration
Martin Richard	Guardian Technologies
Marios Savvides	Carnegie Mellon
Dana Schaa	Northeastern University
David Schafer	Analogic
Elan Scheinman	Reveal Imaging
Markus Schiefele	American Science and Engineering
Jean-Pierre Schott	JP SCHOTT, LLC
Thomas Sebastian	GE Global Research Center
David Sheen	Pacific Northwest National Laboratory
Michael Silevitch	Northeastern University
Steve Skrzypkowiak	Transportation Security Administration
Steve Smith	Tek84
Paul Southam	University of East Anglia
Lee Spanier	Department of Homeland Security
Simon Streltsov	LongShortWay
Greg Struba	Department of Homeland Security
Zach Sun	Boston University
Ben Tsui	Johns Hopkins
Peter Tu	GE Global Research Center
Amit Verma	Tek84
Melissa Vo	Harvard Medical School
Chris Wald	Lahey Clinic
Jeff Waters	SPAWAR/Navy

Mike Watkins	Pacific Northwest National Laboratory
Whitney Weller	L-3 Communications
Dana Wheeler	Radio Physics Solutions
Tim White	Pacific Northwest National Laboratory
Suriyun Whitehead	Department of Homeland Security
Lerry Wilson	Intelliscience
Horst Wittmann	Northeastern University
Jeremy Wolfe	Harvard Medical School
Masashi Yamaguchi	Rensselaer Polytechnic Institute
Birsen Yazici	Rensselaer Polytechnic Institute

16. Appendix: Participant Biographies



Omar Al-Kofahi



Claus Bahlmann



Naveen Bansal



Michael Barrientos



Doug Bauer



John Beaty



Richard Bijjani



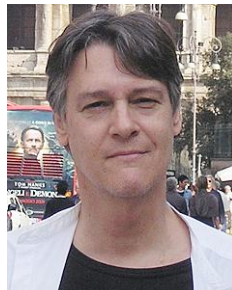
Christopher Boehnen



Charles Bouman



Douglas Boyd



Mark Carlotto



Gary Carter



David Castañón



Carl Crawford



Chris Crowley



Bob Daly



Pia Dreiseitel



Xin Feng



Michael Fleisher



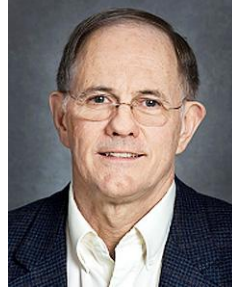
David Getty



Steve Godbout



Ted Grant



Grant Gullberg



David Isaacson



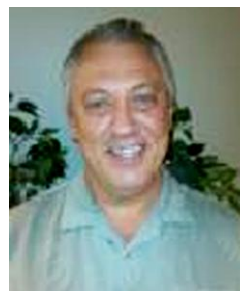
Jeff Jortner



Seemen Karimi



W. Clem Karl



Tracy Kennedy



Ron Kikinis



Iztok Koren



Patrick La Riviere



Jose Martinez



Eric Miller



Rick Moore



Xiaochuan Pan



Laura Parker



Luc Perron



Homer Pien



Lauren Porr



Tom Ramsay



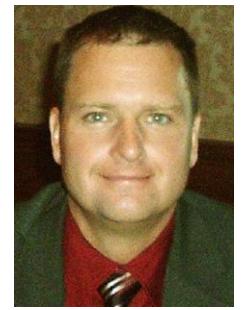
Visvanathan Ramesh



Carey Rappaport



Erick Rekstad



Martin Richard



David Schafer



Elan Scheinman



Markus Schiefele



Jean-Pierre Schott



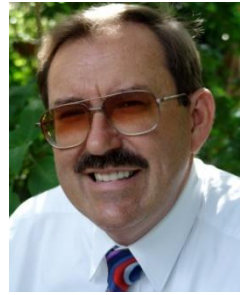
Thomas Sebastian



David Sheen



Michael Silevitch



Steve Skrzypkowiak



Steve Smith



Paul Southam



Greg Struba



Benjamin Tsui



Amit Verma



Mike Watkins



Whitney Weller



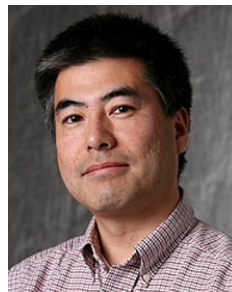
Timothy White



Suriyun Whitehead



Jeremy Wolfe



Masashi Yamaguchi



Birsen Yazici

Not pictured: John Chang, Bryan Donaldson, Gerard Hanley, Jonathan Nickerson, Lee Spanier, Chris Wald, Jeff Waters, Lerry Wilson.

Omar Al-Kofahi

American Science and Engineering
Oal-kofahi@as-e.com

Dr. al-Kofahi received his B.S. from Jordan University of Science and Technology and his M.S. and Ph.D. in Computer and Systems Engineering from Rensselaer Polytechnic Institute. His Ph.D. work involved the design and implementation of a broadly applicable framework to automated scoring of changes in image sequences, designed to mimic the conclusions of a domain expert analyzing the same data. Dr. al-Kofahi joined AS&E in 2005, where he lead efforts to build advanced operator assist capabilities to help users identify anomalies in images and increase throughput. He also designed various algorithms for signal and image processing and enhancement, as well as building new X-ray imaging systems using concepts like coded aperture imaging.

Claus Bahlmann

Siemens Corporate Research
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Claus Bahlmann is a project manager at Siemens Corporate Research (SCR) in Princeton, NJ USA. His research interests include pattern recognition, computer vision, and machine learning. He has applied these techniques in various application domains, including real-time and forensic image and video analysis for safety and security, as well as medical. Before joining SCR in 2004, he was a research associate for the University of Freiburg, Germany. While at the University, he received his doctoral degree with the highest of honors for work conducted in discovering new types of generative and discriminative classification of online handwriting recognition.

In 2002, his work "On-line Handwriting Recognition with Support Vector Machines - A Kernel Approach" was awarded Best Paper at the IWFHR 2002 conference. In 2005, his Ph.D. thesis "Advanced Sequence Classification Techniques Applied to Online Handwriting Recognition" earned the Wolfgang-Gentner-Nachwuchsförderpreis award from the University of Freiburg. Dr. Bahlmann received a Bachelor and Masters of Sciences in computer science from the University of Bielefeld, Germany.

Naveen Bansal

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Michael Barrientos

Department of Homeland Security
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Michael Barrientos has been with the Transportation Security Laboratory since 1995 as an engineer. Initially Mr. Barrientos was assigned to work with the Test and Evaluation Group and was involved with such projects as the certification of the first Explosives Detection System for Checked Baggage. While working he received his Master of Science from Embry-Riddle Aeronautical University (where he received his bachelors degree in aircraft engineering in Human Factors), then was reassigned to work with Human Factors Branch where he played a key role in the development of Threat Image Projection Technology and research on Advanced Display Systems. Mr. Barrientos is now working for Ted Grant under the Personnel Inspection Branch as the Program Manager for the Integrated Checkpoint Program Manager and oversees projects for checkpoint as well as Human Factors while pursuing his doctoral degree in Systems Engineering at Stevens Institute of Technology.

Douglas C. Bauer

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Dr. Douglas Bauer is the Explosives Division Program Executive for Basic Research with management responsibility for multiple programs in basic and applied research, homemade explosives (HME) characterization, detection and damage assessment, development of the next generation EDS x-ray technologies, and counter IED basic research in prevention, detection, response and mitigation. Dr. Bauer also has management responsibility for two new university-based Centers of Excellence addressing explosive threats in transportation through fundamental research. Dr. Bauer holds engineering degrees from Cornell and Carnegie Mellon Universities (where he received his PhD), a law degree from Georgetown University Law Center, and a theology degree from Virginia Theological Seminary. He served in the U.S. Navy as a line officer aboard surface ships, including service in DESERT STORM, and is now retired as a naval Captain.

John Beaty

Northeastern University
jbeaty@ece.neu.edu

Mr. John Beaty is the Industrial Liaison and Director of Technology Development for Awareness and Localization of Explosives Related Threats (ALERT). He is also the Director of Technology Development for the Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems. Mr. Beaty has extensive experience managing research and development for the scientific instrument, semiconductor, and government contract industries. John spent 30 years with three companies, Thermo Electron Corporation, Schlumberger Test and Transactions, and FEI Company developing a wide variety of instruments and tools, using diverse technologies. In most instances, John procured development resources from a variety of sources: government, industry, industry consortia, and venture capital.

Richard Bijjani

Reveal Imaging Technologies, Inc.
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Dr. Richard Bijjani, Chief Technology Officer at Reveal, has been in the security business for over 12 years. In 1990 he managed R&D during the development of a dynamic signature verification product at Kumahira Inc. In 1994 Dr. Bijjani joined InVision Technologies as head of the Algorithm and Machine Vision group. He oversaw the algorithm development effort that led to the successful certification by the FAA of multiple EDS systems. Dr. Bijjani joined Vivid Technologies in 1997 where he led the design and development of the additional EDS systems. Dr. Bijjani has a Ph.D. in Electrical Engineering from Rensselaer Polytechnic Institute.

Christopher Boehnen

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Dr. Chris Boehnen received a Bachelors in Computer Engineering from the University of Notre Dame, where he developed methods and software to capture and store data for the Face Recognition Grand Challenge datasets. He then received a Masters in Computer Science at Notre Dame, collaborating with Sandia National Laboratories on multi-modal facial feature detection in a frontal and non-frontal scenario, commercial 3D scanner assessment, rapid prototyping, and 3D face recognition utilizing principal component analysis. Chris completed his Doctorate, at Notre Dame in May 2009. His dissertation topic was making 3D face biometrics applicable for deployment with a focus on improving the 3D capture hardware via structure from motion, and improving 3D biometric matcher performance and processing time to make the matching algorithms deployable. He is currently a research staff member at Oak Ridge National

Laboratories working on Biometrics and Gamma Ray detection for Nuclear Non-Proliferation.

Charles Bouman

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Dr. Charles A. Bouman is the Michael J. and Katherine R. Birck Professor of Electrical and Computer Engineering at Purdue University where he also holds a courtesy appointment in the School of Biomedical Engineering and serves as a co-director of Purdue's Magnetic Resonance Imaging Facility. He received his B.S.E.E. degree from the University of Pennsylvania, M.S. degree from the University of California at Berkeley, and Ph.D. from Princeton University in 1989. Professor Bouman's research focuses on inverse problems, stochastic modeling, and their application in a wide variety of imaging problems including tomographic reconstruction and image processing and rendering. Prof. Bouman is the Editor-in-Chief of the IEEE Transactions on Image Processing and a member of the IEEE Signal Processing Society's Board of Governors. He also is a Fellow of the IEEE, AIMBE, IS&T, and SPIE and has served Vice President of Publications for the IS&T Society.

Douglas Boyd

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Dr. Douglas Boyd has contributed to the fields of imaging technology, accelerator and beam physics, superconducting systems, nuclear physics, and medical physics. Following his graduate studies in nuclear physics at Rutgers, Dr. Boyd continued his research at Bell Labs under a post-doctoral fellowship program. He then moved to Stanford University and was the project leader for the world's first pion radiotherapy facility. As part of this program he was one of the early developers of fan-beam, Xenon-detector CT scanners. In 1976 Dr. Boyd joined the faculty in at UCSF with the intent to establish a laboratory to develop the next generation of no-motion CT scanners, with emphasis on cardiac imaging. This led to the foundation of Prior of Imatron, Inc., which since 1982 became the leader in development of electron beam Cardiac CT Scanners (EBCT).

Dr. Boyd's team also pioneered in a number of related imaging developments, including the research leading to the first successful explosive detection scanners for airports, for which he was awarded the prestigious Safe Skies award in 1992. Prior to TSS, Dr. Boyd served as a

founding director of InVision Technologies, Inc, a company that since 1990 pioneered in the development of modern CT explosive detection systems that are installed at most major airports in the world today. In 2006, realizing that EDS technology had not yet reached its full potential, Dr. Boyd established TeleSecurity Sciences with the objective to automate the threat resolution process.

Mark Carlotto

General Dynamics AIS
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Mark Carlotto has more than three decades of experience in satellite remote sensing, intelligence surveillance and reconnaissance (ISR) applications, image processing/understanding, pattern recognition, terrain analysis, and other domain/application areas. He has served as principal investigator in numerous programs with the Defense Advanced Research Projects Agency (DARPA), National Geospatial Intelligence Agency (NGA), and the U.S. Government. Dr. Carlotto has about 100 journal and conference publications in a variety of technical areas.

Gary Carter

Department of Homeland Security
Gary.e.carter@dhs.gov

Department of Homeland Security, Director of Test and Evaluation and Standards, Gary Carter is a native of California. He entered the Navy and was commissioned in 1976 through the Aviation Officer Candidate Program at Pensacola, Florida. He holds a Bachelors Degree in Mathematics from the University of Arkansas.

Upon completion of flight training, he completed flying assignments in the E-2C, Hawkeye as mission commander, flight instructor and evaluator, squadron operations officer and squadron maintenance officer. From 1992 to 1993 Carter, commanded Carrier Airborne Early Warning Squadron 125 flying from USS SARATOGA (CV60). He accumulated more than 3000 hours in the E-2C. He served three staff tours, first as combat systems officer on Commander Cruiser Destroyer Group Twelve; Head of Officer Procedures Section, Naval Military Personnel Command and Director, Navy Test and Evaluation Resources and Infrastructure, OPNAV 91. He retired from active duty in Jun 1999, but continued to serve as the Director, Navy Test and Evaluation Resources and Infrastructure. In September 2008, Carter was promoted to SES and assumed his current position as Director of Test and

Evaluation and Standards in the Department of Homeland Security, Science and Technology Directorate.

David Castañón

Boston University
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Prof. David Castañón received his B.S. degree in Electrical Engineering from Tulane University in 1971, and his Ph.D. degree in Applied Mathematics from the Massachusetts Institute of Technology in 1976. From 1976 to 1981, he was a research associate with the Laboratory for Information and Decision Systems at the Massachusetts Institute of Technology in Cambridge, MA. From 1982-1990, he was Chief Scientist at Alphatech, Inc. in Burlington, MA. He joined the Department of Electrical and Computer Engineering at Boston University, Boston, MA in 1990, where is currently professor and served as department Chair in 2007. Prof. Castañón is Associate Director of the National Science Foundation Center for Subsurface Sensing and Imaging, co-Director of Boston University's Center for Information and Systems Engineering and a member of the Air Force's Scientific Advisory Board. He is also a member of the IEEE Control System Society's Board of Governors, and has served as President of the IEEE Control Systems in 2008. His research interests include stochastic control, optimization, detection and inverse problems with applications to defense, medical diagnosis and homeland security.

John Chang

Laurence Livermore National Laboratory
Chang16@llnl.gov

Dr. John Chang is a Group Leader for Signal Processing and Imagery Systems at the DOE's Lawrence Livermore National Laboratory. Dr. Chang and his team have been involved with investigating the use of RF and optical systems and signals for characterizing organic and in-organic materials and structures. He specifically leads the LLNL efforts in the development of ultrawideband technology for medical applications specific to non-invasive diagnosis of traumatic injuries. His team also studies standoff detection capabilities using speckle imaging and adaptive optics approaches. He is a member of the Institutional Review Board overseeing human research subject protection.

Carl Crawford

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crawford.carl@csuptwo.com

Dr. Carl Crawford is president of Csuptwo, LLC, a technology development and consulting company in the fields of medical imaging and Homeland Security. He has been a technical innovator in the fields of medical and industrial imaging for more than 25 years. Dr. Crawford was the Technical Vice President of Corporate Imaging Systems at Analogic Corporation, Peabody, Massachusetts, where he led the application of signal and image processing techniques for medical and security scanners. He developed the reconstruction and explosive detection algorithms for the Examiner 6000, a computerized tomographic (CT) scanner deployed in airports worldwide. He was also employed at General Electric Medical Systems, Milwaukee, Wisconsin, where he invented the enabling technology for helical (spiral) scanning for medical CT scanners, and at Elscint, where he developed technology for cardiac CT scanners. He also has developed technology for magnetic resonance imaging (MRI), single photon emission tomography (SPECT), positron emission tomography (PET), ultrasound imaging (U/S), and dual energy imaging and automated threat detection algorithms based on computer aided detection (CAD). Dr. Crawford has a doctorate in electrical engineering from Purdue University, is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and an associate editor of IEEE Transactions on Medical Imaging.

Chris Crowley

Morpho Detection

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Dr. Christopher W. Crowley is currently a Principal Scientist with Morpho Detection Inc., at the Magnetics Center of Excellence in San Diego, CA. Dr. Crowley obtained a Ph.D. in Electrical Engineering in 1988 from McGill University. He has over 20 years of experience in the fields of nuclear magnetic resonance, nuclear quadrupole resonance and advanced magnetic sensing. He has worked in the fields of both medical imaging systems and security systems. Dr. Crowley's current research interests include the development of advanced security technologies for screening personnel.

Bob Daly

Brijot

bdaly@brijot.com

Robert P. (Bob) Daly leads Brijot Imaging Systems, Inc.'s engineering and technology teams as Vice President, Engineering and Chief Technology Officer. Prior to Brijot Daly served as Vice President of Manufacturing at Triton Network Systems, Inc. Daly has developed the long-term product development plan for Brijot. He has also been instrumental in the complex

direction of improvements in algorithmic software, facilitation of customer hardware technology cost reduction, and the recruitment of a highly talented technical and engineering team. Daly's leadership ensures optimum product performance, the highest engineering standards, and the ability to drive development to meet specific market needs.

Daly has presented at IWPC – Millimeter wave Sensors for Transportation Security Applications and other respected industry events. He is also a member of MACF Board of Directors and APICS Certified Production and Inventory Manager (CPIM). Daly recently authored “Security by the Layers; Facility Security Magazine 2008 and “Body Bombs: Threats and Detection of Suicide Bombers”; Security Info Watch Magazine 2009. Daly holds a bachelors degree in Industrial Engineering from the University of Central Florida, and a masters degree in Project Management from the George Washington University.

Bryan Donaldson

Intelliscience

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Pia Dreiseitel

Smiths Heimann

Pia.Dreiseitel@smiths-heimann.com

Dr. Pia Dreiseitel is currently head of Algorithm Development at Smiths Heimann, Germany, in the area of X-ray threat detection. She focuses on image processing techniques (both 2D and 3D), 3D reconstruction algorithms, dual-energy material evaluation for explosives detection, liquid detection, HME, Millimetre-wave imaging, automated object recognition, and computer vision. Dr. Dreiseitel studied Electrical Engineering at Darmstadt University of Technology, Germany, and Heriott-Watt University Edinburgh, United Kingdom, for her master's degree in 1995 in Electrical Engineering and Communications. Her special interest was Signal Processing.

Prior to joining Smiths Heimann, Dr. Dreiseitel worked as research assistant at Darmstadt University of Technology, where she developed novel algorithms and quality measures for noise reduction and echo cancellation in the field of hands-free telephones in car applications. She gained extensive research experience in statistical Signal Processing and Adaptive Filters.

Xin Feng

Marquette University

Xin.feng@mu.edu

Dr. Xin Feng is an Associate Professor in the Department of Electrical and Computer Engineering at Marquette University in Milwaukee, Wisconsin. He obtained his D.Sc. Degree in Systems Science and Mathematics from Washington University - St. Louis. Dr. Feng has more than twenty years of research experience in the areas of Pattern Recognition, Machine Learning, Data Mining, Algorithms Development, and Optimization. He has directed 20+ Ph.D. students and 50+ M.S. students, and has published 100+ referred articles and obtained more than one million dollars in research funding from NSF, NASA and other federal agencies. He also has collaborated extensively in the industrial setting with several industrial patents in the areas of intelligent control and automation, engine temperature control, signal and image processing.

Dr. Feng is a senior member of IEEE, past Chairman of IEEE Computer Society-Milwaukee Chapter, and has organized several IEEE conferences and symposiums in data mining, machine learning, intelligent control systems, and artificial neural networks.

Michael Fleisher

L-3 Communications

Michael.fleisher@l-3com.com

Michael Fleisher has more than twenty years experience in developing algorithms in the areas of Image Processing, Machine Vision, Pattern Recognition and Machine Learning. In the last seven years he is leading the effort of developing the capability of Automatic Threat Recognition and Image Processing for the Provision mm wave scanner produced by L3 Communications – SD&S. Michael holds a PhD in Electrical Engineering from the Technion – Israeli Institute of Technology.

David Getty

Harvard Medical School

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Dr. Getty is a Senior Research Associate at Harvard Medical School and the Center for Advanced Medical Imaging (CAMI) within the Radiology Department at Brigham and Women's Hospital. Over the past 35 years, Dr. Getty has conducted research primarily in three areas: (1) visual pattern recognition, (2) image-based medical diagnostic and decision-aiding systems, and (3) applications of stereoscopic human vision in medical imaging.

As a now-retired Lead Scientist at BBN Technologies, Dr. Getty developed a medical imaging system to acquire and display stereoscopic digital

mammograms. In a recent clinical trial conducted at Emory University, stereo digital mammography was found to reduce false positive lesion detections by 46% compared to standard digital mammography while also improving detection of true positive lesions by 23%.

Steve Godbout

Optosecurity
sgodbout@optosecurity.com

Mr. Godbout is the Director of Technology Engineering at Optosecurity. He is responsible for Optosecurity's algorithm development and scientific research team. Following Optosecurity's CTO lead, his role is also to lay out the architectural road map to Optosecurity's scientific innovations. After completing his Ph. D in Astrophysics, Mr. Godbout was awarded a government grant for Industrial Post-Doctoral research. With this grant in hand, he joined the ranks of the world's leader in white light 3D digitizing hardware, InSpeck, Inc. As a scientific developer for InSpeck, he acquired enviable experience in 3D acquisition, modeling and editing. This experience carried over to a short period as a game developer at Ubisoft in Québec City.

Mr. Godbout joined the ranks of Optosecurity's software team in January 2007 as a scientific developer and soon moved to the Liquids Detection R&D team where his experience in physics played a pivotal role over the different incarnations of Optosecurity's liquid detection software. Mr. Godbout's work and passion for scientific challenges helped him quickly climb the ranks at Optosecurity as he was promoted in 2009 to Senior Technology Architect and then to head the entire team as Director of Technology Engineering.

Ted Grant

Department of Homeland Security
ted.grant@associates.dhs.gov

Ted Grant is the Checkpoint Program Manager for the Science and Technology Directorate of the Department of Homeland Security, which is developing the next generation of aviation checkpoint technologies. He has participated in the development, evaluation and qualification of numerous personnel inspection systems. He served as primary technical monitor on TSA's Camden program, which developed Backscatter X-Ray Whole Body Imagers from AS&E and Rapiscan for airport checkpoint use. Investigated numerous systems in development, including active millimeter wave Whole Body Imager, Quadrupole Resonance bulk explosive detection systems, the CastScope, walk-through and handheld Metal Detectors, bottle screening devices, passive millimeter wave imagers, and Raman scattering systems.

He has been the system architect and team leader for several large integrated hardware / software systems, including the Drivers Enhanced Vision System, which combines infrared imaging, moving-map displays, wireless communications, and Differential GPS to track and control airport vehicles and received the Technology Innovation Award presented by Aviation Week and Space Technology. He also led the effort to develop a regional tracking system in Shenyang China, and founded a nationwide tracking service in the US. He holds a bachelor's degree in Physics from the University of Vermont, and a master's degree from Cornell University.

Grant Gullberg

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During the past 35 years Dr. Gullberg worked in the field of Medical Imaging in both industry and academia. His professional research interests are in the field of physics and nuclear instrumentation and their application to medical problems and medical imaging. He received his PhD in Biophysics from the University of California, Berkeley (1979) where he also worked as a staff scientist at the Lawrence Berkeley National Laboratory. After his PhD studies he worked in the Applied Science Lab of the General Electric Company for 5 years before taking a position at the University of Utah where he was Professor of Radiology and Director of the Medical Imaging Research Laboratory for 17 years. In 2002 he returned to the Lawrence Berkeley National Laboratory as a Senior Staff Scientist and he is also Adjunct Professor of Radiology at the University of California San Francisco.

Gerard Hanley

Rapiscan
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Mr. Gerard Hanley, Manager of Advanced Detection at Rapiscan Systems, leads a world-class team of scientists and engineers developing inspection algorithms for a variety of imaging platforms used in security applications. Automated threat detection solutions are developed for personnel screening applications with Backscatter x-ray imaging, carry-on baggage screening with multi-view x-ray inspection, hold baggage screening with 4th generation CT, and vehicle and cargo screening with high energy x-ray inspection. Prior to Rapiscan, Mr. Hanley has 10 years experience working in product development roles for GE Security (Quantum Magnetix, a subsidiary of InVision Technologies), QR Sciences, and Spectrum San Diego, developing a series of technologies including Quadrupole Resonance, micro-dose x-ray imaging, and electro-magnetic sensing for the detection of explosives,

weapons, and IED components. Before entering the security business Mr. Hanley developed neutron and gamma flux measurement instrumentation for reactor safety systems and gamma spectroscopy instrumentation for bulk elemental analysis. Mr. Hanley holds a BS in Mechanical Engineering from the University of California, San Diego.

David Isaacson

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David Isaacson is a Professor of Mathematical Sciences at Rensselaer Polytechnic Institute in Troy New York. He received his Ph.D. in Mathematics from the Courant Institute of Mathematical Sciences in 1976. In the early years of his career he worked on developing numerical methods to approximately solve problems arising in Statistical Mechanics, Quantum Mechanics, and Quantum Field theory. Since 1986 he has devoted his career to applying mathematics to the solution of problems in medicine and biology. Along with his collaborators at RPI he has developed Adaptive Current Tomography systems for monitoring heart and lung function. He is currently collaborating on the construction of an Electrical Impedance Tomography system specifically designed to improve the diagnosis of breast cancer.

Jeff Jortner

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Jeff Jortner (Ph.D. Mechanical Engineering, Louisiana State University, 1986) is a Principal Member of the Technical Staff in the Infomatics & Decision Sciences Department at Sandia National Laboratories in California. Jeff is the project manager for the Automatic Target Recognition for Advanced Imaging Technology project which began in late 2008. He has been involved with the development, evaluation, and utilization of tools in the areas of Computer-Aided Modeling, Scientific Visualization, Geospatial Analysis, and Visual Analytics for the past 23 years.

Seemen Karimi

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Dr. Ramesh has served on numerous conference and workshop organization committees. Dr. Ramesh, who earned his Ph.D. in Electrical Engineering from the University of Washington where he defended his dissertation on "Performance Characterization of Image Understanding Algorithms" in December 1994. He also was a co-author of an award winning paper on real-

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Previously, Dr Schott was Director of Advanced Development at Medispectra, managing directors, managers, engineers, scientists and consultants of the algorithm, image processing, database and software groups. He also architected the overall classification and image processing algorithms and led the cross-functional team, including external counsel, which produced 9 patent applications covering the intellectual property of the key technology. Dr. Schott has also served as Director of Engineering at Synapix, managing the entire engineering department, including 2D and 3D graphics groups, QA, documentation, UI and computational geometry.

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Image Quality of X-ray Computed Tomography (CT) Security-Screening Systems. He developed the Computed Tomography Image Quality (CTIQ) hardware and software to measure the image quality of Explosive Detection Systems for the Transportation Security Laboratory (TSL). As Director of Engineering, Steve led the L-3 communication team from the development of the 3DX6000 through TSA certification and fielding before becoming Director of Advance Systems Engineering. He is a Florida Professional Engineer and member of the IEEE, SPIE and NSPE.

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Jeremy Wolfe graduated summa cum laude from Princeton in 1977 with a degree in Psychology and went on to obtain his PhD in 1981 from MIT, studying with Richard Held. His PhD thesis was entitled "On Binocular Single Vision". Wolfe remained at MIT until 1991. During that period, he published papers on binocular rivalry, visual aftereffects, and accommodation. In the late 1980s, the focus of the lab shifted to visual attention. Since that time, he has published numerous articles on visual search and visual attention. In 1991, Wolfe moved to Brigham and Women's Hospital and Harvard Medical School where he is Professor of Ophthalmology. The lab is currently funded by the US National Institutes of Health and Department of Homeland Security. Wolfe teaches Psychology courses at MIT & Harvard.

Jeremy Wolfe is Past-President of the Eastern Psychological Association, President-elect of Division 3 of the American Psychological Association, and editor of the journal "Attention, Perception and Psychophysics". He won the Baker Memorial Prize for teaching at MIT in 1989. He is a fellow of the AAAS, the American Psychological Association (Div. 3 & 6), the American Psychological Society, and a member of the Society for Experimental Psychologists. He lives in Newton, Mass.

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Masashi Yamaguchi received his B.S., M.S. and Ph.D. degrees from Hokkaido University, Sapporo, Japan. In 1991, he joined Research Institute for Electronic Science, Hokkaido University as a research scientist. In 1994, he moved to the Department of Applied Physics at Hokkaido University with a promotion to a tenured associate professor. In 1999, he was on a sabbatical leave at the Department of Chemistry, University of California, Riverside, for 15 months. During this sabbatical leave, he made a decision to pursue his academic carrier in U.S. In 2001, he left his permanent position in Japan and returned to the University of California as a postdoctoral research associate. He moved to MIT in 2003. In 2004, he accepted a position at RPI as an

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Masashi's current specialty is THz spectroscopy and its applications. He has worked with the Department of Homeland Security S&T, Gordon-CenSSIS and its industry partners, American Science & Engineering, Raytheon Corporation, and Siemens Corporation R&D on a suicide bomber detection project (BomDetec). His group achieved simultaneous real time (<1 sec) and stand-off (> 3 m) detection of chemicals using THz spectroscopy in 2007. Currently, he and his group are working on generation and control of intense THz wave in laser induced plasma, and its applications to THz spectroscopy. His recent publication on THz pulse shaping and optimization in the Journal of American Optical Society B was selected for a "Spotlight on Optics" of the issue.

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Birsen Yazıcı received B.S. degrees in electrical engineering and mathematics from Bogazici University, Istanbul, Turkey, in 1988, and M.S. and Ph.D. degrees in mathematics and electrical engineering from Purdue University, West Lafayette IN, in 1990 and 1994, respectively. From September 1994 until 2000, she was a research engineer at the General Electric Company Global Research Center, Schenectady, NY. During her tenure in industry, she worked on radar, transportation, industrial, and medical imaging systems. From 1996 until 1999, she was a member of the GE Research, L3 and Analogic team that developed the 3D X-ray CT explosive detection system for airport check-luggage. In 2001 she joined Drexel University as an assistant professor. In 2003, she joined Rensselaer Polytechnic Institute, Troy, NY, where she is currently an Associate Professor in the Department of Electrical, Computer, and Systems Engineering and in the Department of Biomedical Engineering. Her research interests span the areas of statistical signal processing, inverse problems in imaging, biomedical optics, and radar. She holds 11 U.S. patents. Dr. Yazıcı is the recipient of the Rensselaer Polytechnic Institute 2007 School of Engineering Research Excellence Award. Her work on industrial systems received the 2nd best paper award in 1997 given by IEEE Transactions in Industrial Applications.

17. Appendix: Questionnaire

Workshop participants were asked to fill out a questionnaire. These are their responses, grouped by question:

Question 1. *What opportunities are there for developing advanced algorithms for the following topics? (include in your answer modality, application and algorithmic needs)*

- a. Concept of operations for using sensors*
- b. Modeling of sensors, probe interactions with targets. And clutter sources.*
- c. Reconstruction algorithms*
- d. Automated threat recognition (ATR)*
- e. Sensor and data fusion of multi-sensor systems, including adaptive processing.*
- f. Advanced display including privacy filters.*
- g. Other*

Question 1 Responses⁹:

Response A:

Modality – passive millimeter wave

Application – people screening

Algorithmic needs – automated detection

d. Detection first. Recognition based on shape, texture, etc. would add some value as well, but we do not expect it to be reliable enough for practical use (referring to PMMV only)

e. All of the above.

⁹ The response notation refers to the number of responses to each question. As some participants did not answer every question, the number of total responses varies by question; therefore, it should not be assumed that each letter is an identifier for a specific person.

f. N/A

Response B:

Image reconstruction/restoration for almost all modalities, especially MM wave, THZ, etc.

I am interested in position – a energy-recording detector could be used for x-ray backscatter to further improve image quality and perhaps use to threat I.D. rather than just anomaly detection. This would involve modeling and inverse problems.

a. – Sensor thresholds should be adjusted based on threat level and passenger behavior/identity.

- Sensors should reveal when they are “blind” – signal need for secondary screening/imaging.

b. Modeling would be valuable for mm-wave, x-ray backscatter. Someone could generate general tools that manufactures could use to simulate their specific hardware. Think of combo of GATE + GEANT in emission tomography.

c. See above.

d. This is challenging given limited data. The database from Sandia is an excellent step forward. More such steps will be beneficial.

e. - We need more data in information to help determine the “orthogonality” of the various modalities.

- Consider parallel vs. sequential. Parallel ideally gives you registered data with multiple parameters in each pixel. Sequential lets you use one modality to inform the next in terms of focus of attention, threshold, spectroscopy.

Response C:

General Comments:

1. The AIT systems are in a very early stage of development, yet they are being deployed.
 - a. There are huge disincentives to performing R&D to improve systems, especially by 3rd party vendors;
 - b. No robust SBIR/STTR program such as DOD, NSF, NIH, etc.

- c. Previous BAAs were not funded, causing 3rd parties to lose confidence in DNS.
2. Even the vendors, who at least have huge incentives from the possibility of procurement, have not received R&D funds in recent years.
3. The most significant barrier to progress is the lack of R&D funding for a diversity of projects.
4. Another problem is that there is only a single customer for U.S. airports: TSA. If a novel idea does not interest TSA, then the only alternative is to search for customers outside the U.S., which may require more resources than a small company can support. For example Invision was accepted in Israel, England, and France years before U.S. TSA took an interest.
5. This workshop serves the interests of academic investigators more than industry and innovative small companies. Not a bad thing, just an observation.

Response D:

Operator assistance tools for the Z “high-end” modalities (x-ray backscatter and acting mm-wav)

In my opinion, two other areas have such a low probability of leading to a useful end point that they don’t deserve attention:

1. Algorithm development for “low-end” modalities (positive mm wave, ultra sound, etc.). These have such a low information content that it is not likely to be productive.
2. Full ATR (operator out of the loop). This is too difficult of problem with current technology. It should be viewed as a very long term goal—10 to 20 years.

Response E:

Tomographic image reconstruction for MM imaging.

- a. Fast x-ray imaging, code-aperture imaging
- c. Cone-beam CT from limited data (function, motion, few-view data)

Response F:

- a. Via modeling→(b.)
- b. High – integrates disparate points-of-view potential
High feasibility if moderate data becomes available.
- c. Explore:
 - 1. Sequential cue-ing (guided interrogation)
 - 2. Use of priors by modality 1 to improve modality 2-n (medical example PET-CT)
- d. $ATR + \text{human} > ATR$
 $> ATR$
But permits monitoring the interpretation workflow = better operator management.
- e. Model the benefit to decide.
- f. Privacy filters are a waste. False idol.

Response G:

Consider combination of sensors

Include “fusion” with non-imagery information to get better AIT experience. Example if such information include prior history of the passenger, presence in watch-lists, security clearances present travel pattern (whether traveling with kids), advanced behavior recognition (anxiety detections)

d. Lots of relevance in anomaly detection—leverage expertise and experience from other domains such as medical imagery (CAD), defense ATR applications, video analytics, industrial inspection applications.

e. - See answers in (a)

- Opportunities in integrality facial recognition and biometrics with AIT for better sensing and comprehensive threat detection.

Use of video, IR (or other modality) to automatically target and integrate individuals with secondary sensors (e.g. spectroscopy sensors)

Response H:

- a. Factors to consider:

- Flow of passengers (throughout)
 - Floor space needed for divesting
- b. Modeling lets us do feasibility analysis and to explore the parameter space. However must make sure models are good.
- c. MM wave seems very likely
Spectroscopy perhaps
IR, THz, thermography is a possibility
- d. Should we go completely auto or go with assisted setups
By having algorithms do a lot of the detection, do we lose information?
The need for ATR is also controlled by the CONOPS
For development
- Better training data
 - Data standardization
- e. Sensors currently use fusion (humans)
Future opportunities- ways to take humans out automation
Cost, accuracy, automation all want to be improved upon
- f. At some point perhaps to appease groups like EPX, but for us let's focus on the actual problem.

Response I:

Modeling for this would be key in the development of the overall system design and multi-technology systems. At this early stage detection is key, but future needs include throughput, floor space, privacy concerns, and passengers' ability to maintain eye contact on belongings.

It would be very helpful early on to model the system to take these additional items into account.

Again you need to determine the performance of the system in a real world setting. If you can model this and then remove clutter you can provide an improved image for review.

- d. This has become very important to TSA due to the staffing needs of an AIT. I would consider this the most important area to improve algorithm development.

Deployment of current AITs will be dependent on the ability to reduce staffing and increase throughput while maintain detection capabilities.

e. It would be important to determine what technology is good at detection for some items with a low processing time and combine that with something which is able to handle detecting the other items.

The idea is to maintain a low processing time . If x-ray takes 20 seconds to process the image for x explosive but only 10 seconds to process for y. Then it should be combined with another technology which is able to detect explosive x in 10 seconds. So the overall system is able to do a full process in 10 seconds.

Response J:

- a. Opportunities primarily in fusion or internal cavity examination.
- b. Limited importance. Measuring/texting more important. For more basic R&D concepts modeling is more important.
- c. Most important area for improvement:
 - Least understood performance.
 - Lack of performance understanding for non-ATR systems which serve as a benchmark.
 - Insufficient data exists to develop this area. Workshop focused on access to existing data but even developers do not have enough data on their own systems for a complete understanding.
 - More long term vision needed.
 - More funding needed.

Response K:

- a.
 - understanding the maximum information that can be extracted from a particular sensor.
 - understanding the limitations or challenges of each sensor.
 - identifying the most important research areas to improve the technology in terms of improving the accuracy of the data/images and throughout.
- b. Modeling is important in:
 - 1. sensor and systems design
 - 2. validate algorithms, e.g. reconstruction algorithms for accuracy with the "truth"
 - 3. systems + algorithm evaluation with the availability of "truth"

Important components of modeling:

1. Accurate and 'realistic' models of objects or 'human'
 2. Accurate and 'realistic' models of sensors and system
 3. Validation of modeling techniques with real data.
- c. - learn from Medical...about "statistical image reconstruction methods with models of physics of the image process using iterative algorithms", not just any iterative algorithms.
- understanding the advantages of the above for simultaneous improvement in image noise and resolution.
- d. - start with good data/image with the above
- learn from the field of shape analysis and surveillance.
- e. - see comments in part 1.a. above
- true complimentary information/data/images
- accurate registration which may require non-rigid transition in imaging
- adaptive processing is important to maximize information, e.g. signal + noise in each image are different
- f. - Make sure to protect privacy without sacrificing important information.

Response L:

- Most of the speakers did not explain what algorithms they are using. I have a feeling that mixture statistical model would be a good tool to use to model image data as it works well for the medical images.
- A team of engineers and mathematicians should work together from the academia. As a mathematician I know there is way we can contribute toward reconstruction of images and target prediction.
 - a) Does not fall into my expertise.
 - b) I think this is challenging for us in academia. Unless we know how sensors are deployed it would be difficult to understand the modeling without any feedback. Beside one has to be in the field to really understand the system.
 - c) This is the area in which mathematicians and statisticians can help. Many ideas were presented in the workshop. It is not clear if any particular method works. There is a good chance that Bayesian statistical modeling for spatial process based on Hidden Markov Model can provide a good reconstructive algorithm.

- d) If the threat target is well defined that would be a wonderful problem to work on. It would be a challenging problem, but I think there is a lot of potential in our research.
As we heard in the Wolfe's presentation that perception of target can be different if viewed differently. Automated threat recognition can work in the lab perfectly, but I am not sure how it would perform in practice. A way to check is to do a random pilot study where the system is installed.
- e) Interesting idea. This was the first time, I heard about the terminology of data fusion. I am not sure how data fusion works. If my understanding about what I heard of data fusion is correct, there is a lot of work in signal process modeling literature.
- f) Not sure if this is important.
- g) Other.

Response M:

TSL's Integrated Checkpoint Program is developing the vehicle for vendors and academia to test/evaluate/implement their algorithms for a better detection, for standardization of imagery and controls, for processing of data, etc...

a-e) Same as above.

f) Same; this is an important issue and an area that can be improved upon which goes hand in hand with image quality. Until great strides are made to improve automated threat detection at the checkpoint, operator currently rely on the image quality and the rendering abilities of imaging systems to assist them with object recognition to determine if a bag is benign, definitely contain a threat, or require further scrutiny.

Response N:

I see a few possible opportunities. But these are very much basic research questions and may not be so directly related to near/midterm needs.

1) Transmission X-ray imaging for screening – I was very surprised to see the quality of the transmission images that could be achieved at very low dosage (0.1 μ Sv). I think that through proper modeling of the human body together with sparse reconstruction of anomalies (all using regularized inverse methods), I think it could be realistic to perform 3D reconstruction at ultra low dosage. This could be very important for detecting internal threats in subjects.

2) Anomaly detection – It seemed that a number of speakers mentioned that current methods for whole body imaging threat detection do not use holistic methods to determine if the data is “anomalous”. For high dimensional multimodal data, it is impossible to have enough training data to know exactly what is anomalous. Therefore, we need to have implicit models of, for example, the human body, that can be efficiently trained to determine accurate distributions for “normal” subjects without threats.

- a) Yes, I think that modeling can be very important, particularly modeling of the target and clutter sources.
- b) It’s difficult for me to say how much improved reconstruction algorithms can improve overall systems performance without a better understanding of how reconstruction artifacts are interacting with detection algorithms.
- c) For example, with CT, it became clear to me after some study that the current reconstruction artifacts are limiting the accuracy of segmentation algorithms. However, with some of the whole-body imaging modalities, it is less clear to me at this point how much benefit improved reconstruction offers. It might be very valuable, but it is difficult to say.
- d) It seems to me that there might be substantial opportunities here, but there wasn’t enough depth in the discussion to tell where the opportunities might be here. My sense was that existing methods seemed to be relatively local in nature. Perhaps more global human image models might be useful for threat detection. For example, these types of approach have been very valuable in face detection, which has made substantial progress in the last 5 to 10 years.
- e) I have less understanding of the opportunities here, but this must be important.
- f) I don’t have much understanding of these issues.

Response O:

Current deployed technology modalities such as mm wave, x-ray backscatter, and infrared have demonstrated success in taking laboratory prototype and concepts into commercialized products. While these can be argued to be demonstration of technology transfer successes, the successes in detecting traditional and non-traditional explosive and weapons are not as clear. The trade space between specificity, efficiency, and effectiveness of

deployed technologies and emerging technologies alike varies tremendously. Bridging the major gaps in the trade space will require not only continual and persistent incremental advancement of system components such as sensor fidelity, signal processing efficiency, and target recognition discrimination but also implementing disruptive techniques of real time sensor fusion and automatic knowledge extraction from cohort of sensor data.

- a) Each sensing modality provides insight into a sensed environment. The ability to interpret that environment is limited by the what the sensors “filter in” and “filter out”. The broadest and most generic sensor is one that is able to gain environmental information in the continuum of time and space. In view of the existing deployed sensors/platforms/systems, opportunities for improvement might be identified by extending the capabilities the current static imaging system into a dynamic environment. Further opportunities might be to explore portal tunnels for implementation.
- b) Sensor modeling in complex environments are pre-requisites in gaining insights into the capabilities and limitation of the sensor/target interactions. Realistic capabilities of accurately portraying the heavily cluttered target environments will require tremendous computational power that may reside in the supercomputing realm where the availabilities of the resources are very limited. Improvement of modeling/simulation algorithm as well as identifying significant challenge problems is an area of opportunity that can be reinvested into directing development paths for both deployed and emerging technologies.
- c) Reconstruction algorithms are critical components in reducing raw sensor data into actionable (or not) information. Opportunities here would appear to lie with driving reconstruction algorithm to be more efficient, more real time, and more effective in highlighting objects/targets of interest. Reconstruction algorithms should not be solely driven by resolution unless there is a good cause.
- d) ATR is a highly desirable notion. It is opined that nothing does this better than the biological brain . One opportunity in pursuing this notion is to explore and understand the mechanism of the human (or otherwise) brain in how it process and filters environmental information and reduce that down to actionable decision points.

- e) Sensor/data fusion systems are very attractive in attempting to fill gaps in individual sensor modalities. Adaptive processing has been demonstrated to be very successful in the disciplines of adaptive optics and speckle imaging through turbid environments. The opportunity here is the possibility of exploring the integration of adaptive processing techniques to enable efficient, real time threat detection capabilities.
- f) Privacy filters is of social/political importance. Opportunities to develop advanced techniques to obfuscate sensitive regions of the human anatomy improve user-interface process can leverage from great capabilities in the commercial computing/product development disciplines such as gaming/software application spaces that utilized advance graphics processing capabilities.

Response P:

A key philosophical point: algorithms can do things such as de-convolve data or glean traits such as edge extraction. But if there is no attribute of any type that is tied to a threat, then an algorithm cannot compensate.

Instances where there is simply no physical data pertaining to certain threats represent holes in the system. Again, algorithms can't fill holes.

A critical need is to fill the relatively obvious holes in the AIT approach to scanning bodies.

While there exist threats that can be seen with AIT, there also exist threats that cannot be seen.

However prevalent such threat are now, they could become more prevalent in the future.

This means that an actual threat detection modality, e.g. NQR, needs to be introduced.

The deployment could be:

- Secondary screening, e.g. a wand, which is used to clear anomalies - found with AIT
- Primary screening, in which the vulnerabilities (e.g. body cavities) are scanned for every passenger.

- a) Conops are pretty straightforward: Primary screening is ideally one-stance scanning, in which multiple sensors are brought to bear on the person. Secondary screening is anomaly-driven: someone sees something suspicious and needs to evaluate the content.

Response Q:

1. What opportunities are there for developing advanced algorithms for the following topics? (Include in you answer modality, application and algorithmic needs).

- Great opportunities for us to get involved in developing algorithms to achieve the AIT goal by applying our expertise in Pattern Recognition/Machine Learning by analyzing the images to identify the anomalies in the bag/body images.

- a) Modeling of sensors, probe interactions with targets, and clutter sources

- b) Reconstruction algorithms

- This certainly is in my interest. The concept of reconstructing multiple images with separate features could reveal more info of the object that is not normally detected.

- c) Automated threat recognition (ATR)

- This is definitely one of the most important topics that we would get involved using state-of-the-art machine learning algorithms. Some of the vendors already implemented it. The key issue is to reduce the false alarm rate

- d) Sensor and data fusion of multi-sensor systems, including adaptive processing

- Data fusion is a system engineering effort, and will have the significant impact in improving the overall performance of ATR. One of the issues is the data visualization and data analytics, which means that how the overwhelming amount multi-modal data be displayed in the limited screen space, and in real time.

- e) Other

- Our biggest concern is how to get the data and how the multiple sources of data (DHS, academic, and vendors) be coordinated. Can the Center of Excellence play more important roles in coordinating the distribution of data and act as the sharing points of research and testing results?
- We at Marquette University will be happy to help in this direction. Let me know what roles we could play.

Response R:

a) AIT:

- RAFF: Sensor data level fusion - -Ideally would like to fuse at the data level however, not practical given contractual issues. Fusing multiple algorithms from one device as well as multiple algorithms from multiple devices each provide a level of increased probability.
- Current Checkpoint screening. Stop, scan, review, respond. Tunnel of truth idea is achievable.
- Would AIT eventually move to doing full body scans of not only what's superficial to the person but also what may be internal (more like an MRI)? Costly, time consuming. As current AIT improves, terrorists could adjust to hide threats inside the body.

Beyond AIT:

- The Next generations Security Architecture will evolve to a "true" open architecture whereby devices are integrated at the logical data level. This will enable Real-time Data Association, Tagging and Tracking: Aggregating different types of information (data) with a specific passenger and then performing analytics and higher level risk assessment and rapid response
- Dynamic Security and Situational Awareness: Can raise threat levels, sensitivity for screening, allocate resources/personnel to higher risk areas, etc
- Predictive Security: Anticipate threats and tailor based on events, time of day, etc.; keep an eye out for coordinated events, etc.
- More automation & analytics with Operator providing oversight, confirmation, and action/response.

b) Modeling is good to a point. Can save lots of time from data collection if the models are pretty high fidelity. Need to characterize realistic situations, environments, threats, etc.

If the models are good, then can save lots of time and costs associated with developing robust data sets to evaluate AIT system and algorithm performance.

Good for helping develop new algorithms to rapidly respond to new threats.

Be good for DHS to fund academia-industry partnership for checks and balances and allow for faster prototyping and improving performance. Could be tough b/c of sensor provider's IP.

b) Fundamental to some of the imaging modalities

Different kind of reconstruction – Forensic Analysis

- Leverage modeling tools and “playback” processing to analyze security status and dynamics before during and after a threat event
- Useful for training and improving system

d) Previous work in overhead imagery ATR suggests that improved performance can be achieved by fusing the outputs of multiple algorithms operating on the same sensor. One approach would be to divide the image under test (IUT) into a number of overlapping regions, which can be related to threat locations. A spatial anomaly detector (SAD) compares the statistics of all regions within the IUT to discover those regions that “stand out” from the background. A temporal anomaly detector (TAD) then compares each region in the IUT with the same region across an ensemble of no-threat reference images. TAD is in effect a change detector. We have found in signal-level fusion studies that the false alarms from these two types of detector decorrelate and provide fusion gain in a single sensor.

e) There are many different fusion techniques. Fusion can occur at the signal (pixel) or decision (post-detection) level. The former requires access to OEM IP, which appears to be a non-starter. Alternative is to encourage collaboration between manufacturers at the decision level. Although the theoretical fusion performance gain will be lower using post detection results, decision-level fusion can address a number of issues including spatial data registration and non-time coincidence. In lieu of detailed knowledge about the single sensor ATRs, decision-level fusion can utilize empirical techniques for estimating correlation statistics (covariances) from training data without having to know specific OEM algorithm performance.

f) Not difficult to implement. Can do ATR on actual image and in the display to the operator, can blur sensitive areas. Balance security and privacy. Can only store the blur images to protect privacy, for example, but preserve algorithm outputs for any ATR alerts.

g) Question came up concerning how to do cost/benefit analysis for fusion. It can be conjectured that current TSA requirements dictate what the single system/sensor operating points are (i.e., false alarm rate vs. probability of detection). These requirements are based on some cost criteria; i.e., what is the cost of missing a threat vs. the time (cost) to process false alarms. Suggested the use of Bayes Risk, which assigns costs to misses and false alarms. Fusion gain can be expressed as a ROC curve with increased Pd/Pfa. Can use Pd/Pfa after fusion to assess cost/benefit of fused sensors relative to baseline (single sensor).

- Risk Assessment fusion Engine (RAFE) concepts for algorithm fusion (multiple 3rd party and vendor algorithms)
- Tough problem. Need to understand the system, physics, threats, and environment.
- Orthogonal information allows for fusion gain.
- Try and let individual algorithms do what they do best. More tailoring and targeted ATR algorithms based on threat, body type, environment, sensor, etc. Then optimally fuse.

Response S:

There are opportunities for better modeling the physics of the whole process of detection and the interaction with the human body and motion.

a) Algorithms will be necessary for any sensors that you develop to model the physics of the detection process.

b) Developing better Monte Carlo simulators and potentially phantoms that simulate the human body.

c) Algorithms that better model the physics of the whole process.

d) Problem of motion and different resolution and scale, differences in physics- similar applications as done in medicine. Maybe use microwave for detection motion.

e) This is where this whole thing becomes ridiculous. Has it gone too far???

Response T:

-Basic research in 5 year funding chunks cycles (grad student life cycle) -- Solicit proposals by stating areas of interest and ranking incoming proposals based on scientific quality (peer review) and programmatic priorities (careful about fighting nepotism: Darpa model versus NIH model) - translation of basic research into products is enabled by SBIR's and direct interaction between companies and the scientific community through workshops every few months.

In order to analyze bodies from volumetric scans you will need atlases as databases for algorithms that search the scanner data. I heard this mentioned in the introduction talks. This is something that I can really work on and would be actually interested in doing it.

Response U:

- Doug Bauer stated that it is always the same ideas being brought forward each time we try to make a five year plan to improve things; need new ideas – “poverty of new ideas”
 - **Problem** – does five years really give us enough time to successfully meet the goal they are looking for of bringing out new and evolving technologies
 - To address this issue we need to figure out is what are the fundamentals issues and problems that we face and facilitate an on-going dialog with those who write the algorithms with those who build the systems.
- Forums like this are one of the ways in which we allow for communication across government, vendors, and academia, but need more continuous financial vehicles to allow for this greater thinking to solve the problem.
 - **Problem** – seems to be a chicken and the egg problem as the vendors want funds to look into new areas and the government wants the vendors to bring these ideas forward first to prove the capability prior to funding it
 - Suggestion to set up recurring, set meeting open for all players; a Center of Excellence open to being the conduit for this discussions
- Difficulty associated with foreign involvement restrictions – how are we going to ensure that we get the best people involved, regardless of nationality
 - Doug Bauer – needs to be informed of these issues to ensure that people at the right levels are informed of continuing issue

- While they are successfully pulling together the international community at a senior level, it is not getting down to the working level where it has to be
 - Need the help of those who have successfully broken down the walls keeping out international support to provide their lessons learned and best practices
- As DHS is a young organization, how can we leverage lessons learned and best practices from more veteran organizations (DoD, etc) to move forward more effectively rather than trying to reinvent solutions to problems.
- “We live in a measure/ counter-measure world in the detection of threats”
 - **Problem** – if we are always looking to solve how to catch the bad guy, we are always going to be one step behind. Need to be far more pro-active in our thoughts and ideas in terms of detection
- “No single technology will solve the problem of threat detection alone; fusion is key”
 - Need to look scientifically and mathematically to determine what technology combinations will best meet the desired goals
 - Why has this not been done already?
- What level of “openness” of systems are required to achieve “fusion” – cannot just have black box solutions to the problem
 - Suggestion to have vendors open their systems to academia and others to see the data to do better work – requires NDAs to ensure that proprietary nature of information is maintained
- Someone needs to do the cost-benefit analysis to figure out just how much money TSA “should” be willing to pay for a given system type in order to remove specific numbers of TSOs or reduce maintenance or other recurring costs by specific levels. Has this been done?
- DHS proposals must, currently, be reviewed by federal employees
 - **Problem** – how do we change this to allow for academia, institutions and others to be involved in the review process? This is not the problem with other government agencies where they are reviewed frequently by academia (NSF and NIH)
 - Non-federal employees can provide insight and recommendations but final decision made by feds
 - How do we get around the security issue (sharing of the information)
- How do you prove to vendor management that pooling of money for academia will allow them to recoup their costs down the road

Response V:

Seems like opportunity exists to use NQR in sequence or parallel with an imaging technology like mm or x-ray backscatter.

And/or THx could also be used as second method.

Response W:

Optosecurity's business model is based on developing generic solutions and algorithms that are vendor agnostic and thus apply to multiple technologies and products. We do not build scanning equipment, but generally work with the raw data produced by these devices to fully exploit their capabilities. We combine physics with 3D vision and context analysis to deliver innovative solutions for today's complex challenges.

a) Concept of operations for using sensors

We are currently working with various clients in Europe to try to improve CONOPS and solve actual operational issues for both the X-ray checkpoint screening and AIT, the goal being to improve Pd and Fa rates, increase throughput and/or reduce manpower depending on the client's priorities. This is done in concert with the regulators, but contrary to the US and Canadian markets, European airports have more latitude to try new concepts.

b) Modeling of sensors, probe interactions with targets, and clutter sources

Our X-ray solution is designed to be vendor agnostic. In order for it to work properly, we had to design methods and tools to extract the raw data from each of the supported X-ray models and convert this data into a generic format that takes into consideration the specific characteristics (geometry, sensor, source, etc.) of the host X-ray machine. We intend to use a similar approach with AIT systems and try to exploit the data that is buried behind the basic images.

c) Reconstruction algorithms

As a result of our vendor agnostic image acquisition strategy, the output image and GUI we produce has the same look and feel, independently of which machine it came from. The resulting model is precise enough to generate a scientifically correct simulated X-ray image of any object based on a 3D model and the physical properties of the materials (ex: we can accurately simulate a glass bottle filled with H₂O₂ in any

position/orientation in the tunnel). On the AIT side, a similar approach can be used for backscatter X-ray, but for millimeter-wave this is much more complex. Due to the complexity of this kind of imagery, we don't intend to spend much development time on reconstruction for this application and we will have to limit ourselves to basic variations of using readily available imagery, such as modifying the number of distinct views, taking advantage of the 3D information, or combining information from multiple views. This is still at an early stage of development.

d) Automated threat recognition (ATR)

Optosecurity's core business is automated threat recognition. We already have several ATR solutions deployed in the field for checkpoint screening. We have just started a R&D project for Transport Canada to perform algorithm development designed specifically for AIT. At first, the focus is going to be on addressing known operational problems with current portals in the field to help streamline the process and reduce false alarms, not on detecting threats.

e) Sensor and data fusion of multi-sensor systems, including adaptive processing

Our solutions are primarily software base, so we do not usually deal with multiple sensors unless the system provides such information. We have a project on the X-ray side where we intend to combine a video image of the bag/tray with the X-ray data to help support a network screening solution (i.e. the screener is no longer next to the X-ray machine). We might apply the same concept to AIT portals to help reduce false alarms by identifying features on a person (ex: unique clothing) that can potentially generate anomalies.

f) Advanced display including privacy filters

Advanced display should be an integral part of any X-ray or AIT system, especially since we will likely have to deal with operator-assist rather than fully automated solution for quite some time. Current privacy filters are still fairly crude and should be optimized. However, privacy is not the only reason for developing advanced display solutions and some effort needs to be placed on developing tools to help assist the screener looking at the image. For example, we are working on some layer removal techniques to remove some of the clutter in an X-ray image.

g) Other

We are also developing tools to help with remote monitoring, remote support and process optimization.

Response X:

The government is seeking out solutions for systems on the TSA AIT QPL. At this time, the only system on this list are the Rapiscan 1000 SP and the L3 ProVision , but more systems may be added as they are approved.

- a. As stated at the workshop, it is important to consider the end-uses of the systems, not just for operations at a console, but ultimately as part of a checkpoint (for instance, a system with a large footprint may not be considered by the TSA for use because it may eliminate a lane.)
- b. Modeling of sensors is absolutely necessary. The government will not test on mock passengers when radiation safety may be an issue, for instance. In the case of ATR, proof of concept without the necessity for actual test subjects or use of actual systems is important.
- c. Reconstruction algorithms will be important when implementing ATR (see below).
- d. ATR and the manufacture will be extremely important, not just for improving Pd, Pfa but also throughout, particularly if ATR can to some extent eliminate an operator in the loop.
- e. This will be extremely important on two fronts:
 - i. Increase the effectiveness of detection with more than one view. Extensive work has been done by the DOD (Dept. of Defense) on multi-sensor systems, so fusion is neither unprecedented or uncommon.
 - ii. Is especially important for integrated checkpoint. Integration of sensors could mean data fusion, but loosely defined at this point.
- f. Roughly same importance as data fusion.

Response Y:

- a) Concept of operations for using sensors

Advanced Technology – baggage screening – Reduce the need to rotate bags and minimize the number of bags to be opened. New algorithms have been developed by Guardian that does not rely on Zeff for segmentation,

identification, and classification of threats. Typically, the use of Zeff is limited by the variations in threat weights, positions in bags, and combinations of threats and non-threats where the non-threats combine to give a Zeff for the threat that is not typical of that material if imaged without clutter. Needs include access to raw data and a large collection of both threat (explosive) bags and non-threat bags from a variety of airport locations.

AIT/ATR – Improvements in passenger processing can be made by developing advanced algorithms to minimize the number of false positives. Developing a clear capability of discrimination of body part responses should be the basis for classification. Data collection is critical. The work going on at Sandia Labs is a start to the process. Having access to raw data is very important.

AIT/ATR Data Fusion– Sensor data fusion/multi-modality imaging. Use second modality to interrogate areas of the body that are difficult to image by primary sensors (backscatter and mm wave). They can also be used to validate decision of primary modality. Secondary modalities can include IR and acoustics. These may either be mounted in same position as primary, as a second location, or using a hand held device. Data collection needs to be coordinated so images/responses from both sensor systems are gathered from the same people at the same body location and time. Analysis should first be made, as discussed in the meeting, as to the degree of orthogonality between them. This can be determined experimentally and plotted in feature space.

Cargo Scanning – This area of threat detection requires the greatest correlation between algorithmic development and CONOPS. Multiple sensors are critical for this application since the range of materials, their sizes and potential content is so great. Information regarding the shipping materials such as the type of packages, boxes, containers, as well as the originating source and final destination needs to be considered to determine the modality and algorithms applied to the shipment. Guardian has been working on these strategies for some time.

b) Modeling of sensors, probe interactions with targets, and clutter sources

MM wave - There are numerous ways to modify current mm wave interactions with targets that have not yet been explored. Getting the best image for analysis is always critical. Recovering data from dark areas where noise is most significant is not desirable. We have developed algorithms to compensate for variations in air spaces and folds in clothing and body shape

variations where detection algorithms typically lead to higher false positives.

AT threat detection – Algorithms that characterize signatures rather than Zeff for detection mitigate the factors associated with heavy clutter in bags. Signature analysis does not require finding explosives behind metal objects, instead, it is possible to characterize the combination of metal AND threats. It is not a matter of removing the metal.

c) Reconstruction algorithms

Key to building better reconstruction algorithms is going to be the implementation of DICOS so 3rd party developers can provide input to the process. While the manufacturers themselves are best suited to provide the initial reconstruction, minimizing changes to the raw data prevents arbitrary inclusion of artifacts and color mapping from limiting exploration of new analysis methodologies.

d) Automated threat recognition (ATR)

ATR is employed when there is not enough image data to characterize the materials/threats. Advanced algorithms are essential for AIT, cargo, and stand-off applications. Data collection criteria are critical. This includes having a large and representative image sample data set for both T and NT. It also includes accurate truthing as to the location of threat materials, reasonable testing and scoring criteria, and availability in some cases (such as cargo screening) additional meta data about the object being scanned.

e) Sensor and data fusion of multi-sensor systems, including adaptive processing

Algorithms for AIT, cargo, and stand-off applications most certainly will require sensor and data fusion of multi-sensor systems. They may be used in parallel or in series. Multi-sensor approaches for AIT may work sufficiently in series, and in fact may be restricted to this approach by space limitations of the scanning machines employed. Cargo and stand-off applications can be used in parallel for faster through put. The biggest trade-off to be made, as always, is the Pfa cost versus Pd gain. In addition to considerations of orthogonality between two modalities, issues in algorithmic development significant improvement in mitigating decisions where the two modalities are in conflict with one another. Failing to address

this issue successfully could lead to even greater levels of false positives as compared with only one sensor being employed.

f) Advanced display including privacy filters

It appears that most companies are employing a “manikin” bases for display locations of anomalies. Guardian has employed methods for removing details of people in body scanning for some time. This might be useful when a second look is desired after ATR is employed. This could provide a screener with a way to validate the ATR-identified anomaly, rather than having to pat the person down.

Guardian proposes using a coding system on the manikins to indicate to TSA agents, additional information detected in the ATR process regarding the anomalies that might be helpful to them.

Response Z:

a) Concept of operations for using sensors

Research should be conducted on optimal poses to reduce illumination limitations of current imaging systems. Throughput is highly important, but we should conduct studies to determine if additional poses can help performance.

b) Modeling of sensors, probe interactions with targets, and clutter sources

For the mm-wave sensors, modeling could be used to further understanding of how regions of the body are illuminated by the sensor, and explore potential improvements.

c) Reconstruction algorithms

For the existing mm-wave sensor, I believe the current reconstruction algorithms are mature, and improvements (if any) will probably be incremental. However, alternative scan geometries could require different reconstruction algorithms, and novel reconstruction techniques could potentially reduce the cost/complexity for future systems.

d) Automated threat recognition (ATR)

ATR techniques have been presumably been extensively developed by L-3, however, they are not disclosing their proprietary techniques. Still it seems highly likely that the wider community that you have engaged could provide novel techniques and these should be encouraged. The 3-D(depth)

information present in the mm-wave data has not been incorporated into the current ATR techniques, and this could provide a rich area for new research.

g) Other

I recognize that the current focus is on providing ATR techniques to augment the performance of the current sensors, however, I believe that the research focus should be longer term (3-5 years). This longer term research could be directed at radically improving sensors and ATR algorithms for those potential sensors. For current systems, ATR may be used to reduce cost and alleviate privacy concerns, but I don't believe it will significantly improve detection performance. To that end, I would propose engaging institutions like PNNL to further investigate next generation systems. Without the constraint of having to build full-speed cost effective hardware in the short term, we could experimentally investigate the weaknesses of current techniques, and the performance of potential improvements. Additionally, a moderate number of next-gen data sets could be generated and provided to a larger community for ATR and image reconstruction algorithm development, and for comparison with modeling results.

Response AA:

- Millimeter wave – The removal of reconstruction artifacts from the images. There are too many artifacts present in the reconstructed images to indicate if they are part of the original image or are the result of the reconstruction process.
- Terahertz – The speed of reconstruction along with the area to be reconstructed. The necessary devices to generate, conduct (waveguides), attenuate and reflect the THz wave.
- Infrared Imaging – The ability to detect temperature changes on a human body as the person moves free within the airport.

a) Concept of operations for using sensors

For all modalities:

- The personal items that must be removed before the person is scanned. It must be determined through testing what items can remain on the passenger without comprising security.
- The position of the person in the sensor in order to generate a properly reconstructed image.
- The set up time for the equipment before a person is scanned.

- The use of privacy filters and blurring of images.

Millimeter wave – the positioning of the person who is being scanned and the positions that the person must take in order for the person to be properly imaged.

Terahertz – the effects of humidity within the scanning chamber on the THz attenuation and how to control this between passengers. The procedures necessary for passengers who have been caught in the rain and are wet before entering the sensor.

Transmission X-ray and X-ray back scatter systems – the acceptable level of x-ray radiation that is acceptable to determine if an item on a passenger is a threat without causing harm to the passenger.

Infrared Imaging – the determination of how passenger's movements can be controlled without having to instruct them. How a passenger moves through an IR imaging location could be enhanced to allow maximum temperature differential of the passenger body to detect explosives.

b) Modeling of sensors, probe interactions with targets, and clutter sources

Terahertz: the different types of generating devices, the biasing configurations and the spectrum generated by the devices. The improvement of modulators which are high speed and have low insertion loss.

Millimeter wave: Better modeling of generators and receivers to allow for higher image resolution through simulation optimum placement of generators and receivers in the image chamber. Modeling of the generator noise to determine the noise floor of reconstruction.

X-ray Backscatter: The application of a flying focal stop which can lead to a more efficient detection of x-rays, reduced x-ray exposure and a simplified scanning protocol for humans. Improved methods of for error in detector efficiency.

c) Reconstruction algorithms

Millimeter wave: The removal of reconstruction artifacts in the image. The number of views of the passenger which are necessary to generate an acceptable image of the passenger to determine if there are any threats present. Improve the image quality through the application of image processing techniques.

Terahertz: The small area of the sensors that is being used. A wide area sensor and the ability to reconstruct quickly would greatly aid the fielding of terahertz.

X-ray Backscatter: The application of dynamic reconstruction using different size masks. This also may include moving detector platforms.

d) Automated threat recognition (ATR)

Millimeter wave: would greatly increase the detection rate over a human inspector and would eliminate the need for images to be sent to an inspector or even be saved. This would overcome the biggest obstacle for the AIT fielding.

Terahertz: the same as for millimeter wave.

Quadrupole Resonance – how to make the detection ability of the system independent of temperature. Also how to reduce the high number of shield alarms which arise as part of the explosive detection process.

Infrared Imaging: The ability of the ATR to determine passenger walking patterns for normal, caution or danger. Also the ability to detect passengers who are showing signs of excess bulk on the body.

e) Sensor and data fusion of multi-sensor systems, including adaptive processing

How the data gathered from each sensor will be weighted to generate a resulting detection probability.

How to perform registration an object between the different sensors. The first item is the definition of the coordinate system for a passenger that will be moving.

Millimeter Wave: The Multispectral image fusion of band ratioing, wavelet transform and principle component fusion.

f) Advanced display including privacy filters

For all modalities which generates an image the elimination of the display of the person being scanned for review by an inspector. If an image is going to be generated, the face and private parts of the individual must be blocked so that the person could not be identified after leaving the check point.

Methods need to be developed that does not generate an image for an inspector. In order to gain acceptance by the public, ATR needs to be

implemented to such an accurate level that no images need to be generated for inspector review.

Response BB:**d. Automated threat recognition (ATR)**

State-of-the-art Automated Object Recognition Algorithms, in which the aim is to detect and identify certain object within a given image, perform significantly worse than a human who is attempting to perform the same task.

The domain areas where Automated Object Recognition come close to human performance are when looking for a very specific object within a background of little variance. In our case we are not looking for very specific objects since the 'threat' object can be a great number of different things. The background against which we are looking for threat objects is also quite variable since people have different clothes, jewelry and surgical modifications (false hip, pace maker ect). (Accounting for different body shapes and size should not be a problem, can use AAM's to do this easily.)

Being able to automatically and reliably detect and identify guns, knives, explosives and other threats in whole-body images with any degree accuracy is a long way off possible at the moment: which is why all vendors are concentrating on the very different (easier) problem of anomaly detection. Anomaly detection boils down to a two class problem in which a system can be trained on a large number of non-threat images (people scanned with no threats) and threat images (people scanned with lots of different threats).

Would be interesting to do some comparisons ATR vs. human pat-down searches. How much of an added risk to safety are we accepting when using whole-body scanners?

All the scanners have specific weaknesses that could be exploited to smuggle threats through them. Lots of scope for developing countermeasures for ATR algos to counter specific weakness of the technologies. Was no mention of these specific countermeasures in workshop – do they exist??

f. Advanced display including privacy filters

Depends on what the privacy filters are going to be used for.

Given that algos are operating as anomalies detectors, a human still needs to see all of raw data to make a threat classification so privacy filters cannot be used during this process.

If the privacy filter is only used as a display for the subject (person being scanned) to view themselves, then any human-shape-model to cartoon representation will do and it's a trivial problem.

Response CC:

I see two main opportunities/needs from the meeting. These are discussed in more detail in the subsections below. The first is ATR development; this will require vendor participation in description of the "corner cases" and the generation of data. The SNL data is an excellent start. The second opportunity is understanding of the signatures of threats and benign materials from each of these technologies, and the implementations that result in confusion (folds in clothing, hidden areas). These questions can be addressed with bench-scale measurements and models and will lead to potential fusion opportunities at the signature/observable level, but represent longer-term research opportunities (and thus require roadmapping and priority information from DHS (and an honest assessment of promising technologies and capabilities from the techie types)).

a) ConOps for using sensors

Two obvious opportunities were mentioned. Each involved a primary AIT screen (presumably mm-wave or XRBS) and ATR, followed by secondary investigation of anomalies (threat ID) using:

- THz spectroscopy – could a handheld probe (or a robotically controlled probe) be developed that could automatically examine a region of interest (and be robust enough to handle the difficulties due to things like folds in clothing)?
- NQR – the concept that the temperature-sensitivity problem is less of an issue for the case of a threat on or in a body is intriguing. (the limitation of solid material detection is a disadvantage)

An additional opportunity could be the differential thermal measurement combined with mm-wave or x-ray backscatter. The advantage here is that the infrastructure to create the temperature difference would be in place in the AIT portal, the thermal camera is a mature technology, and thus the footprint in the screening lane would not be changed significantly. The downside is that we do not know much about the thermal detection of

threats on people; there is modeling and experimental data needed. Unlike the other two examples, this combines two anomaly-detection sensors; the most that we can probably hope for is confirmation that an anomaly is most likely not a threat; identification of the threat will be difficult.

Clever use of the metal-detector portal (coarse 1 or 2D spatial resolution) in combination with AIT could help validate anomalies due to metals and allow algorithms to be focus on identifying and classification of the other anomalous regions of the image. (this is similar to the thermal example)

Is there a place for standoff IR spectroscopy and a portable “puffer” system that can be used to “liberate” and examine threat molecules from an ROI determined by the standoff system?

b) Modeling of sensors, probe interactions, clutter

Modeling of full systems that incorporate all relevant interactions is difficult. I think that it is fair to say that even the x-ray CT and radiography manufacturers (technologies with more mature products) do not have models that fully incorporate physical effects that impact system capabilities (Compton scatter, for instance). They do have models that are used for system design and to estimate system performance at some level of fidelity, but I do not think that these models are robust enough that they would use them to simulate test data to do a ROC analysis of system performance – they collect a bunch of images of bags to do that. Asking for a full model of a mm-wave imaging system may be a tall order. The point of the model is more likely to be to ask the question, in the best-case scenario (parallel layers of textiles), how much depth resolution can I hope to achieve using frequency range A vs B, or how can I solve some of the geometry-related questions? Critical to these models will be data on material (benign and threat) using these probe technologies

c) Reconstruction algorithms

I think that the only reconstruction discussed was the PNNL/L-3 holographic work. The other imaging systems collected data using voxel or surface sampling techniques. Smiths did not discuss their confocal approach to mm-wave with enough detail to know if there is a place for additional software.

What about a combination of the holographic reconstruction and iterative ROI reconstruction over anomalous regions? Could shape be determined better? Could the speckle type interference from sheet-like dielectrics be resolved, or used as a threat-material signature? An advantage working only

over an ROI is that the processing time may become reasonable; the location of the sources (antennas) is well known in these systems; the initial recon defines the location of the reflector fairly well (I think that is true – since they presently do not really care where the person is in the scanner this information may not be preserved). Could a better job of threat ID be done?

d) ATR

We have a great start with the SNL data set, and DHS should be applauded for making the data available. Engagement of the academic community on the AIT ATR problem will be a reality more quickly because of the lessons learned in the earlier workshops with distribution of EDS data.

I think that the definition of the problems for these data is much less mature than for the EDS community. We did not hear about the corner cases, for example.

The SNL data will soon be shown to have limitations; that is inevitable. We need to start thinking now how to collect more data and perhaps better correlated data. Could this be done with at universities with volunteers? Do we have sufficiently robust simulants that can be used? Do we need to go overseas t

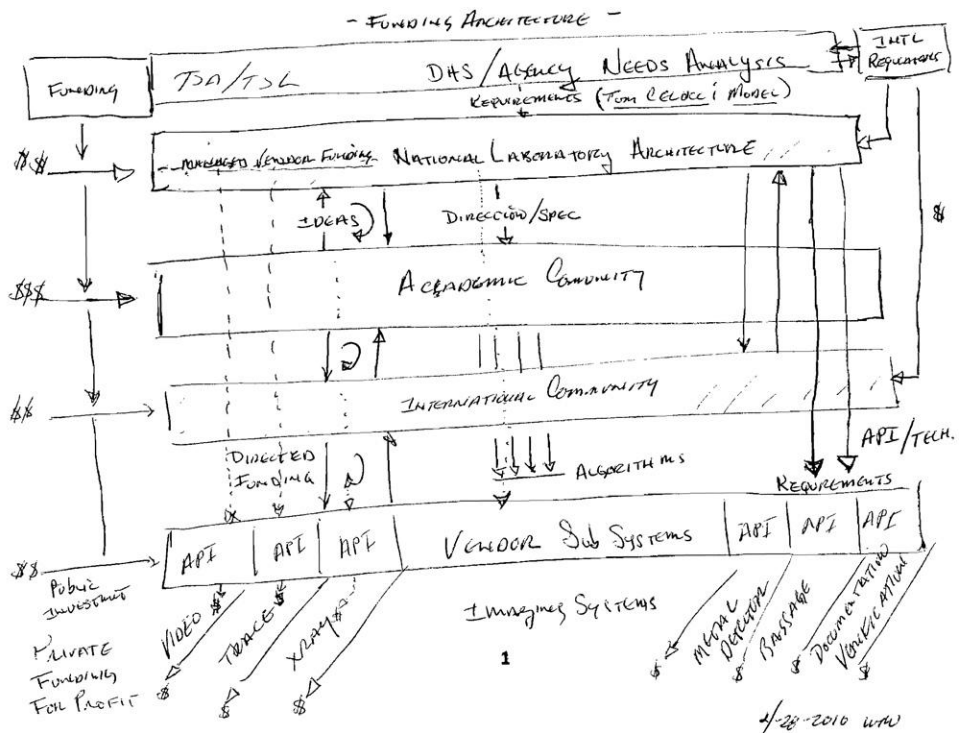
e) Sensor and data fusion

See “a” above. That really is not fusion, but I do not think that we discussed other fusion opportunities. I think that we need to look at the signature level, or perhaps the observable level, to really ask about fusion.

f) Other

The National Academies report that was provided on the CD recommends that study be done to understand the signatures of threat and benign materials for mm-wave and THz systems. The strengths of these signatures, and the corrupting components (wrinkles, water, thickness, etc.) need to be understood and incorporated into any modeling or understanding of system analysis or fusion.

Response DD:



a)

Customer

	TRACE OPERATIONS	Image OPERATIONS	METAL OPERATIONS	STAND OFF DETECT	BIO METRIC
TSA	X	X	X	—	—
EU	X	X	Y	X	X
Commercial			X		

b) Local value for vendor – more important when mixed source, Pd & Pfa variations are modeled and those feed into data fusion algorithms as companders and scalars to build a fuses sensor “threat index”.

c) Yes, but done by the vendor under the control and requirements of the overall architecture with funded support for the national labs to coordinate activities above and below the API line.

- d) Same as “C”.
- e) Ideas from academia, matched by national lab to agency needs. Direct funding from DHS for performance/algorithm improvements. Below the “API” line by private vendor.
- f) Ideas from academia, matched by national lab to agency. Requirements causes direct funding from DHS for performance based improvement below the “API” line by private vendor one specific system.
- g)Support and fund both vendor and academics under an over arching architecture.

Question 2. *What information and material would you need to develop advanced algorithms for AIT?*

Question 2 Responses:

Response A:

More resources. More government funding would definitely help.

Response B:

- I would need a clear thorough sensor model, geometry information, and calibrated data.
- Could potentially be from a test-bed system that does not exactly replicate the performance of any commercial system.

Response C:

More datasets collected and detailed like the one(s) Jortner @ Sandia is collecting.

TSA/DHS should fund, collect and publish these datasets.

Response D:

By far, the most important thing is to facilitate 3rd party algorithm of image data sets. In spite of the commitment made at the workshop, I don't see that this in process. The planned limited distribution of the sandia database is an example of this.

Second, the government should setup several experts in the various areas (modalities) to give advice to 3rd parties with interest/ I'll be glad to serve for x-ray backscatter. Dave Sheen would be sad for mm wave.

Response E:

Reasonable true-negative context for each modality. Don't forget the context!

Response F:

ATR

- labeled data that captures the underlying variability
- vigorous performance evaluation metrics/tools

Response G:

Relevant data to work on would be useful.

Response H:

I would assume access to equipment, test images and detection requirements.

Response I:

Proprietary information about sensors and system designs is important and needed.

Response J:

From my point of view, we need to first understand the modeling. People like me have to first get a training how data is collected. Just having the data (if possible) is not enough. The bottom line is that some of us have to give our full commitment to this problem. The problem is so much complex and specific that we have to fully understand the system before we can use our expertise substantially.

Response K:

Standards / requirements for advanced algorithm development.

Response L:

More data, and better connections to organizations with aligned interests.

Response M:

Valuable information that are highly desirable are information and raw data pertaining to the environments of interest including threat targets and environmental clutter. Other desirable information will be listing of operational constraints, the essential capabilities, and the desired capabilities.

Response N:

Something akin to the EDS certification kit, as well as images obtained with the standard kit.

There needs to be a standardized set of targets. This is the problem statement. Then, ideally, there needs to be a standardized set of images.

This is a structure that may exist already, in the TSL qualification program.

Response O:

- Lack of feelings getting involved;
- Lack of feelings making greater contribution to the workshop.

Response P:

Image simulation tools would be helpful to reproduce the image formation and processing chain in current commercial AIT systems (Flexibility to process raw data through AIT simulator). These would enable innovative and rapid response algorithm development, collecting raw and intermediate data so even as algorithms evolve the data sets can be reused and just reprocessed, modeling threats/targets to save on data collection time and cost. Could also be used to develop algorithm performance estimates for single sensor and fused (multiple) sensor algorithms.

This approach would give the algorithm developer options to adjust processing algorithms used to generate the processed image output (smoothing, sharpening, noise reduction, interpolation, etc).

Need a robust data set for tuning advanced algorithms. Data should include robust set of non-threats and threats in various environments, threats, situations, people. Very time consuming and costly to collect this data set but would be valuable for evaluating new algorithms for performance.

With the AIT system simulator provided by each vendor (not the guts of the algorithms themselves so as to protect their IP but to allow for some options for tuning the processing algorithms used to generate the final image) as AIT systems and their algorithms evolve, you can update the simulator in parallel and then simply reprocess the RAW data collected through the large data collection event. This helps the government rapidly evaluate new algorithms and new AIT systems.

Response Q:

You would have to know the details of the imaging equipment and the physics involved.

Response R:

The most significant obstacle to AIT is access to information. Because of privacy issues, it is not possible to collect operational data for AIT. The number of test images is very limited and represent test cases that are for the most part “canned images” that do not necessarily reflect the complexity and variety found in real life scenarios or even realistic terrorists scenarios (putting a threat. The image capture exercise performed by DHS is a step in the right direction, but it is not going to be enough and will need to be repeated somehow. There should be a way to access some of the field data to get more exposure to real-life problems (this could be done by denaturalizing the images and making sure there is no way to associate the image with its origin). A simulator would also be highly beneficial at generating more test cases.

Response S:

Vendors need better access to qualified products. A number of vendors, as well as representatives from academia, expressed concern that they felt like they were unable to compete with system vendors for development funding because they don't know how to get their algorithms into the operating environment.

Response T:

- Cooperation from sensor manufacturers to access their images or access to images through DICOS is critical. Receiving the full set of data from the manufacturer before “improvements” are made to the image(s) mitigates the need to later remove artifacts such as white and black pixels around edges that were created for human perception.
- Funding for algorithmic development.
- Clear set of criteria defined for developmental success including performance levels.
- Access to the “real” materials to be encountered at airports or other scanning facilities. Guardian initially developed its algorithms for detecting threats using TRX machines and simulants specified by TSA.

Guardian then discovered that the signatures of the simulants recognized by its developed PinPoint product bore no resemblance to real explosives. What is valid for human perception is not necessarily valid for ATR algorithmic development.

Response U:

Additional data sets that include the full 3-D information. Also, funding to acquire next-generation mm-wave data sets in the laboratory.

Response V:

For all modalities, real image data needs to be provided. If this is not possible, volunteers or paid travelers at the check-point must be implemented to gather the data. Without real data, it is very difficult to develop algorithms for reconstruction and ATR.

The required detection and false alarm rates required for the check points.

The required minimum number of passengers per hour through the check point.

Response W:

A comprehensive database of images. Current database being developed by Jeff Jonter et. al. (Sandia National Laboratory) good step but still needs much more data.

Given algos are anomaly detectors (two class problem) also very important for this database to contain many examples of people without hidden threats. Can't remember if this database has any/many examples of this. If not it definitely needs it.

Following completion of a comprehensive database of images and some initial test results, a detailed requirements spec with which to further develop and enhance algorithms.

Response X:

An honest assessment of the limitations of these technologies.

This applies to the labs, the academics, and the vendors. Taken at face value, the ATR problem has been solved for mm-wave, the subsurface threat ID has been solved with THz, and, the body cavity ID with NQR. Some honest info

about the capabilities and pitfalls of these technologies is necessary in order to advance the conversation. It seems like we all acknowledge that there is no silver bullet but then take offense when the limitations of our pet systems are discussed. At a meeting like this, we need to be more open about the warts. Warts may not be vulnerabilities.

Response Y:

Each AIT vendor would develop the unique AIT algorithms associated with the specific vendor/product that is in line with the DHS/TSA requirements as filtered through the national laboratory architecture pushing up through the “API” northbound interface a standard dicos & XML files.

Question 3. *What issues would be barriers for you in participating?*

Question 3 Responses:

Response A:

- Security clearances could be an issue (I am Canadian a green-card holder)
- I would need funding for a student.

Response B:

Need to keep control of IP to ensure future profitability.

Response C:

Many people in the workshop underestimate the ability of manufacturers to work together. There should be no expectations that competitors can collaborate on these issues.

Response D:

- Data availability
- Con-ops understanding
- TSL/TSA view needs clarification

Response E:

IP issues

Response F:

Lack of data

Without data we can try to develop algorithms, but we'll have no idea if they're of any use to anyone.

Response G:

The ability to provide classified material

Response H:

- Access to data
- Funding

Response I:

- Funding possibilities
- Open and fair grant application and review process

Response J:

Vendor not willing to share their data.

Response K:

Proprietary information/data thus reluctance to share.

Response L:

Barriers include tighter connections with organizations that have closer ties to the application and instrumentation, and of course, money.

Response M:

Funding is the primary barrier.

Response N:

- The informal, interactive atmosphere
- Opportunities to meet people in both academic, government, and industrial settings.

Response O:

We propose an Open Architecture with Open Business Model OA/OB approach but it may not be favorable to AIT sensor companies and protecting their IP. Need to balance their IP with enhanced data processing and development capabilities that are possible with things like an AIT system simulator, collecting and distributing raw and intermediate data, integrating algorithm outputs, and integrating sensor outputs with other information in a larger Security Architecture.

Response P:

No funding!

Response Q:

Any participation in such program needs to make sense from a business point of view. We will not participate if it does not lead to potential (short term or long term) revenues or jeopardize on-going product development. Furthermore, we have no problem licensing applications but would be very reluctant to release our rights to our IP since this reduces the value for our company.

Response R:

- Closed and/or proprietary systems.
- Lack of proper suitability/clearances.
- Lack of funding.

Response S:

- Lack of funding
- Lack of access to image data
- Lack of road map and time frames for implementing developed process as a product

Response T:

Lack of actual images taken from the sensors.

Running into classified or business proprietary information in trying to solve the problem.

The inability to publish any articles on the topic.

The short term around time required by industry for a solution thus eliminating Ph.D. and post doctoral students.

Response U:

- Time.

- Grant please.

Response V:

Access to data. That is being worked.

Learning which system limitations are engineering constraints and which have been shown to be fundamental (physics) constraints is a barrier. Engineering constraints include keeping the system cheap enough to sell as well as limitations that TSA or regulatory agencies may impose. There are no antennas on the floor of the mm-wave system or scatter detectors below the backscatter detector because ... no reconstruction algorithm, no signal, added expense, all of these reasons?

One of the problems that we seemed to bump into here (and in ADSA2) was the audience saying “Why not do this?” and the vendors saying “Yeah we tried that once” but we never seem to get to the why.

Response W:

- The IP of vendors must be protected, public domain is the large concern for vendors and DHS/TSA and national labs.

Questions? – Do we give away our hard fought IP for free to other groups and other countries as well as potentially to the “Bad Guys”?

-Focus is too much on funding academia without focus by the real world problems that DHS/TSA and vendors struggle with.

Question 4. *What do you like about this workshop?*

Question 4 Responses:

Response A:

Bringing together a diverse enough group of experts.

Response B:

Ability to network with a variety of academics and industrial representations.

Response C:

- Vendor presentations
- Meeting other vendors

Response D:

- Open discussion
- Participation from the three parties

Response E:

Liberal atmosphere allowing for real brainstorming.

Response F:

Good opportunity to network. Good instructions at the beginning of the workshop to be outspoken.

Response G:

Give-and-take

Lots of questions

Lots of time

Very-few shutoff

Response H:

Open and engaging discussions.

Response I:

The structure was really nice

A nice overview that branched into the individual details helped get it focused and then led into a nice summary in our respective specialties.

Response J:

The discussion of issues.

Response K:

Good presentations and open discussions.

Response L:

This was the first time I was introduced to this problem. The workshop gave me an opportunity to further explore the topic and perhaps look on this problem in my future research.

Response M:

Made the security community aware of the problems/issues faced, goals (near & long term), well- organized, networking ability, food, materials.

Response N:

I learned quite a bit about the basics of whole body imaging.

Response O:

I very much liked the broad spectrum of participants. I do not like the seating arrangement. It makes face to face conversations more difficult.

Response P:

The context of a moderately small meeting with encouraged open-discussions was good. However, open discussion should be scheduled as opposed to colliding with scheduled presentations.

Response Q:

The enthusiastic discussion and promotion of it by the facilitators. Participants, for the most part, are all interested in solving the technical scientific challenges. - - -All good intentions.

Informational and good to hear from the perspective of several vendors, Govt entities, and academia.

Response R:

It was a very informative workshop and it showed how some groups have made advancements on important technology that will potentially be useful at the checkpoint.

Response S:

Very information; great collection of people and ideas.

Response T:

The most significant benefit from such workshop is the networking opportunity (Industry, Academic + Gvt). This particular workshop also helped to learn more about some of the AIT specific technologies that are not necessarily well known.

Response U:

It received better responsiveness than a general Gov't inquiry. Academics especially got the opportunity to voice concerns about how to get on-board with Gov't development efforts.

Response V:

It was helpful in the following ways:

- Interaction with others in the industry
- Identification of needs by DHS
- Opportunity to focus our company's algorithmic effort
- Possible partnering relationships

Response W:

I think this workshop was very effective for networking. A multi-disciplinary group of highly intelligent and skilled researchers was assembled to examine these problems, and the discussion was very interesting.

Response X:

A large amount of information presented but not enough time to explore the details of the information.

Response Y:

Mix of people and expertise.

Response Z:

The free-for-all discussions were good.

Response AA:

Very interactive, good food! Great chance to network!

Question 5. *What would you like to see changed for future workshops?*

Question 5 Responses:

Response A:

There must be at least minimum time guaranteed for all speakers. Afternoon speakers were reduced to a small subset of the slides they prepared due to the time used by morning speakers.

Response B:

A little more willingness on the part of the industry to speak candidly about challenges.

I think there is a way to address these issues without sacrificing competitive advantage or security.

Response C:

Please stick with agenda, it's good that we came back to agenda in the afternoon of the first day. [There was a comment made that the agenda does not matter]

Response D:

Suboptimal facility: bad acoustics, poor audiovisual

Need more structured and focused presentations which was largely a function of the actual presenters.

Workshop needs more structure/guidance throughout the process, moving it along.

Response E:

Too much time allocated to fringe technologies—ultrasound, IR, etc. The community needs focus.

This was a workshop on algorithms, but the only presentation that was on this topic was Dave Sheen's. Far too many off-topic presentations and discussions.

Response F:

I wish I understood Carl's directives better (any fault) (???)

Less grandstanding.

Response G:

Research

- Staying on schedule (or planning additional discussion sessions)
- Give out a structured template (few slides) for presenters to use so that the discussions stay on topic. Add on backup slides if time permits.
- Maybe we have a fixed set of questions at end of each session that the group has to answer.

Response H:

There is a total disconnect between this group and TSA operational needs. A lot of what is being discussed does not jive with the needs TSA has for checkpoint operation and our current requirements document.

Response I:

- Better adherence to time
- If vendors are going to talk useful info important
- More time to talk offline

Response J:

Presentations from academics about what they have and what they can offer both in long and short term.

Response K:

More technical presentations. Many presentations looked like marketing the product. Probably reduce the number of speakers and invite more technical individuals from the vendor's side.

Response L:

List out before the meeting/sessions the goals and/or objectives expected to meet at the end of meeting. Keep a flip chart or something to note issues that can be “coached” or “tabled” for later discussion so not hold up the flow and put the meeting behind schedule. Coached or tabled issues can be covered at the end of the meeting or another session.

Ask participants beforehand what they would like to discuss or resolve, then publish prior to meeting so to give time to others to think about it and prepare to answer.

Response M:

I’d like to see the opportunity in future workshops to have a classified component so that the appropriate/authorized individuals can share more as appropriate.

Response N:

Somehow the benefits of open-forum discussion need to be reconciled against pursuit of a structured agenda.

For example, there seemed to be a near-unanimous agreement that non-US scientists can and should contribute to US security work. However, few in the audience are in any position to address the problem, and too much open-forum discussion time was spent on it.

Another problem is the issue of classified material relating to system vulnerabilities.

It was awkward and inappropriate for some of the participants to encourage folks who lack clearances to speak openly about the vulnerabilities. Although such encouragement may be technically legal, it violates the spirit of the rules pertaining to the protection of classified material.

This issue needs to be managed differently.

Response O:

The workshop size is fine.

The audio system; Anyone asking question/answers should use the microphone.

The day seems too long, may be shortened a little bit.

Response P:

Believe several of the obstacles discussed are actually issues which the Government agencies can and need to resolve before the workshop. Government can solve the security and policy issues. Should do so in order for the workshop to progress much more effectively.

Response Q:

Continue to present the advancements in the hardware development.

Response R:

- More openness on issues that do not seem like they are really security issues
- Esp eg acceptable secondary screen rates, and related issues to FP
- And more openness by vendors, consistent w/ their need to keep IP etc private

On logistical issues

- Use room w/ better acoustics or get more mics
- If speaker had clip-on mic, they could move to the screen and still be heard
- Putting several PPT presentations on one memory stick might save time in the transition process

Response S:

We need to find a way to talk about current shortcomings of existing solutions and actual R&D requirements.

We need more opportunity for networking.

A second wireless microphone would have been useful...

Response T:

- Limited breakout sessions
- Dedicated panel discussions
- Focus on one concept (for instance, vendors might benefit from having a round-table discussion on CONOPS or sensor fusion).

Response U:

Break out sessions in small groups for discussion then returning to the large group to integrate ideas. The large group appeared to limit input by many people.

Response V:

In light of the focus on group discussion, I think that the presenters should be given specific instructions to show only their most provocative data and/or ideas, and then go to group discussion. Most presenters, myself included, had prepared 30 minute talks (without leaving much room for discussion). Limiting us to 4-10 slides, would make the preparation easier, and would allow for more technical presenters while preserving the important discussion.

Response W:

Reduced the amount of material covered in order to arrive at a plan of action. Presently there is too much information presented and there is not enough time for a constructive discussion and action to be taken.

Response X:

The funny rule about certain people not being able to start conversations about specific topics due to clearance issues, but being able to talk about them if someone else starts the conversation first.

Quite a demanding timetable for a jet lagged person.

Response Y:

The free-for-all discussions were over the top.

This is a really hard one to regulate. The concept of the open and wide-ranging discussion is great for this type of meeting. I think this worked better than the break-out sessions did in ADSA1. However, It is a bit annoying to put together a talk and not be allowed to give it (how would I know; I was the only one to get through my slides).

I have not been able to participate in a meeting of this size that successfully, interactively put together a list like Doug and Carl mentioned a number of times (what are the research priorities, what are the specific problems for a,

b, c). The meetings that I have been to have had focused breakout sessions that presented results on a specific topic back to the audience and then had a feedback session.

Another approach might be follow-on web-based meetings. Launch the process by getting a large group together for a couple of days. Follow up with short 2-4 hour web meetings with a couple of presentations and discussions. (I think that these meetings would require a moderator and better use of the web-based interactive tools than I have seen in the past).

Response Z:

- 1) A closed session for SSI qualified individuals.
- 2) Closure of a targeted funding approach.
- 3) Not much discussion of the passenger/public as a respected group, what Techn is acceptable, safe, protects privacy, non-invasive, operationary practical.

Question 6. *What topics would you like to see addressed in future workshops?*

Question 6 Responses:

Response A:

Participation of TSA. We would want to see specific requirement and criteria one could pursue.

Response B:

Better programs for matching specific vendors with specific academies and third parties.

Response C:

I would like to see some performance statistics for ATR - Pfa, Pd presented for anomaly detection. If vendors do not present this, academics should present this data.

Response D:

Image quality assessment in the context of task performance.

Response E:

- Algorithms- what works and what doesn't.
- Field and test results – ROC curves, reports and acceptance/unacceptance from 3rd party testers
- Methods for conducting tests of algorithms—preparation of databases

Suggestions:

- Develop and make available a databases of images (without this, all else is meaningless)
- Recruit several experts to serve as advisors to potential 3rd party advisors (myself, Dan Sheen, etc.)
- Solve the problem of not being able to discuss SSI within the group (or data that the government mistakenly believes is SSI)

- Focus the community on approaches that have a chance of being successful. Stop spending time on techniques that have failed for decades.
- Keep in mind the two main complaints that industry usually has with University research: (1) they don't know the history of what has happened in industry, and want to reinvent the wheel, and (2) they want to conduct broad research, instead of focusing on the specific problem at hand.

Thanks for letting me attend the workshop!

Response F:

- The actual (written) industry concerns, pre-collected.
- The actual TSA con-ops presented by TSA do-ers.
- Direct dealing with jurisdictional issues.

Response G:

- Focus on areas of research needs in the field
- (Learn from NIH) Form workgroup composed of DHS, industrial and academic members to work on RFP (request for proposals) for proposals similar to those in NIH SBIR, STTR and BRP mechanism
- Open and fair review process for proposals

Response H:

Explosive detection, spectroscopy.

Response I:

What came out from the previous meetings – updates (who connected with who (e.g., collaborative efforts), visits/interactions, publicize opportunities to community (i.e., BAA).

Response J:

Perhaps it would be good to have break-out groups on specific technical topics.

Response K:

I would like to see case studies being presented so that we can learn more effectively what works and what doesn't.

Funding opportunities/announcements

I would like to see less "commercial" type presentations that are not technically informative and make less contributions to the community in the R&D community to advance the technology.

I would rather see presentations from vendors that have technical contents with "normalized data."

I would like to see presentations of recent research results in this front.

Some survey/comparison presentations

Response L:

Thanks for inviting me to the workshop. It was interesting and potentially very fruitful (made some good contacts for possible joint development).

As promised here are my thoughts about algorithm development opportunities for AIT:

In my opinion most of the work should be aimed at developing the fusion of multiple types of AIT and other sensing technologies. This fusion can take advantage of the internal results of the various scanners which may be images, volumetric data, decision of internal ATR etc.

Such opportunities can be made possible to anyone with a bright idea via proper standardization efforts. My vision is that each vendor, as a requirement, will have to supply an output interface to the external system integrator. DHS, if they choose, will be able to fund such integration efforts. Such standardization will have to take into account data formats as well as appropriate definitions of communication protocols which will allow to practically combine components into a single, more comprehensive, solution.

The other, most obvious type of opportunity is direct interaction between vendors and external developers. Any party of two or more sides that come up with a good idea for improvement via algorithm development should be able to easily pursue it. By "easily" I mean – with (financial) support from DHS.

Response M:

This summarizes my thoughts.

- Greater emphasis on automated ATR/fusion algorithms.
- Some time devoted to discussion of the problem solution at a level or two above the sensor - -if we cannot solve the total problem at the individual sensor/device level, then how can we integrate at the next level to increase the probability and address the risks

Response N:

More on reconstruction algorithms –more on algorithms themselves. More discussion on video. And more discussion of psychoanalysis.

Response O:

We need to share more ideas related to technology that target process improvement and process automation rather than just threat detection. The integrated checkpoint is one part of the equation, but there are a lot of other smaller initiatives out there that could be highly beneficial to help improve process efficiency and reduce operating costs without jeopardizing security.

Response P:

Help in understanding DHS funding procedures and gaining knowledge about programs where we can work more closely with TSA/DHS in our efforts to solve some of their problems. Additionally, setting up mechanisms to assist TSA in their evaluation of proposals and supporting efforts for teaming among different companies.

It was suggested that there be follow up meetings via phone/some other link to keep updated on topics. It would be helpful to have that ongoing info from TSA so we might keep abreast of their changing needs and requirements and to discuss how we might all work together to accomplish this task.

Response Q:

I would like to see more focus on improving the systems in general, without as much restriction to just ATR and algorithms. I think government funding is important for system improvement, because a long term outlook is necessary. Vendors necessarily have to focus on selling current systems, and cannot devote resources to systems that may be practical 5+ years from

now. Government funding would allow development of new ideas that may mature into the next system.

Response R:

Check point concept of operation.

Review of the parts of explosive detection algorithms to see if improvements can be made in any of the areas. This may require a series of workshops.

Response S:

A workshop on developing counter measures for specific limitations in current scanning operation and technology. 'How can we beat this machine and what can we do to fix it?'. It would seem that currently anyone with a working knowledge of the scanning technology being used can smuggle threats on to airplanes.

Response T:

Classified discussion of real problems and how we can abstract these for the external community?

Discussion of the SNL data (if we all signed the NDA could we show a bunch of images and potentially ATR results?).

Focus on either short term or longer-term goals of this process.

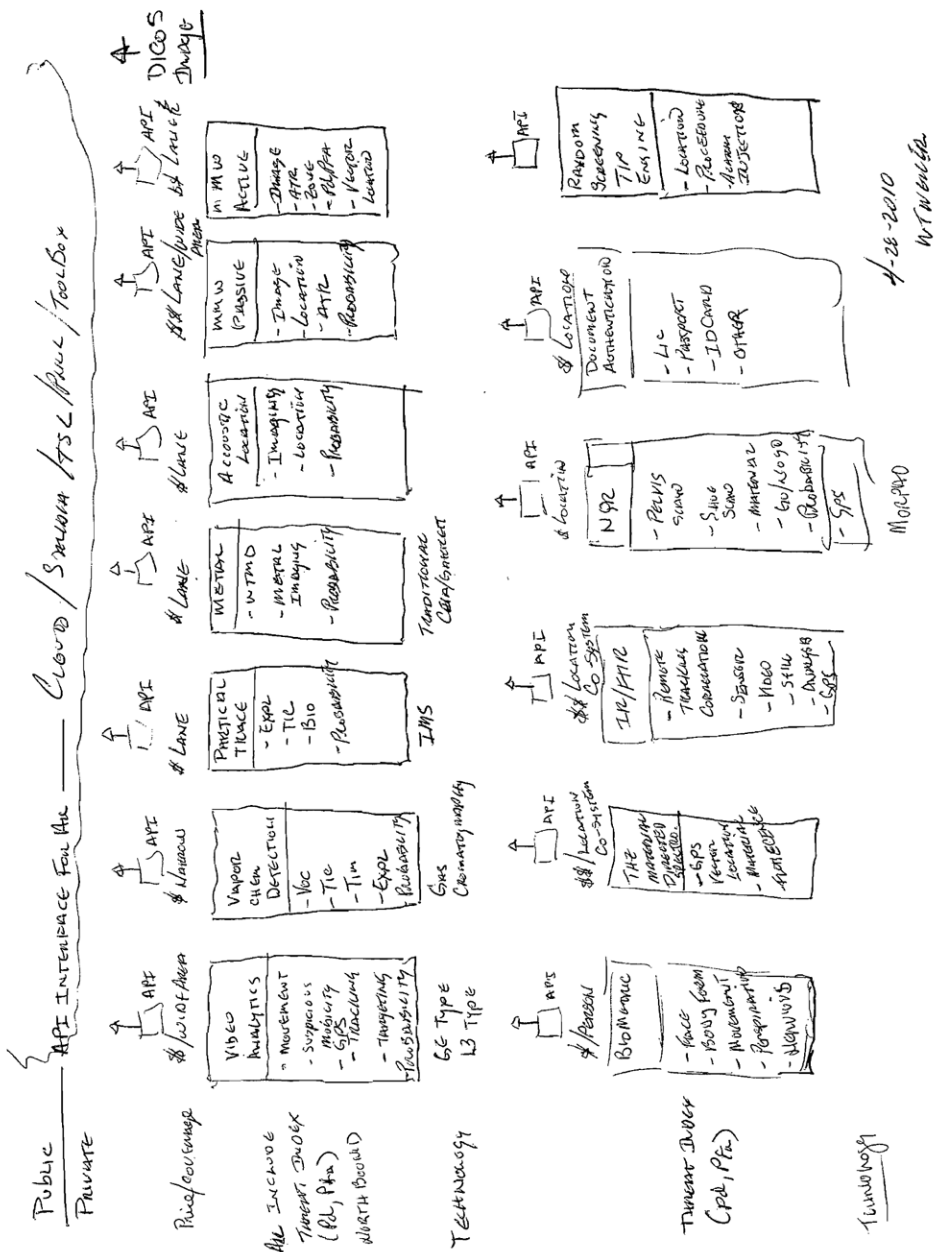
Response U:

1) I would like to see an architecture developed as a structure on which both vendors, academics and gov't organizations can build on.

2) See figure below for architecture details.

3) Horizons developed like the Honeywell model, where are we going. (Horizon 1: 1-2 years; Horizon 2: 3-5 years; Horizon 3: 6-7 years).

4) Layered funding.



18. Appendix: Minutes

18.1 April 27, 2010 Minutes

Introduction:

CC: Welcome. We're here today because terrorists are smarter and trying to take down our planes. We need to gather smart people in a room to find a solution. Bottom line: Find advanced algorithms/participants to find explosives concealed on or in people. How to detect it, how to do it non-invasively, how to do it without inconveniencing the traveling public. DHS needs to know what technologies to invest in, how to invest. For those of you with a clearance, this meeting is in the public domain. Anyone else can talk about whatever they want. This is an informal meeting, a workshop to stimulate conversation. You are all obligated to ask questions of anybody at any time. People sit here and don't talk and we fail. This is a loose agenda, so keep asking questions. Thank you for participating.

MBS: Be provocative. Be incisive. Try to get at some of the phony issues that bother you intellectually. If it's off the wall, ask us anyways. Engage us, ask 'what next? How do we really solve these problems?' One thing that has to be very clear as an axiom – there is no one silver bullet to solve. Multiple modalities, different disciplines. We need to respect that and encompass that in the strategies that we engage in, a successful WBI strategy is not just technology, it's awareness of what's going on. ALERT is the host. We look forward to creating linkages between academia/industry/govt labs/govt agencies, that encompass but go beyond DHS. A global community of those interested in the problem. This is just one event, but it should be a kicking-off point. Let's crack this problem wide open. Thank you.

DB: It's my pleasure and privilege to be here. Points to emphasize: It is true that the events last Xmas had important effect on way high level govt is viewing challenges, particularly those of people arriving at checkpoints worldwide. Aircraft Security Enhancement Program (ASEP). Partnership between DoE/DHS. Systems aspects associated with variety of sensors etc. Third component is related to advanced technologies, particularly screening, that safeguard against threat while allowing for flow of commerce. Even though we have been allowed to develop 5 year plans, too often it leads to – personal observ.- I am seeing the same stuff warmed over served up. This isn't going to do.

I think there is an openness and a willingness to research if demonstrated, we need 5 year plan, lurching toward the immediate doesn't do justice to

complexity of the issue and the approach required. Help us fill and describe and articulate the kinds of fundamental issues we have to address and resolve. There is much we do not know yet with AIT applications. We are very weak in diagnosing anomalies that we detect. How can we reasonably project automated threat detection, when we don't know some of the basic physical principles underlying what we are looking at when someone passes through a checkpoint?

The easiest thing is for us to come together occasionally and anecdotally, but Carl has emphasized from the very outset that what we need is an ongoing conversation . Unless the conversation is continuous, we run the risk of having creative ideas in image processing etc. become marooned concepts not tied to an actual technology realization strategy. I am hoping this will be just the first stage of talk between people in different professions and different responsibilities to discern threats and non-threats without disrupting commerce. There is a poverty of new ideas, and we're asking you to make that creative input so that the government invests your money with some degree of sensibility and not just the momentum of inertia. We want to capture your ideas and embed them within a sensible five-year strategy. Thanks for being here.

Tom Ramsey (Guardian): Are there going to be changes that you see in terms of how we can communicate at the same time with government at all levels – private sector. Is there an opportunity for more continuous conversation to create an opportunity for ideas to move forward?

DB: We hope so. The kind of forum we are having here and in previous workshops can hopefully occur so that those who are in acquisition responsibilities (TSA) can have a better idea of what is possible now/3years/5 years. We take at our peril assumption that there is very high technical expertise in government. Therefore, part of your task is educational and tutorial. What is possible/ What are the capabilities, and what should be our cautions? That teaching role can only be accomplished if we're working at multiple levels. The CoE concept is a jewel in our crown, not only because of their research, but because they're educating a generation of young people. How well that's done and how explicit and shared that conversation is will affect not just us, but the rising generation. If you have ideas on how to make that richer and better, please let us know – I am sure that Tara O'Toole will be very interested.

CC: Any comments to the ~10 students in the room?

DB: Good. Outstanding. We had a SAFETY web conference last week (Friday) and what was thrilling about that WebEx was that we had both professors, grad and undergrad students involved in that work. We don't want such a stratified base of communications.

MBS: You know, we could do the same thing with creating the kind of dialogue that's happening right now. Once a month, say, 2 hour WebEx that creates an interchange, that might be something to think about in terms of getting industry/nat labs on table, as long as it's easy, we might be able to do it.

DB: Unless you've got vendors talking with people in the trenches, it won't work.

MBS: Ongoing, one-offs don't work.

John Beaty: It's my job to be industry liaison. I'm interested in the commerce of ideas. If you have an idea to promulgate, I'll do my best to help you find contacts and opportunities. That is our mission. We try to find these and bring things together and make them happen. If you have something you want to do, let's talk about it.

MBS: Any naysayers?

Fernando Quivira: I'm an undergrad student foreigner. As a foreign national, are we able to interact in such a sensitive area?

MBS: How do we not include foreign participation, especially with our undergrad/grad students? We can't restrict, we need an open dialogue.

DB: At 9/11, I was at natl academies. Kneejerk response was to cut off foreign participants. What happens to US research enterprise if you cut off foreign students? Not good, so sensible policies have been enacted to maintain security while enabling access to creativity. If you're telling me that's not working, I need that chapter and verse. I need to know the problem explicitly, and this is not the first time I've heard it.

Jeremy Wolfe: We were working with folks at Logan on screener behavior, I have a lab that represents mostly EU and only US citizens were allowed to look at the data.

DB: Part of our continuing concerns are research, but some of them may be process recommendations. How do we access creativity? Cutting out every foreign student is not a good start. Let us know how to have cake eat it too.

How you can understand and respect security interests while allowing reasonable access.

MBS: And the reverse is true too. We are not the fount of all wisdom, this is a worldwide problem . If we make headway, hopefully we can reach out to the international community. WebEx etc can really bring us together locally.

Whitney Weller: You're also broadcasting intellectuals thoughts on countering terrorist activities to world, including terrorists.

DB: It is a balancing issue, but my experience is that people who set policies may not be aware of all the implications of the policies that they set. It helps us to rid ourselves of the delusion that we are the source of all creativity, which I don't think is defensible.

MBS: These are realistic concerns and we have to deal with them, but we are an open society.

Jose Martinez: This collaboration (ALERT) has been amazing for us. We have been able to develop really good crossing techniques and foster international participation. I am a permanent participant but from a different country, and I think that the global way of work is producing amazing results.

DB: Can you and Carey tell me how you threaded the eye of the needle, to involve students without running into red lights?

MBS: DHS was critical because they linked the international program and funded us under that. This was really an overt action by DHS which should be bigger, maybe.

DB: We have a lot of international flyers, but I'm not sure we're connecting at the worker level with people who are doing actual research.

MBS: Justin Fernandes (grad student) is a case in point, he flew to Germany (with Jose/Carey) to work on research.

JM: I think Michael and Carey deserve a lot of credit for getting intl on board.

CC: I think something to recognize is that DHS is a relatively new organization and I ask all of you to be patient in this process. It's growing and learning how to do this, funding etc. The goal is to identify barriers and break them down.

Ron Kikinis: You're not the only agency with this security problem, have you talked to DoD etc about the solutions they have found that may be applicable with slight modification?

LP: We're all aware that other agencies have these same issues and many of them have worked through them. We have been looking and talking to other groups. It's really good if you can give us feedback on the kinds of issues we're working through, but it is a work in progress and we do try to do outreach with agencies.

WW: There are TME agreements DoD does in case you have to work internationally, where you describe the problem and they approve it.

Carey Rappaport: I'm the academic organizer of this workshop, although I don't really have any responsibilities! This is the third of these workshops – the previous two were on baggage screening. The problem with these objects is revealing what's inside. There are going to be a number of perhaps unusual or unexpected characteristics in objects we are scanning and screening. Some non-obvious issues will be addressed. (SLIDE)

I caution vendors not to present what is essentially a marketing talk. This is ADSA03, there will be an ADSA04 and so on, to the extent that you can talk as openly as you can, we appreciate it.

There are ways of solving current problems, but it's the next problem we want to deal with. Anomalies in bodies are a really challenging problem, and it's the next problem we have to anticipate.

Carl Crawford

(SLIDES)

RMoore: Is there anything we shouldn't discuss?

CC: No.

JB: We should mention that we live in a measure/countermeasure world at this point. I think that the Christmas bomber proved it by the location and his demeanor. The next easy step is what will occur. Their job is to make it expensive and difficult for us. Thinking about one single sensor is a non-starter, we are being too mundane, we need to talk about tomorrow's problems and the problems afterward.

Chris Boehnen: There's a lot of issues that weigh into trying to address this next problem of explosives in body cavity. Ethical, technological, feasibility, comfort level. They're issues that technology plays a role in, but guidance

from DHS/end user in this area would be helpful. Myself and I think a lot of people in this room would appreciate that guidance.

Patrick La Riviere: It seems sometimes that the political will in this country is to spend money only to address the threat that just occurred. No will to solve hypothetical threat.

JB: If you have an idea, there is sufficient communication within this community to help you find the resources to solve the problem. What is the CONOPS to solve that problem, or the sociological problem?

PLR: Do you think the public would have stood for WBI without the Xmas threat?

Suriyun: Depending on the situation, it has been shown in other places to be successful.

CC: There's women all over the world who get dosed annually by Xrays for screening purposes.

Jeremy Wolfe: Yeah, but one of the major issues in the medical community right now is how to cut that dose.

MBS: You go on a plane to Europe, everyone accepts radiological dose. I think if the solution is reasonable and realistic, people will accept it.

DB: I think it's important for us to remember that we're a common-law country, and part of the reason that we have this conundrum between technology and its capability. When civil liberty cases are brought, have to weigh security interest vs privacy infringement. As we develop technological capability, we should look for the very best capability we can get, and then if a suit is brought, bring it, we'll defend security interest, and then that case law will be the legal policy, not any declarative judgments that you can get up front. It is true that we see very elastic notions of where that balance is. People have a different view of where to draw line dependent on currency and relevance of experience. We won't get the performance of threat detection if we back off. If we are running into problems with conflict of values, let that be played out in court under clinical facts.

Chris Wald: There were over 6k publications on radiation exposure etc. Bear in mind that anything that uses radiation faces an uphill battle.

RM: I'd like to second what you said but also add to it. It's an uphill battle with regard to perception, not to risk/benefit ratio.

CC: Want to deter people from trying. Fusion Assumption-no single modality will be solution.

DB: Fused is a catchy phrase but I'm not sure bureaucrats understand it. I hope you will help us fill out agenda in applied mathematics to get better solution than any one solution will offer. Basic research issue is from fund. Science basis. What are attributes of complimentary system. I would like to see the agenda filled out. I want to see your thoughts about fund. Sci. applied mathematics solution.

MBS: Mutual science-??? Medical systems started to do this (optical helps xrays tell more about breast image.) One system helps the other. I think that is what Doug is getting at. It develops a strategy for multiple modalities.

Gen. Dynamics: L We have potentially much more cooperative scenario. There are different scenarios for fusion (report fusion vs. someother type of fusion).

CC: Answer question: vendors here selling

Gen. Dynamics: Get multiple modalities working on single platform. Not possible here but do it at post diagnosis level.

?: We have found coincidence imaging using learning ??????????

MBS: One issue, if you are going to do effective fusion, the fused system needs to know all details of subsystems. This is where you get closed barriers. Vendors don't want to reveal details but only when they do will effective fusion occur.

GD: There are ways around this. Might not be best.

MBS: Can't have black boxes.

DB: What is recommendation for research to bring ideas over into security area. We want agenda of specific things we should be doing over next few years to bring about fusion and how it can be accomplished. We don't want to lose the points here. Even if you put it in your notes you leave for Carl.

MBS: One point is vendors give details to DHS so researchers would know them. There would be an agreement between vendors and DHS to allow this.

CC: Algorithms-6 types (see below)

Concept of operations for using sensors

Modeling of sensors, probe interactions with targets and clutter sources

Reconstruction algorithms

Automated threat recognition (ART)

Sensor and data fusion of multi-snesor systems incl. adaptive processing

Advanced display including privacy filter

CC: Please keep your focus on these types today. Algorithm definition-recipe to perform a task in scope(in scope)

Implementation is out of scope of discussion today.

CC: Please fill out questionnaire you were provided with. We will probably transcribe them.

We will discuss hardware at a later workshop.

Deliverables: Written report which will be released to the public.

Threat: Concealed (body cavity, etc)

Requirements: They are classified and this causes a problem. It is a job to figure how to desensitise the problem so 3rd parties can work on it.

RM: Heard from vendors-it would be helpful if it was in a format (does or doesn't meet spec.)

DB: Anecdote: Evolution of requirements for checked baggage-false alarms vs. detection. The intention in the acquisition by TSA which is 1 billion dollars that they will acquire the best of both detection and false detection. It is a drive to perfection which is being driven at by the acquisition authority.

Quality of Life Spec.-slide-Terrorism causes loss of life and loss of quality of life

Acronym Soup-slide

Security System Vendors (Slide)

Goal of DHS: Best of the Best-how it will be integrated is out of scope, it will get done somehow

Presenter-Tim White-xray imaging background

TW: Lay foundation for the rest of the workshop is my talk's main focus. Overview of AIT Technologies (Slide) What information about threat material is key to sensor fusion. How do we probe for the material. . It's important to understand the space of the data for the algorithms people. I won't go into vulnerabilities. One thing not covered is body cavity screening. I didn't realize Carl was going to cover this area. Summary Table (Slide) This is to show the scope of what we are trying to accomplish. Trying to fill in the boxes. What signature \are we trying to detection\? Are we detecting an anomaly? All of these detections need lab work but some are matured and ready to be deployed. What is status of threat recognition? Last column. I would appreciate your insight and correction of any mistakes.

??: We already have ATR (I think) already implemented.

CC: People should speak up about strengths and weaknesses. This is the object of the workshop.

DB: Has TSA been looking into deployment?

Whitney Weller: Yes.

TW: I had a hard time capturing what should go in the ??? column (I think threat recognition column). Ground Rules (Slide) I am going to show images, difficult to find. No vendor preferences. Slides are work in progress. My goal is not to get to all of my 20 slides. Things not covered include algorithms, ultrasonics (could be part of body cavity screening), vulnerabilities, concept of operations.

JB: One thing else-no multi-modality being viewed here. This is important.

Chris Crowley: Littany of technologies-uncertainties- if it's uncertain what I will confront as a terrorist. We have to be careful we don't come up with a silver bullet. If I come up with a countermeasure for a back scatter solution.

TW: Is this a concept of ops. Topic?

Chris C.: It's an observation

TW: (Shows slide with title Active mm-Wave)

??: What is typical penetration?

Whit Lawrence: A fraction of a millimeter.

TW: A two D sequence of a 3 D series of operation.

??: What is the depth resolution?

TW: Not sure.

??: Beyond a couple of centimeters.

JB: Depth is highly dependent on what is outside of the body such as a leather coat. No manufacturers or DHS can discuss this. We who don't have security clearances must do this if we are going to honestly talk about this.

JF: Penetration-you can easily get through woven cotton. For standoff detection it's a problem such as leather, polyester or thick down coat. You are limited on a person with millimeter wave by line of sight. So person would need to raise arm to see under it.

CC: Justin, you discussed clothing so this brings up concept of operations.

??: systems should recognize their own weakness. A system would pass it off to another system.

RM: Or a series of xrays done at different angles.

Tom Ramsay: Looking for explosives mean you have to find explosives. Body scans mean you only have to find what is not the body. The body is standard. This changes the entire operation.

DB: As we go on with our discussions, I hope we keep in mind that we may be evolving toward is not algorithms from one sensor, but as different threat levels, dynamic screening.

CR: Finding things that aren't part of the body, it's a good approach, tissue is definitely part of the body, but one problem is that there is no standard body. I mean, people have sort of the same body shape, but there are a wide varieties between that, so it's also the shape and determining what shape is reasonable. What if you strap a steak to your chest and put explosives in that?

Dave Sheehan: Well, with mm wave sensing it is very easy to sense straps.

TW: (back to slides)

CC: Justin, when you did this work, what else was highlighted?

JF: I got back from Germany yesterday so we didn't have much time to process the data. It was very obvious when we tried to fool the radar that stuff like ski jackets weren't an anomaly, so that's a good sign.

Suriyun Whitehead: When I went through a scanner at DCA yesterday, they told me to divest everything, saying the last guy had 3 pennies in his pocket and alarm went off. So that's the CONOPS at present.

MBS: Carey did an experiment – he went through an mm wave scanner and had a crunched up piece of cellophane in his pocket and it went off, probably because it had a lot of reflectivity.

SW: One last thing – my whole activity took 4-5 minutes, it seemed to me to take quite a long time. We're hoping algorithms come through because that's not reliable.

Pia Dreisetel: We need real false alarm data. People from different cultures wear different things, they have different things in their pockets. You really need some time to get all these things resolved, but I think taking off your coat will be part of the CONOPS for the foreseeable future. For mm screening I fully accept that privacy is an issue and we really can't store anything, but it would really help to be able to dissect the data afterward.

CC: I accept that this is probably making the vendors uncomfortable, and I apologize. I want to emphasize that the vendors have produced excellent equipment but they do have vulnerabilities, the point is to make it even better.

TW: (back to slides)

RM: Can someone tell the audience what the operator sees?

PD: The answer is, it depends. Different systems have different outcomes. If you as govt person say we want to watch these things, then yes we can watch these things. But it depends on the discussion and the society if it's acceptable to do these things. If you say no automated detection system will ever be as good as a well-trained operator, well...

CC: Who is deciding how people go through these things? Who decides the poses?

WW: TSA.

CC: Do you as a vendor make recommendations?

WW: Yes, but we're not allowed to discuss it.

RK: Seeing a single image makes it very difficult to see it. If you are trained, seeing these images for weeks and months in a row, they develop a gestalt to

see what the images are supposed to do. We need trained operators, that's an expense.

JW: One of the differences between airport screening/cancer screening from an operational point of view is that the cancer isn't out there deliberately thinking of new places to hide. I mean, here it clearly helps to have the arrow pointing to the simulated explosive. It might not be so easy.

?: Learning the variability of normal is almost as important as learning what's abnormal.

RK: You have to know how many false positives and false negatives you can accept. I assume DHS does not want to accept a lot of false negatives.

David Sheen (Tim White deferred to Sheen to answer some questions): These operators do not need medical degrees, they're going to see lots of these images on the first day. I think many of these training issues are very easy to teach.

Eric Miller: So to what extent are those artifacts the result of the way you collapse 3D data into 2D data?

DS: Some of it, yes, simplified. I don't think there's any artifacts in this image caused by simplification.

Mark Carlotto: Has anyone put an eye chart on the operators to see what they're focusing on?

JW: Yes in radiology, no in baggage screening.

CR: Suppose the body were made of metal, one big mirror. The buttocks are sort of tilted toward the ground, so if you look straight at it, you don't see yourself.

Charlie Bouman: Can you give me some sense of what your process is?

DS: I'd like to defer that to my talk.

JB: So it's reflecting off the front surface and the back surface and you're getting the two.

DS: Correct.

JB: If you are thinking about countermeasure, I would be thinking of contour.

JM: If we are able to use this wave modeling, we may be able to improve. If we think about the full physics of the problem, we are able to create better image.

DS: Yes, we have done that with polarization.

TW: (passive mm-Wave slides)

Iztok Koren: I will talk about this in more depth in two hours.

CR: Tim, what about depth resolution?

TW: I'm not sure about depth resolution here.

IK: It depends on your optics. We have a far greater depth field from a distance.

Ted Grant: The bigger the mirror, the better your resolution is from far away.

IK: If you go larger and larger and larger, at some point you will beat the wave itself.

Dana Wheeler: Has anyone combined passive/active mm wave in one season. Are there any good qualities in this?

Bob Daly: You can combine the positives of each and reduce the negatives of each.

TW: I think what you're saying is that if shape is a signature as well, perhaps there is some interplay between the two systems.

CC: Clothing issues?

BD: Passive systems are much simpler.

CC: If we threw a lot more money at the system, could we improve the resolution?

BD: Yes. But there is a practical limit on how large the optics can be. CONOPS wise, more time could reduce the number of sensors.

CC: Is there a reason we haven't thrown more money into the system?

BD: We have a funding limit, like most companies, but we are working on high-res images.

JB: Can you think about this in the same way that you think about infrared?

BD: The answer is yes. There's not a lot of data in mm wave space. When an object comes into equilibrium from a radiometric standpoint (can't hear) It is an anomaly detection system, so if you have a cell phone in your pocket and we detect it, we consider that a detection. There's a lot of variation in the human skin temperature, and those variables are within the range of what we're trying to detect within the body itself.

TW: (X-ray backscatter slides)

RM: Were you able to gather any information amount about dose from this?

SW: The dose on the system is typically about 3 microram, natural background radiation is about 300 microram per day, so it's equivalent to just a few minutes.

TW: You get a lot of reflection from meaty areas like the calf, other areas like shin are more of an artifact.

RM: Energy?

??: Roughly how many beams do these use?

TW: It's related to the resolution, so I don't know, but the smaller and faster the beams, the higher the resolution. It's not just a gray level threat, your threats can show up as light or dark.

Xiaochuan Pan: Could you do an xray projection of this image?

TW: As far as I know only backscatters collected, but at higher energies you will get penetration.

PD: Later I will show penetration images on my scanner with very small voltage/dose.

Marcus Schiefle: The radiation dose for backscatter is very small. On the transmission image there's not much that you can see.

TW (Xray transmission imaging)

High-Z stuff will attenuate more, low-z stuff will attenuate less.

RM: Can you say anything about the bore size/ active field view size for these scanners?

TW: Less than a meter, 30x45 centimeters, about the size of a piece of luggage on bore size, you've seen them at the airport. As far as I know, this

hasn't been proposed to be used for AIT work, although I believe the prison system uses it for body cavity scanning.

Gerard Hanley: These are not N4217 (?) compliant systems so they will not be used by the general public. They're in Customs applications for suspected drug smugglers, etc.

TW: (passive thermography)

RM: So that means if there's a heat source within the body, that can influence the look?

TW: Yes, or a heat sink.

MBS: You can actually do spectroscopy on this too.

TW: Yes, people have proposed this at least in the lab stage to ID explosive materials.

MBS: It's really a surface detection technique.

Mike Watkins: My talk will really relate to the sensors out there and how they have been exploited. An area where thermography has been used quantitatively, if you look at it as a boundary problem that looks like it might be fruitful in terms of gathering information.

RM: Any red light/green light on this kind of thing?

TW: The claim was that they could use these during the SARS epidemic to detect fevered /non-fevered people.

RM: And that worked?

TW: I don't know.

JB: There's a huge body of data on using infrared spectroscopy astronomically. All of that technology is directly applicable, for example, the work done at Physical Sciences, Inc. Thinking of this as a surveillance tool much as we use video might be a very creative crowd diagnostic. This is a commercially available technology.

IR/THz Spectroscopy (Slide)

TW: IR is lab based but detectors The reconstruction process is matching the . The strength weakness is IR doesn't penetrate clothing but the Terahertz does. THz weakness is.... Questions:

Absorbance-Mid-IR to THz (Slide)

TW: Resonance gets weaker as you go to the right. In the IR regime you have less attenuation.

MBS: My question to the group is if you are going to tryr and fingerprint with IR or Terahertz or a combination, can you really ID without any ambiguity? Or what is the ambiguity?

RM: How long does it take?

TW: I don't know. I think IR is real time but Terahertz is more lab-based.

??: .5 seconds for terahertz. Answering MBS' question, it gets difficult when the material gets mixed together. It's not just terahertz, it's any material.

CR: Since Terahertz provides spectrographic imaging does spectrographic variation affect the image?

??: If you knew the material was explosive you could use narrow-band but since you don't you have to use broad-band.

TW: What is the reflectant of the clothing at various different points? My point is that it seems to be empirical.

DAC: Do you see variability and how much in the same material? What is standard deviation?

TW: I think that information is available but I didn't have time to find it. The data needs to be collected.

JB: The extrapolation from the infrared is 3 components, you need all 3 to be able to characterize it. Theory will allow you to predict each mode.

??: This material doesn't have features in each field so you have to look at the background. I don't think it is possible to accurately model but I don't think it is necessary for this image.

CR: Just the area between the weave is going to cause variation.

TW: The characterization needs to be understood.

DS: There have been some modeling studies I believe. There is literature available. The results are averaged over enough of a region.

JF: I found these graphs aren't very useful because the shape of the clothing really effects the signal you are going to get. At least with mm waves.

Fernando Q.: How can you trust previous research?

MBS: You have to verify it if you are unsure. If you don't you as a researcher have to validate the research.

Nuclear Magnetic Resonance (NMR) (Slide)

TW: Different relaxation rates can be used for discrimination. Compare this to a library of results. This is used for medical imaging can possibly be used for whole body scanning. Has been used for package scanning. Also discriminate between different liquids that is the image being shown. I believe they are now working how to do this with packages but not yet used for humans. Questions? (no)

Nuclear Quadrupole Resonance (NQR) (Slide)

TW: You are looking at charge in the nucleus. Wait for the interactions to relax.

TW: I think they are using lower fields. If they want to use it with baggage they have to get to lower fields.

ELM: Pixel based?

TW: It is _____ based. You get a very small signal from each individual spin. You characterize each threat material by its individual response. It is very specific to materials.

JB: So you are trying to find a relaxation time for a specific material.

TW: It's the resonance. You can only look at solid-phase material.

CR: What is the potential for false alarms with other materials?

DB: There is enough distinction between...

TW: Last two slides. Metal Detection (Slide)

TW: Real time, information is pass-fail. Online there are claims you can do 2D imaging. Some indication of metal and positioning. You can try to coupling this technology with whole-body imaging to alleviate the false reads.

Trace Portals (Puffers) (Slide)

TW: Puff of air to divest you of chemicals and concentrate this into collector. There are problems keeping the machine clean.

TW: (Shows slide with no title showing spectrums they are working on.)

MBS: One comment. You have the whole acoustic spectrum which is complimentary. AS a fusion strategy we might want to think about this or any other ones.

(David Sheen is the new speaker)

Millimeter-wave Imaging for Concealed Weapon Detection (presentation title)

Outline (Slide)

Terrorist Threats (Slide)

Introduction (Slide)

Weapon Detection Imaging Technologies (Slide)

Brijot Passive MM-wave Imaging System (Slide)

Agilent Active MM-wave Imaging Technology (Slide)

DS: Advantage of this is it is done in real-time.

PNNL Active Wideband Holographic Imaging (Slide)

DS: It is a mannequin covered with metal.

??: Why are the arms so dark?

DS: Primarily the angle, so it's spectrographic.

??: Has anyone tried to use inverted color table?

DS: Yes, we did some of this at the Seattle airport. You really have to train the operators because it can be caused by the shape not because it is significant.

Chris B: ?

TW: The gun in this case is reflective?

DS: Yes but we also see this in humans.

TW: Is it shape or edges?

DS: Edges. If the mannequin was not there we would have the gun there. You can get interference which causes some of this.

Advantages of MM-wave Holographic Imaging Technique.

DS: Range resolution , lateral resolution is typically higher.

Licensed Commercial Cylindrical Holographic Imaging Systems (Slide)

DS: Crude system we built in the 1990s. L3 has continued with this and have built a sophisticated fantastic system.

Holographic MM-wave Imaging Technique

DS: At every point on the aperture we sweep the frequency causing an image.

CR: Multi-monostatic?

DS: Yes.

JM: Done any work on multi or bi static?

DS: No. Problem is if the source and receiver aren't too far apart. One of the reason we haven't though we've considered it.

MM-wave Transceiver (Heterodyne) (Slide)

Holographic Image Reconstruction (Slide)

CC: One of the feedback from the other workshops is.... Is iterative reconstruction a better solution? We'll come back to this.

DS: Holographic Reconstruction-Depth of Focus (Slide)

DS: You only get this if you know the depth of the source.

Wideband 3-D Image Reconstruction (Slide)

DS: New algorithm for this.

ELM: Is this similar to diffraction tomography?

DS: It could be. I would have to talk with you about this.

CR: It is as it is all reflected.

DS: I'm not sure.

DS: Yes, it is scanning over this 2D aperture.

Image Resolution (Slide)

DS: We can achieve wavelength to half-wavelength.

Sandia??: Have you done a broad scan then go in and scan at a higher resolution.

DS: No.

Range Resolution (Slide)

Prototype Wideband Imaging System (Slide)

Comparison of Wideband and Narrow-band MM-wave Images

RM: When done?

DS: Approximately 1995

Wideband Image of a Man with Concealed RDX Plastic Explosive

DS: Operator training is required

Xin Feng: Would it be possible to explore more features other than the ones you found?

DS: Perhaps, but I'm not sure that there's reason to believe a reconstruction algorithm would improve things.

CC: How much of the image quality is a function of body type?

DS: Certainly the resolution is the same... we have not collected a large amount of data with this system.

JW: What's the variation of data, the same image two times through the same machine?

DS: That's a good question, we haven't done that.

Mike Barrientos: Have you looked at any displays other than standard 2-D displays?

DS: We tried stereoscopic, but didn't see an advantage over cylindrical display, although I would not claim last word in that area.

Mike Watkins: At the lab, we don't deal with commercial systems, but as such, the volumes of data typically don't allow you to collect the data that would allow us to answer these very relevant questions.

DS: We did do a large test at Seattle airport, but we were looking for screener performance rather than a threat reduction system.

??: What kind of bit depth are you working with here?

DS: If you crank up the dynamic range, you would see wrinkles in clothing and other lower-level effects. (wide-angle resolution slide)

CR: Why is specular reflection bad?

DS: It's not, we're trying to optimize it. What I mean is that it's those characteristics that optimize what we're seeing.

MBS: One can think about if you put clay or something like that that's sculpted to the body... Have you tried that?

DS: No, but that is an issue – I'm quite sure what happened.

MBS: So you wouldn't see it.

DS: Perhaps not, least not in that location.

CC: So the implication is, with more computers you do better reconstruction.

DS: Different reconstruction, certainly.

XP: What size of system are you dealing with? (data size)

DS: Maybe 1000x1000x100 frequencies, which is pretty tame by today's standards.

MBS: So David, from the standpoint of where the research needs to go, what would be the most potent Q you'd want to see answered over the next 3-5 years? Any fundamental physics that need to be looked at to enable better understanding?

DS: I think the physics are fairly well understood, although not by entire community. It's a line-of-sight technique, so if you want to see under someone's arm, they have to lift their arms, etc.

JB: It seems we have agreed that multimodal is the way to go. What would you combine this technology with to provide greater understanding?

DS: I think backscatter x-rays certainly provide some valuable orthogonal information.

JB: We end up dealing with physical properties, molecular information and (?) information. Is there any other approach?

DS: There has been a lot of THz talk, but I am personally skeptical of it being the solution. Clothing etc makes it difficult to screen above 1 THz, and a lot of features require more than 1 THz.

John Chang: We might be able to augment your efforts in image reconstructions in high-traffic areas etc., VBIED detection for example. There might be some opportunities here.

Michael Fleisher

(ATD slides)

MF: The analyst who looks at the images sees 2 images from 180 degree difference, rotating. We have multiple privacy settings. The goal is to ameliorate privacy concerns by simply not showing the image, just showing the area in suspicion. We claim 250 persons per hour. So essentially, we address passenger screening. From the passenger point of view, it's safe. Very low radiation and no X-ray technology is involved. We have all types of options for blurring parts of the body and we don't store data.

RM: If the subject moves during the scan, do you have an automated detection of movement.

MF: No. We haven't had any complaints about it. People typically don't move when they are standing in the system. The scan time itself is less than two seconds and another few seconds for processing time. Analysts take more time.

CR: Is that a matter of training, people get faster?

MF: Yes. It takes some training but it's not unreasonable.

RM: Would more power equate to better results for you?

MF: Not much, I believe.

MBS: Are you doing blind tests where you're comparing the ProVision against the ProVision ATD?

MF: We are testing it against the operator, but we don't test them together.

JF: Do you see a need for quasi-static targets to do the image, or do you see people being able to walk through in the foreseeable future?

MF: I'm sure we've thought about it, but it's not coming right now.

JW: If there's no image, what's the remote analyst looking at?

MF: We are offering an image-based solution as well.

RM: Have you looked at the CONOPS of remote operating?

WW: There are different application depending on the environment the system is put in

JW: What are you alarming on?

MF: Basic anomaly detection.

DB: I may be missing something, because this sounds too good to be true.

WW: We can discuss that the system works and it's on the QPL list, but we can't discuss details.

DB: So how in the world do we improve if we can't talk about a system's limitations and statistics? We're stuck, how do we get better?

MBS: One strategy is to let academics that aren't bound ask questions that you can perhaps give insight to. There are a lot of questions that could be asked by the academic community.

CB: A while ago DHS commissioned a study that looks at a variety of sensors, including this one, that is available to you if not the general public.

DB: Carl, I'm sorry, but are we on a fool's errand here? We're trying to establish a multi-year research agenda and if the answer is boy, I really can't help you because of the NDAs, is it that bad?

CC: No, I mean, from a vendor perspective, is it useful in general to find ways to bring 3rd parties into this?

Richard Bijjani: It's always useful from a vendor perspective to get new ideas into the mix. We had a discussion last time where if we are asked to put images on a website for academics, we cannot do that. We need to get approval from DHS. Can we do it one-on-one, absolutely. From an intellectual standpoint, it's fun to talk to smart people and improve your systems and do something better than you do today.

Simon Streltsov: I think the missing link between trying to put vendors and academics together is small business relationship with DHS and vendors. Using small business to test SSI data is a way to solve this problem. I don't think it's realistic to try to build a relationship with *all* academics and poll them.

CC: So Justin, you did all this work, you're a student, how'd you get access to all this data?

JF: Because we were in Germany. They were very helpful and had a lot of ideas. For example, why don't we have sensors and transmitters underneath and on top of the target?

MF: I don't know. There are weaknesses in every element of technology.

Suriyun Whitehead: A couple words about DICOS – similar to DICOM, Digital Imaging and Communications in Medicine (with security screening). Having a standard data format. It's very helpful in that if we have standard data, we can systematically address things. The first standard is to be out early next year.

JW: Is that going to address the question of whether images can be put up, worries about reverse engineering?

DB: Jeremy, in many ways that's a legal question. It has to do with the arrangements between vendors and third-party developers. Typically, there are certain restrictions, saying it can be used by the govt. and third parties subject to some kind of restrictions, such that we know who the third party is and they agree not to directly compete based on the knowledge they acquire. It has been tough slogging to make these agreements but they have been done, we have done it lawfully and we're going to now work to try to expand that beyond the third parties we have already worked with. But the devil is in the details of those legal arrangements.

MBS: Again, I keep coming back to there being no silver bullet. Each vendor is going to optimize the best that they can but nothing is perfect. We work to perfect the whole as greater than the sum of the parts, I think that's the path that will be fruitful going forward.

MF: We get around single pose through wide enough field of view.

CC: What does the operator do when they see this?

MF: That's the conops, we are not involved in that.

CC: So why do you have an operator?

WW: To direct them to the high-res area.

New Speaker: Markus Schiefele

Smartcheck in a Nutshell (Slide)

MS: Advantage is you can see a transmission image. There was a talk about the x-ray dose. One Smartcheck scan is a negligible dose of radiation.

Xray Interaction with Matter (Slide)

Dominant Effect (Slide)

Setup (Slide)

Typical Images (Slide)

MS: Metal objects show up dark and make a very good contrast. I have no problem showing this image. The metal stick shows up very well in the transmission image which might not be picked up as easily in the other images.

JW: Does the stick have to be in this angle, what if it was out back by the kidneys?

MS: Yes. Another point about posing, the recommendation is to avoid acute angles as you can hide items which you won't find any with any system.

Steve Smith: This is a fundamental problem with backscatter as metal and bodies both show up black. What he is showing is a solution to this problem. You can see it extremely well in the transmission so if you fuse both the backscatter and the transmission image together it will solve this problem.

?: How can you extend the transmission image below the knees?

MS: It is a limitation and I am not currently aware of any current work to fix this.

Challenges (Slide)

MS: One of the challenges is we only have one chance to find the threat. Privacy is a tough problem. It depends a lot on the culture you come from. Some feel shame to walk through this machine but others don't. We have to maintain a high throughput but there is an unforgiving attitude to errors.

Challenges (continued) (Slide)

MS: Body features look a lot like threats. There are approximately 8 billion people on this planet so there are 8 billion body shapes. This is a challenge to avoid false alarms. There is also a threat from dangerous material being hidden within a body image (example on slide). What can the computer do differently from the human? Computers can look at images for hours without tiring. For short term you have to combine machine and human.

For an example like this slide I can't imagine a computer discerning threat from non-threat quickly in the short term.

DB: Let me ask you this question. Thinking about all institutions involved in discussing this problem, what is best role government could perform to position itself?

MS: That's a difficult question I wish I had an answer to.

Pia Dreiseitel

(Slides)

MBS: How do you get the full 3-D?

PD: The person rotates in front of the system.

CR: Does the focus point change with depth?

PD: There's an area on the floor within which it can focus. It's really a 3-D scanner.

JB: Real-time as in what we are used to in video is 30 FPS.

PD: It's a bit less.

?: That dose limit has been increased, it's now 0.25. It used to be .1 per scan, and a backscatter image would have .1 per scan so you'd get twice as much. You can do it two and a half times and be within regulation.

PD: I think this system even has a little less.

DB: I'm interested as part of this conversation as to whether we have good data from the medical community as to the epidemiological repercussions of dose rates.

RM: The two mindsets are 1) we've all evolved with some level of background, it must be OK for us 2) there is no minimally acceptable dose. We don't expect that.

TG: N43-17 standard, people have been through that whole argument. As long as the exposure is very small compared to what you get anyhow, is the basic threshold. It's pretty hard to argue that you shouldn't have to go through this considering that it's about the same exposute you get after two minutes in the air.

RM: What we say to people that we have to say something to in the human studies education form is some multiple of what you would get in background throughout year.

(Slides continue)

Gerard Hanley

(Slides)

RM: In a scientific sense, would you want to say anything about what the avatar loses for the Conop?

GH: The avatar itself doesn't necessarily lose anything as long as the patdown is conducted in an appropriate fashion. There is some information you could pass on – whether it's a sharp object or a handgun, they may want to know that going in. Other sensors can be used as a quality check on operators.

RM: Do you think this should be formally studied?

GH: I believe it has been, and why not? We study operators in other security applications, why not this one?

If you call TSA today for data, you just cannot get image data of the general public in airports. So that's a real big problem in this particular area of security, meaning vendors have to invest a whole lot themselves in detection.

JW: You're talking about taking that screener out of the loop altogether, what are you going to do about that small collection of false alarms? You're presumably going to have to have someone for false alarm recognition.

GH: Yes, you're always going to need someone. False alarms really are body anomalies, things of natural origin that the person can't divest.

JB: It seems like there are areas where we could work together right now that are not particularly under pressure. You have something that is very valuable to us, imagery. We have imagery experts. It seems that that's an obvious quid pro quo, and in a quiet period, ie before an emergency, it might be possible to conduct some modicum of work while you handle the pressures of your business.

GH: Yes, we are under short-term pressure, but long term that collaboration is something we are interested in. Please contact me if you are interested in further collaboration.

Itzok Koren

Passive MM-Wave System (Slide)

Passive MM-Wave System (cont.) (Slide)

Brijot PMMW Systems Applications Passive MM-Wave System (Slide)

Brijot MobileScan (Slide)

Automated PMMW Processing Goals (Slide)

IK: If we had a perfect detection engine there would be no operator. As it is, it is valuable currently to have an operator.

PMMW Screening System Model (Slide)

Radiometer (Slide)

Image Formation (Slide)

IK: The time from ttop to bottom is 125ms.

Image Formation (cont.) (Slide)

IK: Now you can see the subject.

Automated OOI Detection (Slide)

IK: To clean the image we get rid of the subject. The frame rate we have is very low so we must get rid of some blur. We would also want to see the suspicious object from one frame to the next.

Automated OOI Detection (contd.) (Slide)

IK: Same image as before, there is motion blur; you can see some outliers. We've identified some suspicious areas. The one on the right has some local enhance to give some contrast.

??: Is this representative, it's very low pixel.

IK: Yes, it is a very low cost system.

Display Optimization (Slide)

IK: This person in the picture had explosives strapped to his body and it shows up as warmer than the body.

Privacy Issues (Slide)

IK: No privacy issues as reveals no anatomical details.

Brijot SafeScreen (Slide)

IK: This is the new product being tested by TSA. There are no safety concerns. We are still working on a fully automated system.

Conclusion (Slide)

IK: Improvement opportunities exist. Bringing the automated detection algorithms to the level of human operators.

Ted Grant-DHS

TG: Necessity for Innovation (Slide) If we had automated detection we wouldn't have to worry about privacy. We are trying to level the playing field to include 3rd party vendors.

ATR, ATD (Slide)

TG: The short term goal right now is automatic detection including looking for anomalies.

Algorithm Business Opportunities (Slide)

TG: Three ways for this. TSA buys equipment. It doesn't do research by law. They party with system vendors. Where TSA can't buy the solution the Science and Technology Transitions department's purpose is to fill the gap. The Science and Technology basic research program's timeline long-term is 3 years plus.

Constraints (Slide)

TG: We are focusing on existing, deployable hardware. You have to be realistic about operational reality. Very concerned about throughput. False alarm consequences. Also about personnel operating the machinery both quantity and quality. The procurement system takes patience. We are constrained by competitive disclosures. Last constraint is security. I don't see an easy way around this.

BAA Submission Options (Slide)

TG: Targeted BAA is to get a lot of targeted competitive interest. The funding is set aside for the effort. There are opportunities for follow-on

work. A long range BAA is for “one-off” problems; they have an ongoing window of opportunity. Funding is not set aside.

Innovative Licensing (Slide)

TG: Our ideal is to have complete rights to the software.

Incentives (Slide)

TG: We would like to see a situation where algorithm providers are monetized to solve problems for us such as false alarms as they cost money.

??: When we look at BAA program it sometimes is too targeted. It isn't very flexible. The long term BAA isn't much chance you'll get funding. Is there anything in the middle?

TG: Yes, it is a difficult problem. We have limited resources.

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CC: We want your recommendations first today.

MBS: The algorithms are meaningless without the data to back us up and show that they improve our performance.

CC: DHS has some concerns that, essentially, there are still companies in this room that need to make money, and the issues inherent in this will be addressed, we'll find a way to figure this out.

Markus Schiefele: I'm personally not sure how I and AS&E can help here. Of course third parties need data, we don't really have a big database ourselves. How to overcome the legal issues, that's simply beyond my field of expertise.

Richard Bijjani

(slides)

RM: When things are non-orthogonal, can that give you a basis for registration, mutual information, are there times when that's a good idea?

RB: Absolutely. A great example is video internal imaging. It's done all the time, but are they orthogonal? Not really.

EM: Is there a rigorous way of measuring orthogonality?

RB: Yes, it depends on what you are trying to achieve, the metrics, and how you determine success.

CC: What is cost?

RB: Development, parts, material, sales price.

CC: But doesn't the labor cost dwarf the cost of the equipment?

RB: Yes, but historically speaking, if the equipment is too expensive people will not buy it. You could argue that you are going to recoup your investment in labor savings in 2 years, but it's a hard argument to sell. You can make that argument, but it could go either way, and it's not for us to decide – we're the vendor, we provide for the customer.

MBS: Let me recalibrate this discussion: I think the point of this workshop is to engage 3rd parties, etc. in a way that may adjust cost and performance curve. How can we probe this space even with this unrealistic cost/performance balance?

RB: It's a case study of designing a fused system, what to do what not to do, a guide.

Paul Southam: Are there widely accepted standards for false positive/false negatives in this industry?

DB: The requirements are those that are posted that would be eligible to be put on a qualified products list.

PS: How do you weigh your input to come up with a final decision?

RB: I'd rather not answer that in this forum.

Thomas Sebastian: It also depends on what one means by fusion. (lengthy technical explanation)

RB: Environment is very important. In an airport it's easy, controlled environment, but weather information can complicate the picture in terms of what sensors you use and what you are looking at.

Academia could really help industry in terms of doing our research – we know how to market products, put them together, but the basic research is what's needed.

CC: One of the third-party academics said to me this morning, "What does it take to play in this space?" That's the bottom line.

RB: We typically look for people, they don't come to us.

CC: This is the other people. There are bright people from other disciplines here that you don't know. Should they call you?

RB: Absolutely.

WW: I think one of the concerns we all have in industry is that we have a limited resource. Yes, people can call us and may have interesting ideas to take under consideration, but we have to stay focused on our bottom line and can't go running off after every interesting idea. I don't think it takes a whole lot of sense to take grant money and give it to anyone who has a good idea; focus on the needs of the vendors.

DB: The problem is that although this has been a great discussion, I don't understand the needs of vendors with a degree of specificity that I could come to. Is there a way we can come together, perhaps in follow-up discussion, to merge your needs and our access to universities?

WW: We can draw up a list later.

Ben Tsui: I have a medical imaging background. Most of our funding comes from NIH, not industry. We get funding to do long-term basic research. Usually we ask companies, “What do you need?” If you need something that we are working for a number of years, we say “Hey, we can work with you on the short term application,” and we work on this project and deploy it with you. Those are the kind of things where we work with the company. You come see us and we tell you what we have.

CC: The model you just talked about for NIH is what we are thinking at DHS, but I don’t think we’ve closed the circle on this.

BJ: Elan has issued an internal challenge: “We’re looking at specific ideas to solve these problems. Do you have any?” Any ideas, if we don’t think it’s applicable, we’ll say so, but if there’s research you feel fits in that domain... and it’s hard to narrow it down. The problem is really a very big problem, and any solutions or ideas are welcome. From Reveal’s point of view I would encourage you to contact Elan Scheinman, we are always soliciting ideas and I’m sure the other vendors in the room are as well.

CC: Let’s talk about a specific example. You mentioned acoustic imaging, we have medical people with ultrasound background. What issues do you see evolving?

MBS: I have a provocative idea for our industry colleagues. DHS is funding the CoE about \$4M a year. We are doing our best to bring academics into that mix, we’re looking for the best and brightest and trying to bring them in, trying to get industry input through workshops like this. We need another element. Before this, I ran an industry/university collaborative research center, where industry put out membership money. That money was put in as a pool of funding. Projects were proposed by academics and were voted on by industry. This sparked money for students, research, faculty, and were vetted by industry from the very get-go. I would like to propose that we think about that. If the companies here each put up \$50k under this model, I bet we could make progress.

DB: So universities would come forward with their ideas and industries would vote on which ones they like. That’s a supply push approach, but there could be a demand pull model as well, with a commitment that we want them to specify quite clearly with as much info as they are comfortable supplying, what they are interested in and what they need. That way you’d have notice back to the university about what direction research could be. That’s a possible modification to that model.

MBS: I like it, and that is in fact exactly what happens. Their input effectively filters through so that on the second cycle the academics are much more responsive, but Doug is proposing it right from the get-go, which I like.

JB: There are three parties here that need to be represented. The government is left out –

MBS: They're not. They fund us \$4m a year.

DB: Plus, as everyone in the room should understand, I fund supplementary targeted activities.

ElanS: Reveal is very active in seeking out partnerships, including but not limited to academia. I'm not sure the system we have here is so broken we need to change it. Reveal will put far more than \$50k into research, and already does. We have academic partners, and we go to them all the time.

CC: There's a price point that people are selling at, so fundamental changes to the system are not what we're interested in.

MBS: The difference is that we're bringing competitors together, coming up with solutions together. That's quite different from seeking out ideas from individuals. In a consortium we really get together and we talk.

ES: That's what I perceived meetings like this to be about.

DB: If I were my boss, I would ask, "What are the basic research are you undertaking to flesh out basic research but with a process that includes industry to solve the basic problems that persist?" I don't have that now.

MBS: It is an iterative process if industry's projects aren't what you want you come back again. It isn't left randomly. Industry drives the academic interplay. As Doug s it's a push-pull dynamic.

BT: The biggest resources are with the government. I suggest DHS learn from DOE and other programs such as SBIR program. The BRP program is big and I suggest you look into it.

DB: My experience is in working with groups like NSF and NIH. There are large groups of people to guide what kind of research is being done. This model is imperfect at best. You only have a handful of people who don't have the expertise to make decisions on the projects they review. At NSF it works because they have researchers who have been working in their fields. At DHS it has to be federal employees who have to review the proposals. So we are even more limited. How do you educate DHS and TSA technically to

direct research. That is why we are suggesting this approach. You would have smart people directing this research.

JC: We serve NIH as a review board and also at workshops when they have an idea. They come up with a RFP followed by a review committee. I suggest to you we would be happy to help.

ELM: At NSF they have review panels all the time. I have sat on tons of them; they are the most balanced way to review and adjudicate fairly in terms of technical merit. It is the most level playing field.

??: We have a fundamentally different market than medical. The main problem we have is sharing the information rather than sharing the ideas. It is much more important.

JB: _____ is a model (Semtek???). They pool \$ 1 billion to tackle the next problem they will encounter. It is similar to what Michael Silevitch is talking about. The reason I said there are 3 players as you need to know what government wants as they are the customer. We are helping government build the roadmap. Govt. needs to be part of the discussion.

??: This economic situation is very different from other industries. It is a very small pot of money we are going after. Industry has a very selfish motive such as getting a better product. The difficulty with a consortium is convincing management they can recoup their money later on. How can technological advancements drift back to industry?

CC: We have to look at a different perspective here. We can't lose sight of the fact that that people are trying to blow up planes. Are we safer after 9/11? How can we build better technology to prevent this? The purpose of sitting here is to improve safety.

MBS: You should add subways and buses.

CC: I think we are safer, but the point is the bad guys are getting better as well.

Xin Feng: My question is, we find better algorithms, it has to be integrated into a vendor's machines. Does DHS get it into their machines or is it free market?

CC: I think it's free market.

JF: Lot of industry here who don't want to share their trade secrets. The German group we work here has the same issues. The biggest problem I have is the lack of tools to solve problems with.

CC: You can buy it.

DW: We are devvelling some technology which we got from Ukraine which government partnership is trying to get into private industries. Primary product is a mm-wave system for brown outs.

CC: So Justin could buy one?

DW: Yes.

CC: Is it your belief that medical imaging technology has benefited from third party development?

RK: 5% and the rest was done by academics and done by different mechanisms such as patenting. There are instances where academics made money.

BT: NASA has developed many technologies that are now used every day. We work with companies to develop algorithms. We've been doing it for years with NIH. This is a model for DHS to follow.

TR: On the medical side we would never approach our work in breast imaging without consulting doctors and patients. In the security side it seems the collaboration side is lost. Our problem is not what is on the board here. There is no doubt that we'll solve data fusion problems. The problem is we fear what we lose with collaboration. How do we survive if we miss the sell in opportunity for this technology and why would we assist academia when there is such a wait? This is the problem we need to change; the whole approach. We should look at partner fusion rather than data fusion. That's what this meeting means to me.

Masashi Yamaguchi

MY: Conclusions (Slide) We do spectral imaging in lab conditions. We did a bomb detection problem with DHS. We need to develop multiple sensor systems for faster scans.

(shows Terahertz sensor on slide)

Rensselaer-Zomega: mini-Z (Slide)

MY: If you mix up many compounds this is the problem.

THz Imaging Transmission Through clothing (Slide)

RDX undercover (Slide)

Four Absorption Spectra of amorphous materials (Slide)

MY: We need to identify the material with a lower signal. For the sensor side we need an intense signal.

Spectroscopic Imaging (Slide)

MY: If you take a broadband source you can identify the specific source.

CC: This is not real time. This is RDS.

CC: What are the environmental opportunities?

MY: We know the spectrum of water (Dealing with Water (Slide)). Beyond 30m we have to do it another way. We can use fluorescence. That is the standard detection beyond 30m.

DAC: How long to scan a 1 square meter area?

MY: A couple of minutes.

DAC: From a fusion sensor point of view it has to be targeted.

CC: Yes.

WW: How is the beam targeted?

CR: Have you done any shape imaging?

MY: No, we don't do any processing.

Steve S.: Bottom line, if you had a backscatter image anomaly, could you tell if there was a block of RDX there?

MY: Yes.

CC: Does the government have a role in integration?

WW: Perhaps.

CC: Does something from govt. have to happen to push the gap?

WW: I appreciate the presentation .I think it would benefit a number of vendors.

MBS: In the consortium model, if a bunch of companies wanted to see this go forward they could vote for it.

CR: Is it reflection or transmission?

SS: Have you thought about putting it into a wand for the security operator to use?

MY: Yes.

SS: Is this 5 years away or closer?

MY: (missed answer)

Mike Watkins (Reveal Imaging)

MW: What is new and has some math content. (Shows a thermal movie with infrared and good spatial resolution in real time.) I won't discuss spectroscopy which is a huge topic in itself. I will get to a few main points. R&D Challenges (Slide). It is true that IR energy is emitted from surface. Transients imposed on the boundary are used to look at the depth. It hasn't been exploited because of several reasons. The understanding of heat transfer is difficult to solve and thus interpret on fundamental principles to understand this. You have convection and radiation in a complex dynamic. Using a high radiation gives you more information. While it looks difficult to solve if we solve the basic problems we can use other information. Informed systems, by having information from other systems you can eke out threat signatures. This won't be like mm-wave in depth. It is complimentary to other techniques in depth and you can impose external transients. You would have to design in the transients depending on the threat. (Talks about temperature differences and the difficulty it poses for this approach.) This is a R&D problem for several years.

Chris B: My approach to infrared imaging is in the mid-West and we have very cold temperatures. How do you think this would affect this?

MW: The variations in applications like this and it is these differences you can exploit. It is a complex problem rising to understanding the heat level transfer. You have to answer these questions to understand the problem. It is not a raw guess but it hasn't been exploited quantitatively.

DB: What we don't have is the ability to model the complex geometries which you also have as a model for this.

MW: From a fundamental standpoint, it has sensitivities to different types of properties. It's those properties and the geometries where I think we've got the most work to do.

CC: How do these relate to detecting an anomaly or threat on a person?

MW: If I'm hiding something under my clothes, you get an anomaly on the thermal infrared measurements. Those anomalies are typically analyzed because you look at the picture and say that's a cool spot.

CC: Where do we think it's complementary?

MW: The depth penetration that you get. Mm-wave, X-ray. I'm not talking about millimeters, I'm talking about very thick depth perception that you can get from these thermal transients. It may be possible to look at that signature over some period of time. A rule of thumb for most solid materials, purely conductive, if you hit a solid slab, just do the basic diffusion process, the depth that you could resolve could be on the order of the radius of a cylindrical void. So if it's 5" across, you could see about 5" deep. You could also possibly get information by the rate of the property specific to the thermal conductivity of that material. This is one of the things out there that is not fully understood, untapped potential – this is R&D for sure. There's a community out there that uses it (NASA) but I haven't really seen this applied.

Do you call this passive or active? Your detector might be passive but you're using active variation to exploit understanding of the target.

CR: So if everything comes to thermal equilibrium, could you see differences?

MW: Given that there's a gradient, you'll come to equilibrium but you'll still have heat flow. You're going to take out the time element but by understanding what that difference would be along the surface of the body, you might be able to come to some conclusion about what's on the surface of the body.

CR: If you're outside on a 98 degree day?

MW: Well theoretically if everything is at equilibrium you have no gradients, but your body (trunk) isn't even at thermal equilibrium. Ask medical folks in the house. An obvious thing is an air curtain that you might use to isolate a building.

CC: How long?

MW: Those are the answers you want to find out.

CC: What's your intuition?

CR: You could find it with a puffer, blow cool air over someone.

RM: The CONOPS for breast imaging involved regions within a cm of skin's surface and lowered to about 10 degrees below room temperature (10 years).

MW: The types of threats we're looking for in mass and size IMO are very different from that problem.

??: Will you see natural gradients around the groin, stomach for example, and how do you get around that clutter to detect objects?

MW: The clothes moving and changing the air gap actually changes those things. You do need to understand what those effects are; I don't think we do. Part of the model would be investigating something exactly like that. But it's quite amazing what you can see in variations over the surface of the body.

CC: Would it be useful at a future workshop to have a longer session on IR?

MW: I'll leave that up to the audience.

Chris Crowley (Morpho Detection)

CCrowley: I would defer to Tim's presentation on QPR. Let's jump in: Are there synergies between MQR and AIT? (slides) Shoe scanning presents a big challenge on the temperature range, AIT effectively deals with the temperature range and narrows it. NQR is very closely related to MRI, NQR/AIT narrows the geometry and helps isolate the problem.

We have an automatic concept where the scanner identifies an anomaly and then AIT-directed secondary anomaly resolution kicks in.

Question for audience: What do we focus on as researchers? We have developed whole-body, shoe scanners, what is the problem statement here, are we looking mainly for anomaly resolution or to compliment body imaging at the primary level?

CR: I'd say that to be proactive, we want to scan everybody. But I have Qs myself – what is the false-alarm mechanism?

CCrowley: Magneto-acoustic ringing, suitcase scanning: there's basically resonant noise although there's no NQR per se. If you get rid of all the metal, good.

CR: So no plastics, rubbers, organics anything.

CCrowley: No, it's very specific. The NQR signals are very small and they're vulnerable to radio interference. We've got this hybrid shielding system that allows you to get into an NQR scanner without being enclosed, but it's tricky, there are a lot of interferences.

CR: Why bother with a localized probing system rather than a whole-body coil?

CCrowley: Because of performance. The answer to "is there synergy", definitely. It just focuses the sensitivity. Even if you threw money at the whole-body system, it would not be as clear as a targeted system.

JB: We're more sensitive if we go locally. So why become more sensitive if it's not necessary?

CCrowley: In some ways, those two systems (whole-body and shoe) are two extremes. I would rather have that performance from what I know of the systems I've worked on and aviation security.

WW: Is there any concern with implantable medical devices?

CCrowley: For things like auto-defibrillators, pacemakers, etc. there is definite concern. They usually stay away if they have these, but if they get confused, we need some sort of preliminary detection system, it would be prudent.

CC: Underwire bras?

CCrowley: Shouldn't be a problem.

CC: So this is an orifice scanner, sensing or detecting?

CCrowley: Sensing, which is both a strength and a weakness. If the question that you're asking is about something embedded in the body, the range is dramatically narrower. There is a list of materials you try to find, you can find them in the lab, but deployed is different. The list of materials you can find with QR is pretty well documented.

JB: They're very good methods for measuring temperature. Why not cut out resonance?

CCrowley: That works well for land mine detection, for example, but with shoes etc there's a very complicated thermal profile associated with activity.

JB: But if you're looking at the torso, and you removed a coat, you're not going through some type of temperature extreme.

CCrowley: Exactly, and that is the key to this synergy.

David Sheen

DS: A lot of our ATR work was done a number of years before using input from Doug, etc, a lot of the imaging work has been done over the last few years and we've developed some new concepts. We've developed a number of ATR techniques that were also demonstrated to L-3. They were all developed to a modest level of performance, never integrated into an automated system such as L-3 has done.

(slides)

Obviously a large set of algorithms is necessary and I think that's relevant here because there's presumably an infinite number of threats. Threats could really be anything, so we almost have to do anomaly detection.

Paul Southam: When you say speckle detection, are you talking about texture?

DS: Yes.

PS: So you're actually doing texture segmentation?

DS: Yes, it's been published (included on ADSA03 supplementary material CD).

PS: What's causing that speckle?

DS: (technical explanation)

Potential improvements: Increasing res, both lateral and depth. The 360 degree results can also be incorporated into a single image that uses graphic techniques to renew it. There are also things we can do with polarization.

(slides)

PS: Did you do anything in the spatial domain vs. spatial frequency domain?

DS: Not sure what he did there. It's true that traditional ATR techniques focus on shape. A similar neural network was used by us looking for depth to the reflection.

Grant Gullberg: This seems related to what was presented by L-3 yesterday.

DS: We presented the technology ~7 years ago to L-3, and they've done an extensive amount of work since then.

CC: Is the human observer the gold standard?

DS: Oh I think absolutely, humans are outstanding for taking in the entire image, algorithm techniques typically want to focus on pixels or sub-images, not the whole images.

CC: It's hard to imagine that eventually a computer will not be better.

DS: I guess, but I think most people wouldn't argue that today humans are clearly the better observer. We have great visual processing, but if you deviate too much from what you normally do with your eyes and your brain you get confused.

CC: Do you have forward modeling of this?

DS: I do not; I do of a 2D case. This has hundreds of thousands of full antenna systems, so it is very complicated and intensive to forward model a cylindrical 3-D case. Still, it might be possible.

CR: There are limitations in terms of wavelength. It could be done, but it would take forever.

Thomas Sebastian (GE Global Research Center)

TS: I am from a computer vision group at GE where we do a lot of image segmentation, registration, inspection for several things. We also do a lot of video analysis.

(slides)

I think one of the key things we've talked about, there has to be enough data. You can have hundreds of images, but if they don't capture the variability that you're trying to solve in your own problem, you're not going to get anything. We went through 1000s of images but it didn't add anything because they weren't variable, they had a fixed background and so on.

You want to use domain-specific information whenever possible.

RM: Is this an example of something where you wouldn't do it without the video fusion, it's a given?

TS: No, if there's a video sensor, you want to use that, but there's a lot of cases where there isn't.

XF: What kind of kernel functions did you use?

TS: Depends on machine. (Technical explanation)

JF: Do you have the ability to extract exact target movement and then feed that into mm-wave to compensate for target movement?

TS: Yes, we had a specific sensor that you can aim at a person.

JF: I'm talking about accurately modeling the movement of a person's shoulders and arms.

TS: Depending on how accurate data you have, you can target it to a person.

JF: So you can track someone's hand.

TS: Yes, I can show you an example.

CC: Are you considered a third party now?

TS: I think that is a question for the lawyers. We work with GE, other companies sometimes.

Jeff Jortner

JJ: Sandia is overseeing the Automatic Threat Recognition algorithm development and evaluation. We've evaluated 5 systems, 21 locations. We are also engaging with academia to create algorithms. We will also be helping to evaluate the algorithms developed by the researchers. As far as standards, we were asked to do parametric data collection, which assumes we know nothing about this. We need a common nomenclature in the industry which crosses all industries and areas. Number of Trials Collected Per System (Slide).

Common Data Format (Slide)-see slide for details of format. We have XML data which identifies wherercoupons are. This has some image processing but we tried to collect images with minimal processing.

ATR Algorithm Development for AIT Data (Slide)

JJ: We developed code to give you the scoring algorithms and the exact file naming protocol. See slide for full details.

Coupon Scoring Locations (Slide)

JJ: Basically what we've decided is the algorithm for this particular project is a smaller region of the body than in others. We've come up with a

hierarchical reporting mechanism. There are some definitions coming out of TSA and TSL and we want to make sure we are consistent with them.

RK: 2D data?

JJ: Yes.

Steve S.: Were these images staged?

JJ: Yes at Sandia using various body types. The coupons are not necessarily threat items so we have not just threat items but non-threatening anomalies as well. The last scan set we did was four scans.

SS: Did you have a single...

JJ: Yes. DHS will do some data distribution, not from us.

SW: We are working on that now. The data would come from us in the standard data format.

SS: Available to just those working with government?

SW: We can work it out with people in this room. We aren't sending the data overseas. My contact data is...

CC: Send me an email and I'll provide it.

JJ: Clothing is not detailed as the objects were all placed externally with plastic wrapping so no clothing covering the materials.

?: Metadata?

JJ: Yes. Dimensions and description.

?: I applaud this type of testing as there is a real lack of data collection. I know getting NDAs in place is a real challenge. We've done similar work. It would be helpful to hear back from you as we didn't hear back.

JJ: We are going to share the Statement of Work as well as the _____.

SW: A lot of this is modeled on what we learned from this work. When you grade your own performance against the results and we validate it we will be speaking the same language. It was a learning process for us as well.

JJ: One of the things which are interesting is active and passive mm-wave we'll see. Can we have a common structure or will we have different algorithms for each. Our goal in this is research and development. It is not to produce an algorithm which is ready to be deployed.

Mark Carlotto:??

JJ: We took a large set of these threats put them on the body, as coupons, and then evaluated how hard it was to see these objects with each technology. We created a test matrix. All this was to cover the range and type of items found.

Secure Screening with Video Analytics (Slide)

Visvanathan Ramesh: People are working on overall awareness of what the situation is. We also believe there is a technology push to have common framework for this. Performance, how to guarantee it? We believe systems need to be more sophisticated in order to guarantee performance for the government.

Video Monitoring Technology Landscape and Trends (Slide)

VR: Hardware is cheaper with increased capabilities. All of this is being done with a human-like system. Imagine if you could capture peoples' faces as they walk through a checkpoint or analyze the environment around it. The technologies are available but still questionable in my opinion.

Technology Person R-Identification Technology (Slide)

Object Detection and Matching Using 2D Spatial Ordering Constraints v

VR: This is useful for baggage drop-off and re-acquisition in an airport.

Move Towards Advanced Reasoning and Forensic Search (Slide)

VR: Need common architecture to combine lower and higher level analytics. The last point you need for all the different scenarios on this slide, they are all dynamic and they have a mix of natural and artificial components. Analytics can learn a lot from computer science in developing these types of analytics.

??: Can you talk more about your challenges?

VR: Say you take an abandoned package, you could create a "left-package" station but the users will tell you they aren't happy with it. Their idea of such a station is different. The false detection alarms are too high as the definition of false detections is different between operators. Our approach is to be very precise. Bridging the gap between our definitions and the real-world usage is what we need help with.

CC: Next and last step is to try and synthesize what we've discussed here. I've asked 6 people to list their points for the people in the room to make comments.

David Castanon presenting

DAC: AIT State of the Practice (Slide)

DAC: You look at the spectrum of the ideas and ask yourself, how do we fuse them? Differences in modalities, time frame, prevent each modality from interfering with each other. The basic approach would be to stage one modality after another. Will this be cost effective? Practical? Motivated by this potpourri, I am asking how to fuse this. We currently have fusion, it is the human operator.

The question that we should be asking ourselves is not whether we should be doing but whether there is better architecture compared to our current architecture, and what are our metrics for "better"? So are there better architectures, better CONOPS? Probably. I'm sure we can integrate technologies to come up with improvements.

(Slide: Observations)

Colin: Are you concentrated on reducing false positives or false negatives?

DAC: Most of the systems that I saw up there were aimed at reducing false positives in this context.

Colin: But it's an issue, of course, because every modality has its own false positive, and if you're working on throughput, there might be very little gain.

CC: What is missing off this list?

DAC: We can always basically say the physics principles are different, but we can't quantitatively say that the fusion of these experiments is going to get to that level.

CC: I mean, someplace we gotta get to, what is the return on investment? Terahertz sensor has a very different sensor ATM that can give additional dimensions to an area that you might not know.

DB: I wanted to come back to your question, Carl, because there's a voice we haven't heard here that might answer that, and that voice is the voice of TSA, who set requirements. It needs to be a reach, but not so much of a reach that TSA can't buy anything. If there were a checkpoint here, what in their

fondest dreams would TSA define as a requirement that, if met, would say “this problem is solved, we’re done.” I think it would be a useful exercise to try to engage TSA in this discussion. Not only, what are your requirements today, but what will your requirements be five years down the road?

Mark Carlotto: Why not use some kind of phased risk analysis?

DAC: Almost all statistical analysis of this type requires data to base it on. The potential payoff of a quantitative assessment hasn’t been worked out yet.

RM: So you have to know something about the operating point on the ROC curve to know what you’re improving. I think the operating points are still masked for this group.

MC: My conjecture is that there is some operating point that has been agreed on today?

CC: Not that I’ve discussed here.

JF: So I said yesterday that it is hard to see through, say, a parka, but there are ways of getting around that.

CC: So put that out there.

JF: You’d have to talk to the PI on that one.

CC: But some of this is intuitive. I mean, I feel like we’re hiding behind the data, people have talked about it, we’re there.

DAC: Having this extra data allows you to buy some specificity.

CC: A lot of this is engineering common sense, I don’t think you have to go to Germany to find out these problems.

CR: We had to.

JF: There are vendors there who will work with us. We haven’t even gotten an answer from anyone yet.

Carey Rappaport

(Slides)

(Born Approximation vs. FDFD)

CR: As you can see, a born approximation really has a tough time with high-frequency, strong-contrast scatter.

We know a lot about the way mm-waves interact with skin.

CC: Is this worthwhile to pursue? Should DHS fund it? Pia, can you predict images in advance?

PD: Not probably off a complete person, but in certain parts, yeah.

BT: In CT, for example, we have simulated projection data.

CR: Would you say modeling is valuable.

BT: In medical imaging, yes.

DB: A way, Carl, of answering your question is this. If you ask people “is modeling useful,” people will say yes, but that doesn’t really give you anything to go on. To rephrase the question, Carey, if we don’t invest in the modeling here, what is the opportunity cost, what do we lose?

CR: Modeling is a way of doing experimentation inexpensively, to the fidelity of your model. One example of this is using human objects vs. finding a simulant. And if anyone has a good simulant, let me know, because we haven’t found one yet. With a model you can put it together and see how well it works. The criticism is that models might not work well enough, and that’s a legitimate criticism, but models like, say, the CT models, are pretty good, they’ve been around a long time and they’re useful.

GG: They’re a way to improve our simulators and create better images; a better prior creates better image quality.

BT: To turn the question around, you gain design. In medical imaging, you get a pretty image, it’s not enough. You need to get to the truth. And we don’t know the truth ahead of time.

CR: I also want to add that the models are part of the inversion algorithm. A lot of times, the way to determine what it is that caused the response is based on knowing what the objects that generated the response will generate. If you have a sophisticated model you have a better inverse model.

Simon Streltsov: I do agree there is a good place for models, but there is a potential loss if people look at models all the time rather than looking for real data.

CR: Absolutely. The models themselves have to be validated and the system itself has to be tested to see if it does agree with the model. If it doesn’t, the model is wrong or the experiment is set up incorrectly.

??: Better prior modeling is useful because it determines what we are doing for anomaly detection. If you don't have good modeling you basically can't do it.

CC: Dave (Sheen) when you built your first model, how did you know what you were building?

DS: We absolutely used models. It's very difficult to do a complete realistic model, but simplified models can be used sensibly and effectively. With a reconstruction algorithm you have to be able to test the algorithm.

CR: I imagine modeling is used in every commercial system. Is there anyone who didn't use a model? For a sophisticated system, it seems hard to do it without a model.

CC: So should DHS be investing in this? Is it useful for them?

??: Due to the complexity of the millimeter models, I think it would be highly valuable to get this modeled. If we could do this on the millimeter wave, it would certainly help a lot.

Bob Daly (Brijot): Modeling is really valuable because it represents what you know about the system, and to the degree it is inaccurate it exposes what you really don't think you have.

CR: The rest of my slides describe what aspects of what technologies are important to be modeled.

Eric Miller

ELM: Reconstruction (Slides) Lists the four components-see slide. Other algorithm are iterative ones which aren't close form. These solve underlying optimization problems. They are more or less able to handle prior information in a more natural way into the framework.

Opportunities in WBI (Slides)

ELM: Based on what has been discussed, inversion schemes are applicable to mm-Wave and probably also spectroscopy.

David S.: Not sure what you mean by optimization.

ELM: You could view estimated concentration as an inverse problem. What I mean is accounting for the unknowns in the problem. How useful would these methods be? I think there are some utility.

Utility (Slides)

See slide for details

ELM: I can make a case for geophysics by looking at it in a fusion approach. The government should determine the data limit. What we produce are trained Masters and PhD level people.

Challenges (Slides)

ELM: To be at all relevant you need accurate models and calibrated data to understand the algorithms. Based on the discussion the rest of the challenges are cultural. They are not short term interests. My responsibility to my students is not aligned to private industries' interests. Stability is also an issue. I get stable support from NSF and NIH who provide 3-5 years of funding for a 12-15 peer reviewed proposal. The customer for these methods is not industry, but government.

JB: Eric is about to start work with a grant that hires and aligns a students work with industry.

ELM: I am not against industry as I do consulting.

MBS: I want to remind everyone complete your questionnaire and turn it in before you leave.

Charlie Bouman: Forward and following algorithms, you can get better results but the cost is increased computation.

Rick Moore presenter

Narrow Display Issues (Slides)

RM: All result in a red light/green light signal allowing the operator to take an action. I've heard an undercurrent throughout the day about who can look at the data.

Broad "Display" Issues (Slides)

RM: The undercurrent is that government and organizations would like the maximum exposure to data. There are binary display issues. My work in breast imaging I would ask we rethink the workstation environment. I also would say one lesson we've learned is the importance of 2 readings for data.

CC: Meaning double the readers?

RM: I think maybe it means have the data passed over twice. It usually means an increase of 7% increase in detection. Carl has asked should we invest in privacy filters? People who are suspected of carrying drugs are not

given the choice of what technology we scan them with. I don't know exactly how to answer the question.

Challenges (Slides)

MBS: I have a counter-question. Is asking for privacy putting the "cart before the horse?" I think we need to invest in what we want to see, not in privacy issues.

CC: What kinds of algorithms are required when you do integrated checkpoints?

Mike Watkins: You are going into issues with detection.

CC: Not detection.

RM: In the medical field the humans combined with the machine beats it.

MW: A common interface further down we would like to get to fusion.

CC: So fusion is important.

MW: ICP, we don't know how the interface would be designed; it is an evolving technology.

RM: We have integrated machines in my hospital. We can read a GE imaging machine on a Siemens workstation. Individual algorithms can be plugged in and approved by the FDA. It is a model you might want to think about here.

Mike Watkins

Why ATR? (Slides)

MW: Some quick thoughts: Why ATR? Privacy is one of the big issues. ATR might help us get past this. Another reason is performance. We want to make the process quicker (throughput). Data fusion might be helped by ATR.

ATR Issues (Slides)

MW: Automatic vs. Assisted System. Simplified display-do you lose anything? There are a lot of conops that fall into the area of ATR algorithms, how efficient it is. To develop really good ATR you might need access to vendors algorithms. The last part is the nomenclature, what does PD mean? I can see this impacting ATR.

CC: I read Paul's paper about textual recognition. What is it going to take to make you a third party vendor in the states?

PS: Access to data.

CC: Do you need money?

PS: Funding for PhD students. Another option is through consulting.

CC: You didn't ask for requirement specifications.

PS: Because there is some really basic work that needs to be done before you can give me a spec.

Lauren Porr

LP: Con Ops was the hardest part of the presentation together. I put this together to show the government's side.

What Should the CONOPS Consist Of? (Slides)

LP: Since AIT doesn't operate alone we need a conops to say how it will work with the other systems present in the system. The last thing the conops should have is a realistic description of how the device is working. To do this you must consider space, throughput, flow of passengers, and availability of TSOs. The conops should be developed early in development. Bringing passengers into lab or phantoms. We look at these systems and see what's working well and what isn't. How will these drive how it works? Also should bring TSOs into the development.

What is the Path Forward? (Slides)

LP: Within the next year we should have a conops. Within 18 months we should integrate the AIT into the conops.

CC: What gives you headaches in conops? What is going to happen when you sell the AIT?

Erick Rekstad: If this is going to be commercially viable, what is the space? What is the operation? The TSOs have high school degrees and they have 5 seconds to look at an image. They don't want to pat you down just like you don't want them to pat you down. These AITs need throughputs of approximately 400 passengers an hour. We currently aren't getting this. You need to keep this in mind when designing the system.

RM: Is there a role for getting into the process that the operator is moving with? We've learned a lot in medicine because we've used computer-aided detection to see what radiologists are looking at, how they actually work.

ER: Our end-state goal is that people will look at some cartoon version of the anomaly and do a directed patdown search. But we're not there yet and these other tools could be very beneficial. The vision of ATR that TSA has is to retain all its screening capabilities but simplify it. The office of security operations has the information about acceptable false alarm rates with particular processing times/throughputs.

Simon Streltsov: You need to add one more measure of false performance. You need to not only label what you can detect, but you need to figure out what you want to touch. (gives example with 100 people)

??: We have much more access to TSL at getting detection but not operational feedback. It seems like a change in philosophy is needed. How would that happen?

TG: That's in TSA's bailiwick. The thing is, tradeoff issues are way different for security than for radiology, because you are taking pain for individual gain in terms of your health. In security, the exposure is for the good of society as a whole, not your individual benefit. Also, there is enormous pressure regarding privacy and what the government can and can't do regarding the general public. There is so much public oversight that it is very difficult to do certain things. Because these raw images are so inflammatory, the whole goal is to get people away from looking that.

Around the Room

JF: We have companies competing, is there anything to do to get around that? That's my question.

XF: I think this is a great conference, that we have made connections with people. Concerns 1) With the lack of specific problem statement, that needs to be addressed on how we integrate all the info together so we as researchers can tackle a clear problem.

Naveen Bansal: I agree, the problem has to be defined. If you could make data available so we can get started on the fundamental problems, that would be great.

TW: I think this is the time to consider the next data set for ATR, how are we going to collect that? Multiple modalities? We need that in place. How do we get simulated data?

JPSchott: The challenge is how fast can we move to make data available. Last workshop addressed this, 6 months later, nothing, and it will be harder for this problem.

JB: Workshops 1 and 3 have been similar and since ADSA01 I think we've made significant strides in obtaining data for the grand challenge. I think that we're headed for a discontinuity, today's techs in the workplace are not adequate and I think that we can all recognize that. Community has said multimodal is right direction, this will create industrial discontinuity. I think we need to make this as easy as we can for everyone in the community, and I don't think we took strides toward that in this workshop.

DAC: I agree with Tim – we ought to be thinking about the next steps that will enable us to continue along this line of research, although qualitatively, we won't be starting from scratch there. The data may or may not be sharable, but the sooner we start seeing the data in a joint context the better.

RM: The value of simulation has certainly been discovered by medicine and I would like to see a center where CONOPS can evaluate it in a coherent and specific way.

Michael Barrientos: Thanks for having me, it was really worthwhile. Bottom line: We all have a purpose really beyond our companies, we have to collaborate our efforts against a disaster.

CC: (Personal anecdote about WSG article) My own personal bias is putting the problems out there and asking for help.

PS: I think a database would be very positive and a great step forward.

CC: Would you sign an NDA to get access to it.

PS: Probably.

Chris Boehnen: I think the issue is not just having access to preexisting data, but generating more data for realistic understanding of problem.

Erick Rekstad: I'm kind of disappointed that these TSA requirements that TSA has had since at least 2008, you guys are saying you don't have access to, and there's gotta be some way I can distill this down to some level where you guys can at least have some idea of what you're trying to do. Operational requirements are of course an issue, but we do have that information and there should be some way to disperse that to you. That is for both industry and academia. Also, the traveling public is very different

that what you bring into your labs and I think you need to be aware with those issues.

CC: Can you share some of the issues with the traveling public?

ER: Since they're not here, I'd say the Office of Security Operations would be more than willing to come up with some way to do that. That's their main objective. Keeping the TSOs on task is a very difficult thing to do, and when nobody's there, they do what they want to do.

Mike Watkins: We are going to be doing some more data collection. It will probably happen this year, although the research stuff will slide into next year.

Suriyun Whitehead: This is the 3rd workshop I've come to here, the first AIT one. As and when we're able to deploy systems that have better capabilities, etc., that's what we're driving toward. We've heard issues, there's just a few we haven't been able to solve yet, I mean structurally. I get 15 person sets aren't enough, but data are really, really expensive to get. Think of it as a starting point.

?? (man from Guardian): One of the things that I'd like to have DHS/TSA think about is that false positives are not something terrorists are going to use. It's a nuisance issue, and if we can have info as to what false positive acceptable criteria is, that would help us concentrate on security issues rather than on throughput issues. Even though we're a small company, we would volunteer in participating to help facilitate our involvement with our data collection.

Doug Boyd (Telesecurity): We really have first-generation machines here, and there's a lot of R&D to be performed here; think of this as MRI machines in 70s. R&D funding is going to be critical in seeing this field developed going forward. A robust SBIR/STTR program would be very important for DHS just as it is for most of the other federal agencies.

??: I'm a bit disappointed in the lack of real information as to the problems out there, because you can't work on the problem if you don't know what it is. It might be worth looking outside of the country to access real-life operational data.

Ted Grant: If I had the opportunity I would urge you to look at the problem not from a hardware perspective but from existing standards, because that's what we're going to have for a while. I understand there's a long-term focus, but we also need a short-term solution.

BT: Being from the medical imaging field, I learned a lot as an outsider but I was really disappointed that you cut some people off this morning, although I understand that time was a factor. The reason I came to this meeting is that we agree with you, there's a lot of common problems. I think we should work together, I just am still uncertain as to how. I still don't have a good understanding as to the real focus of this workshop, I think next time you should have a real focus and workgroup. We live and die on grant funding, as you know, so we are looking for funding and would love to participate, but if there is none, we should move on.

PD: Thank you for organizing this, I think it was really worth coming here.

??: I'm encouraged to hear of the progress made since the first workshop, which left me somewhat pessimistic. One thing is where's the funding for next-gen technologies, for 15-20 years from now?

Jon Nickerson: From the security checkpoint perspective, thanks for all your input, if you are interested in supporting our efforts on that program please find myself or rest of TSL team. Our issues – passenger tracking at the checkpoint, as well as user interface information. If we are going to go to a common system to help the TSOs, what are the issues and how can we synergize that?

Laura Parker: I find it very helpful to see the academic, industry, govt. people to come together and talk about their problems.

Steve Skyp: Some people aren't concerned about privacy, but I think we need to be mindful about privacy issues. I also think we need a follow-up workshop.

Closing Remarks

CR: Tech is advancing and there are a lot of smart people interested in solving this problem, although there were frustrations. I don't think we can move to the next step without fundamental research.

(Slide)

My impression is that there is research funding available for technological innovation and that we should take advantage of this. We do have to find the appropriate funding vehicle, and I think that MBS idea of collaborative (alliance) ALERT institution is a great idea and that he deserves some credit for sticking his neck out there.

There will be an ADSA04 workshop and it's good to get third parties involved if for nothing else, just to have training for the next generation. Finally, there are lots of sensing approaches clearly and many visions involved as well. Thanks for coming and making the workshop what it was.

Doug Bauer: On behalf of DHS and the S&T Directorate, thank you very much for coming and we will take your thoughts very seriously coming over. Thanks Carl, for bringing different communities together, thanks everyone from ALERT and all of you have a safe journey home.

MBS: This workshop has been like trying to drink water out of a fire hose. It's been intense, rewarding and we have to sort through it. I don't think we've come to any summative conclusion or come up with the wisdom we need to come up with. We haven't crystallized a path forward like we did in ADSA01 with the grand challenge strategy. It's not an easy problem and we don't know what the sensor is, it's mm-wave, x-ray, a number of things. The notion of a grand challenge in that same format doesn't necessarily play through, but data sets may. We need to have a sense of what the problem is and scope out a specific problem, perhaps, then come up with datasets to illuminate one aspect of the whole problem. I'd like to echo thanks to Carl for his organizational efforts in putting this whole thing together, and all of you for putting in the time and effort.

CC: My apologies for everyone I cut off.

MBS: Meeting adjourned.

19. Presentations

19.1 Carl Crawford, Csuptwo: Call to Order

Algorithm Development for Security Applications (ADSA)
Workshop 3:
Application to Advanced Imaging Technology
(Whole Body Imaging)

Call to Order

Carl R. Crawford
Csuptwo

Umar Farouk Abdulmutallab



MMW images from www.wired.com/dangerroom/2009/12/underwear-bomber-renews-calls-for-naked-scanners/

Richard Reid



3

Goal + Deliverable

- Goal: find advanced algorithms and participants to improve detection of explosives concealed *on* or *in* people
- Deliverable: recommendations to DHS for investment strategy

4

Classification

- Presentations do not include *Sensitive Security* or *Classified* information.
- Everyone else: don't worry about classification

5

Format

- Informal meeting:
 - Presentations to stimulate conversation
 - Agenda is not important
- Ask questions of anyone at any time

6

Thank You

- Thank you for participating

19.2 Carl Crawford, Csuptwo: Workshop Overview and Objectives

Workshop Overview and Objectives

Carl R. Crawford
Csuptwo

Rule #1

- All participants required to
 - Talk
 - Discuss
 - Argue
 - **Interrupt**
- Applies to
 - Academia, industry, government, national labs, students

This is a workshop, not a conference, symposium, tutorial.

Participant Identification

- Biographies and pictures (not AIT) distributed in lieu of formal introductions
- Please identify yourself and institution first time you speak or ask questions
- Minutes will be taken, but edited for final report

3

Bottom Line

- Airplanes still high-profile target and people willing to conceal explosives on or in their body
- A tactic of DHS is to augment capabilities and capacities of traditional vendors of security equipment
- Purpose of this workshop to help facilitate the involvement of 3rd parties in the development of advanced algorithms for detecting threats

4

Technologies

- Millimeter-wave scattering
- X-ray backscatter
- X-ray transmission
- Infrared sensing
- THz imaging and spectroscopy
- Nuclear Quadrupole Imaging
- Nuclear Magnetic Resonance
- Magnetic Resonance Imaging
- Acoustic
- Transmission x-ray
- Other

5

Fusion Assumption

- Assume that single technology will not solve the problem alone
- Fused systems (systems of systems) required

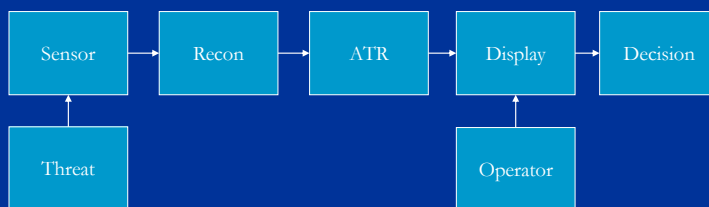
6

Algorithms

- Concept of operations for using sensors
- Modeling of sensors, probe interactions with targets, and clutter sources
- Reconstruction algorithms
- Automated threat recognition (ATR)
 - Anomaly detection
- Sensor and data fusion of multi-sensor systems, including adaptive processing
- Advanced display including privacy filters

7

Generalized Scanner



**Boxes may mean different things to different modalities.
Some modalities may not have all boxes.
Multiple systems may be fused.**

8

Algorithm Definition

- Recipe to perform a task (in scope)
 - Mathematical description
 - Deliverables: report, example code, test cases
- Implementation (out of scope)
 - Product coding: CPU, FPGA, GPU, Cell processor
 - Inputs, outputs, exceptions
 - Integration with other functions
 - Professional coding practices

9

Questionnaire

- Request for everyone to answer questions during the workshop
- Hand in at end of workshop or email
- Questions
 - List of algorithm topics (6)
 - What information and material would you need develop advanced algorithms for AIT?
 - What issues would be barriers for you participating?
 - What did you like about this workshop?
 - What would you like to see changed for future workshops?
 - What topics would you like to see addressed in future workshops?

10

Out of Scope

- Hardware
 - Energy transmit/receive
 - Reconstruction hardware
 - Algorithm implementation
- Policies
 - Profiling
 - Passenger vigilance

11

Process/Agenda

- Presentations □ focus on algorithms
 - Overview
 - Commercial products
 - Emerging technologies
- Identification of advanced algorithms
 - Synthesizers preparing initial presentations
- Working dinner
- Breaks on the fly
- Discussion at all times
- Agenda is guide; will mutate

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Deliverables

- Written report to DHS addressing goals set forth on previous slide
 - Released to public
- Moderator to write report based on
 - Presentations
 - Discussion
 - Questionnaires

13

DHS Goals

- Security System Developers (SSD) doing an excellent job
- But, need
 - Increase probability of detection (PD)
 - Decreased probability of false alarm (PFA)
 - Detect more threats including wide-variation of home-made explosives (HMEs)
 - Reduced mass
 - Reduced labor costs
 - Eliminate human in the loop if possible

14

Some DHS Tactics

- Augment abilities of SSDs with 3rd party involvement
- Sponsor standard data formats
- 3rd parties
 - Academia
 - National labs
 - Industry other than SSDs
- Create centers of excellence (COE) at universities
- Hold workshops to educate 3rd parties and discuss issues with involvement of 3rd parties
- Algorithm development is focus of this workshop

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Threat

- Explosives concealed on or in a person at the checkpoint
- In
 - Body cavity
 - Prosthesis (e.g., breast implant)
 - Swallowed



16

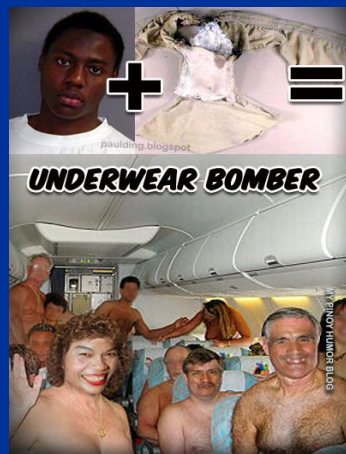
Requirements

- Classified
- Classification causes chicken/egg situation
 - Find a way to break this cycle
- Specs on threat types and mass, PD, PFA, throughput
- Reduce labor costs

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Quality of Life Spec

- ☐ Terrorism causes a loss of life and a loss of quality of life, ☐ Lisa Dolev, Qylur
- Compliance is an issue



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Acronym Soup

- Lots of acronyms, no different than any other field
- Goal is involve people not familiar with acronyms
- Don't know acronym, use Rule #1 ... ask!

19

Security System Vendors (SSD)

- Reveal
- L-3 Communications
- Analogic
- Morpho Detection
- AS+E
- Rapiscan
- Smiths Detection
- Brijot

Excellent equipment developed by very smart people.

20

Academia

- Northeastern University
- Purdue
- Marquette
- Rensselaer Polytechnic Institute
- Boston University
- John Hopkins
- Tufts University
- Harvard
- University of Chicago
- Carnegie Mellon
- George Washington
- East Anglia (UK)

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National Labs

- Lawrence Livermore
- Lawrence Berkeley
- Pacific Northwest
- Oak Ridge

22

3rd Party Industry

- Optosecurity
- TeleSecurity Sciences
- LongShortWay
- Siemens
- Guardian Technologies
- Raytheon
- Tek84
- GE
- General Dynamics

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Government

- Department of Homeland Security
 - Science and Technology Directorate, Washington, DC
 - Transportation Security Laboratory, Atlantic City, NJ
- Transportation Security Administration

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Workshop Planning Committee

- Michael Silevitch, co-chair, Northeastern University
- Carey Rappaport, co-chair, Northeastern University
- Harry Martz, Lawrence Livermore National Laboratory
- David Castañón, Boston University
- Horst Wittmann, Northeastern University
- John Beaty, Northeastern University
- Carl Crawford, moderator, Csuptwo, LLC

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Moderator Roles

- Keep discussions on track
 - Will ask questions
 - Limit off-track discussions
 - Modify agenda
 - End at 4 PM on Wednesday
- Assure delivery of recommendations to DHS

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Logistics

- Mariah Nóbrega, Northeastern University
- Rachel Harger, Northeastern University

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Acknowledgements

- Northeastern University (NEU)
- Awareness and Localization of Explosives-Related Threats (ALERT) Center of Excellence
- Department of Homeland Security (DHS)
- Lawrence Livermore National Laboratory (LLNL)



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Acknowledgements

- Speakers
- Participants
 - For Participating
 - For Completing Questionnaire
- Various people/vendors for supplying presentation materials

29

Funding

- Gov has agreed to find ways to fund 3rd parties
- Implementation and deployment will be resolved later

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Expectations

- Gov + SSDs
 - Open about problems/issues (as much as possible)
 - Current equipment
 - Threats
 - Process
- 3rd parties
 - Understand security problems
 - Look for ways to solve problems

31

Speaker Expectations

- Stick to algorithms
 - Concept of operations for using sensors
 - Modeling of sensors, probe interactions with targets, and clutter sources
 - Reconstruction algorithms
 - Automated threat recognition (ATR)
 - Sensor and data fusion of multi-sensor systems, including adaptive processing
 - Advanced display including privacy filters
- Allow time for questions
- Slides in public domain after security review

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Summary

- Terrorism is real and dangerous
- Let's work together to develop and deploy better equipment

19.3 Tim White, Pacific Northwest National Laboratory: Technology overview – millimeter wave, x-ray backscatter, infrared, magnetic resonance, quadrupole resonance, terahertz



AIT Technology Overview


Tim White
Pacific Northwest National Laboratory
Algorithm Development for Security Applications III
April 27-28, 2010


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Overview of AIT Technologies

<p>Technologies for Personnel Screening</p> <ul style="list-style-type: none"> ▶ mm-wave (active and passive) ▶ X-ray backscatter ▶ X-ray transmission imaging * ▶ IR thermography and spectroscopy ▶ THz imaging and spectroscopy ▶ Nuclear quadrupole resonance (NQR) ▶ Nuclear magnetic resonance (NMR / MRI) * ▶ Trace portals (puffers) ▶ Metal detectors 	<p>Considerations</p> <ul style="list-style-type: none"> ▶ Interaction with threat (signature) <ul style="list-style-type: none"> ■ Physical attribute and geometry of object that can be exploited ▶ Interrogation method ▶ Signature detection ▶ Reconstruction/processing <ul style="list-style-type: none"> ■ Images? Spectra? Data volume? ▶ Strengths/weaknesses <ul style="list-style-type: none"> ■ Confusion (causes of false alarms) ■ Limitations
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* Primarily package screening; may have a role in secondary or body-cavity interrogation


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Summary Table

	Wavelength / energy	Signature	Type of detection	Type of data	Status	Threat Recognition
Active mm-wave	20-40GHz (15-7.5mm)	Anomalous scattering from dielectrics	Anomaly	3D image set	COTS	Human
Passive mm-wave	30-300GHz (10-1mm)	Anomalous attenuation/scattering of natural radiation	Anomaly	2D image sequence	COTS	Human / limited ATR
X-ray backscatter	50-125kVp	Differential scattering (Z_{eff} , ρ)	Anomaly	2D image	COTS	Human
Thermography	8-10 μ m (37.5-30THz)	Differential transmission of thermal emission from body	Anomaly	2D image sequence	COTS	Human
IR spectroscopy	8-13 μ m (37.5-23THz)	RF absorption bands due to molecular vibrations	Material ID	Spectrum Spectral image	COTS, lab	automated
THz imaging	0.1-3THz (3-0.01mm)	Anomalous attenuation /scattering from dielectrics	Anomaly	2D image sequence (~4Hz)	COTS, lab	Human
THz spectroscopy	0.1-3THz (3-0.01mm)	RF absorption bands due to molecular vibrations	Material ID	spectrum	lab	Automated(?)
NQR	0.5-5MHz	RF resonance (molecular environment or N content)	N content, Material ID	spectrum	COTS, lab	Automated
Trace Portals (puffers)		IMS (or MS) spectral match	Material ID	spectrum	COTS	Automated
Metal Detectors		Eddy current induced in metals	Anomaly (metal)	Alarm (1-2D field pert.)	COTS	Automated
X-ray transmission imaging	80-160kVp	Differential attenuation (Z_{eff} , ρ)	Anomaly (explosive det. (CT))	2D image	COTS	Human / Automated
NMR	kHz	Characteristic decay of RF signal from 1H	Material ID	3D material map	COTS, lab	Automated

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Ground Rules

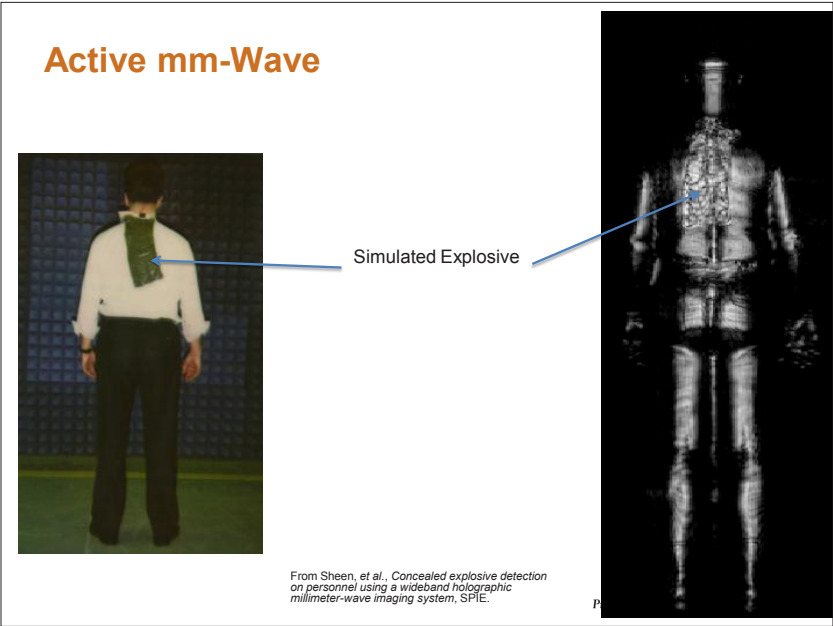
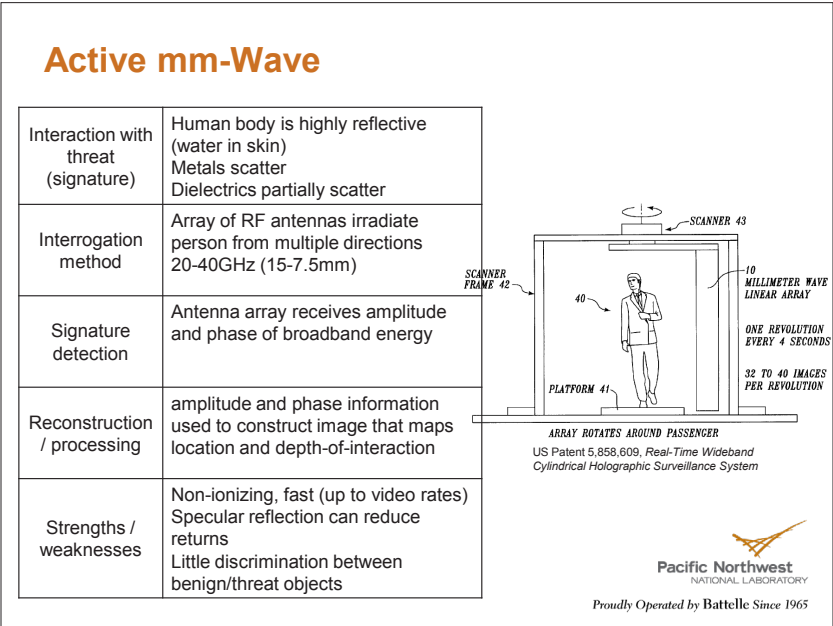
- Images are illustrative
- No vendor preferences
- Slides should be considered to be a works-in-progress ☐ comments, suggestions, criticism welcome
- Not Covered:
 - Ultrasonics
 - Vulnerabilities
 - ConOps

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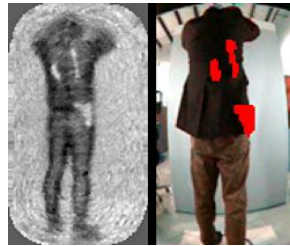


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Passive mm-Wave

Interaction with threat (signature)	Same as active □ body is emitter and reflector of environmental radiation
Interrogation method	Detect black-body radiation from person or reflected from environment 30-300GHz (10-1mm)
Signature detection	Antenna array receives amplitude of broadband energy Weak signals require highly sensitive amplifiers and long integration time
Reconstruction / processing	Physical focusing optics (lenses or reflectors) coupled to moderately sized arrays and scanning mechanisms to form images
Strengths / weaknesses	Non-ionizing Can be real time One sided Low-signal



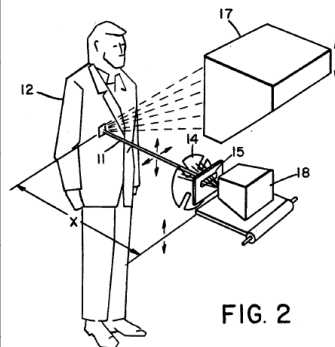
From <http://www.millivision.com/>

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X-Ray Backscatter

Interaction with threat (signature)	Photoelectric absorption (high-Z) & Compton scatter (low-Z) Body acts as a scatterer; threats attenuate signal
Interrogation method	Bremstrahlung x-ray pencil beam 50 or 125kVp (~0.01nm)
Signature detection	Large area detector(s) integrate over scatter angle One-sided system
Reconstruction / processing	Scatter intensity as a function of pencil-beam direction
Strengths / weaknesses	Penetrates clothing May require multiple poses Ionizing radiation (low dose)

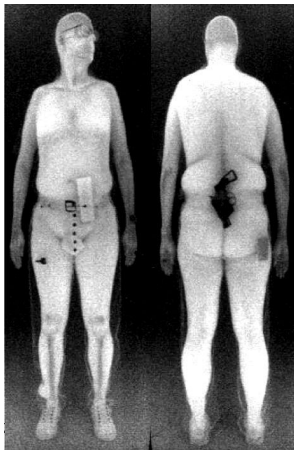


US Patent 5,181,234, X-ray Backscatter Detection System

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Backscatter Images



<http://www.diagnosticimaging.com/news/display/article/113619/1521147> Proudly Operated by Battelle Since 1965

X-Ray Transmission Imaging

Interaction with threat (signature)	Photoelectric absorption & Compton scatter, $f(E, Z_{\text{eff}}, \rho)$ Line-integrals of attenuation
Interrogation method	Diagnostic imaging x-ray energies (80 - 120kVp) Fan- or cone-beam Bremsstrahlung
Signature detection	1D or 2D position sensitive detector arrays Motion (and time) required for CT
Reconstruction / processing	Pixel intensity indicates attenuation along beam (radiography) or weighted attenuation coefficient (CT)
Strengths / weaknesses	High spatial resolution Poor material discrimination (radiography) Ionizing radiation

Primarily baggage inspection; could be used in secondary for body-cavity inspection
Ultra-low-dose systems under development for personnel screening



<http://astrophysicsinc.net/>
http://www.deetee.com/en_US/security.html

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Passive Thermography

Interaction with threat (signature)	IR absorption is a function of molecular vibrations and rotations Variable absorption / emittance of IR by materials between body and detector
Interrogation method	Blackbody radiation from body 8 – 10 μm (possibly 3-5 μm)
Signature detection	2D detector (camera) Up to 30fps $\pm 1^\circ\text{C}$ (0.1 μm)
Reconstruction / processing	Pixel intensity proportional to temperature Attenuation by / non-equilibrium of threats
Strengths / weaknesses	Non ionizing, fast Low-resolution Low penetration through clothing



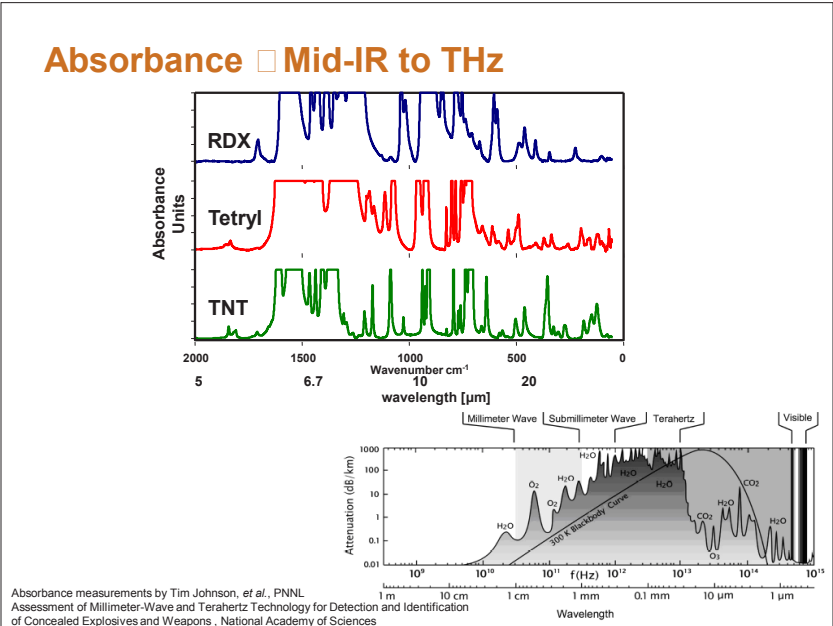
http://www.nec-avio.co.jp/en/products/ir-thermo/lineup/tvs200is_tvs500is/index.html

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IR / THz Spectroscopy

Interaction with threat (signature)	Molecular resonances (absorption by molecular vibration) Characteristic spectrum for materials	Molecular resonances (rotation and torsional states) Characteristic spectrum Transmission through optically thin materials or reflection from bulk
Interrogation method	Solar radiation (passive) or external source (flashlamp, QCL) 8-13 μm	EM waves (0.1 – 3 THz, 3 – 0.08 mm) typically generated in the time domain using femtosecond lasers
Signature detection	IR Imaging detector	Transient waveform or amplitude and phase of signal over frequency range
Reconstruction / processing	Match absorption spectrum to threat in image	Spectra obtained by Fourier Transform of transient signals. Focusing using optical techniques.
Strengths / weaknesses	Identification Surface technique COTS equipment, lab experiment	Identification Variable atmospheric attenuation interferes with spectrum Reflection from non-flat objects alters spectra

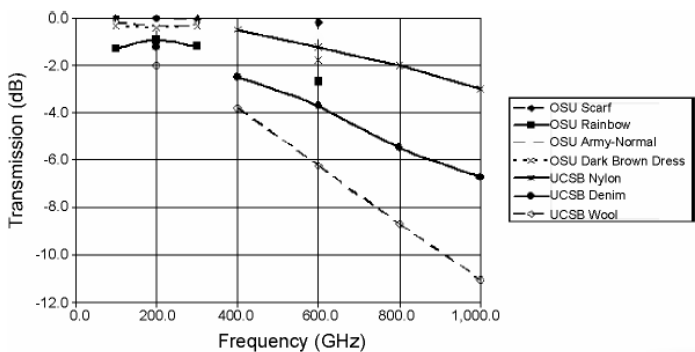


THz Imaging	
Interaction with threat (signature)	Passive □ similar to passive mm-wave Active □ similar to active mm-wave
Interrogation method	Active or passive systems are possible (active systems can be time-domain or frequency domain) 0.1 □ 3 THz
Signature detection	Passive -- detect thermal energy (amplitude) Active -- detect transient waveform or amplitude and phase of scattered wave
Reconstruction / processing	focusing optics (reflectors and lenses) Depth information obtained directly with time-domain systems, or using FFT for frequency-domain systems
Strengths / weaknesses	High spatial and depth resolution Some clothing reflective Time domain systems can be slow

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THz Imaging

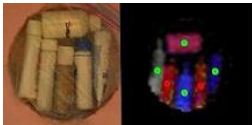


Assessment of Millimeter-Wave and Terahertz Technology for Detection and Identification of Concealed Explosives and Weapons, National Academy of Sciences

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Nuclear Magnetic Resonance (NMR)

Interaction with threat (signature)	Local environment of spin-1/2 nuclei (¹ H) determined by relaxation time Relaxation time correlated with different materials
Interrogation method	Alignment of nuclear spins in static field and perturbation with RF field (kHz)
Signature detection	Point-by-point (3D) imaging of relaxation times by RF coil
Reconstruction / processing	FFT-based inversion
Strengths / weaknesses	Material discrimination Applications for liquids, small packages Potential for person screening



http://www.dhs.gov/files/programs/gc_1234452906195.shtm

Primarily baggage inspection; could be used in secondary for body-cavity inspection

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Nuclear Quadrupole Resonance (NQR)

Interaction with threat (signature)	Local environment (local nuclear fields of nuclei with spin > 1 (^{14}N)) Or detect presence of ^{14}N
Interrogation method	Sweep through RF (0.5-5MHz) to find resonances
Signature detection	RF coils Look for resonances for specific materials (TNT, RDX, HMX, PETN)
Reconstruction/processing	Spectral matching (automated)
Strengths/weaknesses	Very specific Must be solid phase Temperature dependence



<http://www.morphodetection.com/technologies/quadrupole-resonance/>

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Metal Detectors

Interaction with threat (signature)	Conductivity or magnetic permeability of materials
Interrogation method	Induction coil(s) sweep frequencies inducing eddy currents in metals
Signature detection	Detect signal as EC decays Work in time or frequency domain, (EM induction)
Reconstruction / processing	Red-light, green-light Coarse 1D or 2D spatial resolution
Strengths / weaknesses	Fast False alarms Insensitive to some threats



<http://www.rapiscansystems.com/motor250.html>
http://www.garrett.com/security/s_pd6500i_key.htm

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Magnetometers are passive devices that look for perturbations of Earth's field from ferrous materials and have nT sensitivity (Earth's field ~5nT)

Trace Portals (Puffers)

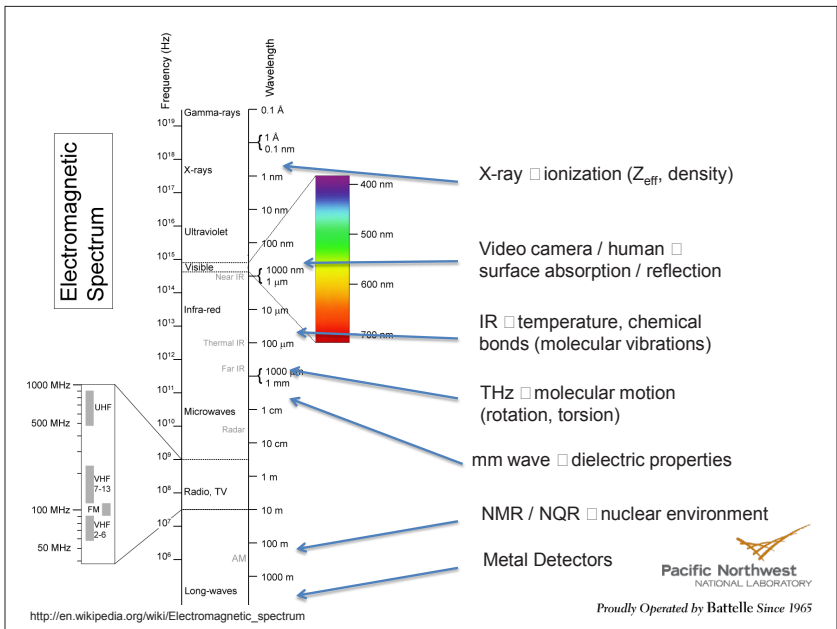
Interaction with threat (signature)	Threat and related-compound specific characteristic spectra
Interrogation method	Remove particulates from body with air pulses and move into ion-mobility spectrometer (or mass spectrometer) 10-15 second screening
Signature detection	Pre-concentration of air flow, ionization of particles, flow through magnetic field
Reconstruction/processing	Match library spectra to measured spectra Red-light / green-light
Strengths/weaknesses	Very sensitive Concealment of threat difficult Almost completely non intrusive Hard to keep clean, loud



<http://www.smithsdetection.com/eng/Sentinel.php>


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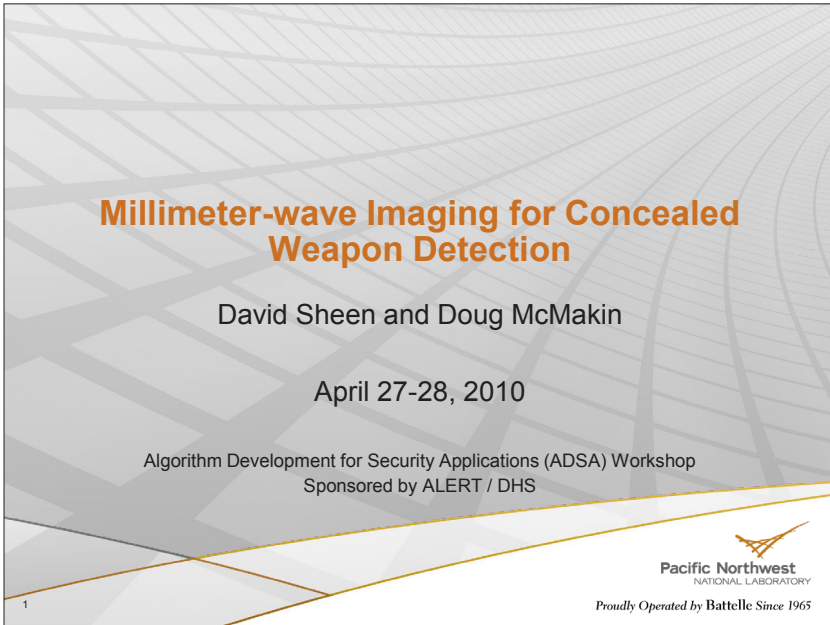


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19.4 David Sheen, Pacific Northwest National Laboratory: Technology Details: Millimeter Wave




**Millimeter-wave Imaging for Concealed
Weapon Detection**

David Sheen and Doug McMakin

April 27-28, 2010

Algorithm Development for Security Applications (ADSA) Workshop
Sponsored by ALERT / DHS


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Outline

- ▶ Introduction and background
 - Concealed weapon detection
 - Millimeter wave imaging
 - Commercialized mm-wave imaging technology
- ▶ Rectilinear imaging technique and results
- ▶ Cylindrical imaging technique and results
- ▶ Conclusions

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Terrorist Threats

- ▶ Explosives
- ▶ Suicide vests
- ▶ Weapons
 - Guns
 - Knives
 - Etc.
- ▶ Nuclear, biological, or chemical materials carried in sealed containers




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Introduction

- ▶ Weapon and explosive detection are critical for airports and other high-security facilities
- ▶ Metal detectors are unable to detect non-metallic weapons and explosives, and are not useful for identification of detected material
- ▶ Millimeter-wave imaging is an effective method of detection and identification of items concealed on personnel
- ▶ Electromagnetic waves
- ▶ Frequency range: 30 – 300 GHz
 - UHF 0.3 – 1 GHz
 - Microwave: 1 – 30 GHz
 - Millimeter-wave: 30 – 300 GHz
 - Terahertz: 300 GHz – 10 THz
- ▶ Wavelength range: 1 - 10 mm
- ▶ Microwaves/Millimeter-waves
 - Communication
 - Radar tracking, imaging (SAR), Police radar
 - Readily penetrates many optical obscurants
 - Reflected by objects and human body


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Weapon Detection Imaging Technologies

- ▶ Active millimeter-wave
 - Battelle, PNNL (wideband holographic)
 - L3-Communications / SafeView (commercial partner)
 - Smiths (Agilent technology)
- ▶ Passive millimeter-wave imaging systems using FPA's and high-speed scanning
 - QinetiQ
 - Trex
 - ThruVision
 - Millivision
 - others
- ▶ Low-power X-ray backscatter imaging
 - AS&E Inc. (*BodySearch*)
 - Rapiscan (*Secure 1000*)



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Brijot Passive Millimeter-wave Imaging System

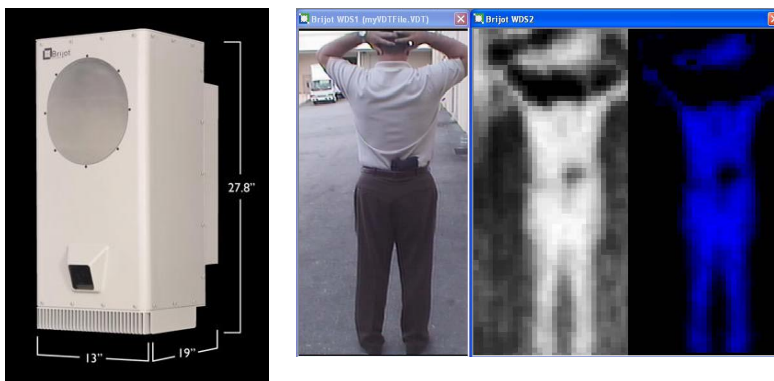


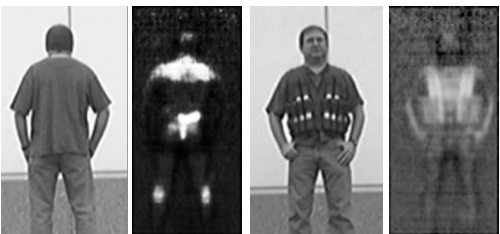
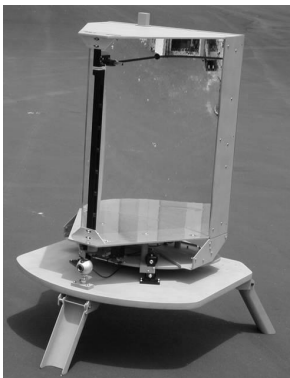
Image from the Brijot BIS-WDS™ Prime that shows a concealed handgun at the rear belt line (Images courtesy of Brijot Imaging Systems)



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Trex / Sago Passive Millimeter-wave Imaging System

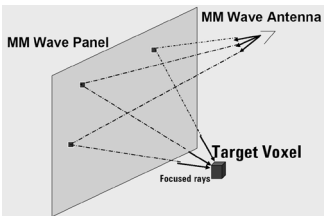


Sago ST150 passive millimeter-wave imaging concealed weapon detection system (Images courtesy of Trex Enterprises / Sago)

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Agilent Active MM-wave Imaging Technology



Agilent reflector array operation. Millimeter-wave reflector array panel alters the phase of the transmitted wavefront to allow high-speed digitally controlled focusing over a range of target voxel locations. (Images courtesy of Agilent).

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PNNL Active Wideband Holographic Imaging

Wideband Image of Mannequin and Concealed Glock 17 (100 - 112 GHz)



Optical



100 - 112 GHz

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Advantages of Millimeter-wave Holographic Imaging Technique

- ▶ Active scanned source imaging results in 2X improvement in image resolution
- ▶ Near-field, large aperture, for simultaneous high resolution, wide illumination imagery
- ▶ Focusing done using computer reconstruction, no lens or reflector required
- ▶ Wideband techniques enable 3-D volumetric imaging
- ▶ Millimeter-waves are low power and non-ionizing and pose no health threat
- ▶ Wide angular illumination suppresses undesirable specular reflection of many targets

- ▶ Lateral Resolution

$$\delta_x = \frac{\lambda}{2} F\#$$

$$= 0.5 \text{ cm at } 30 \text{ GHz}$$

- ▶ Range Resolution

$$\delta_r = \frac{c}{2B}$$

$$= 2.5 \text{ cm at } 27 - 33 \text{ GHz}$$

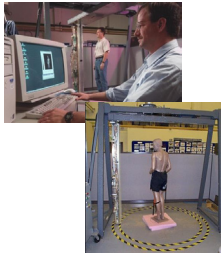
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Licensed Commercial Cylindrical Holographic Imaging Systems

PNNL cylindrical prototype system



L-3 ProVision system deployed in London



Intellifit body measurement system



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L-3 ProVision



► Active Millimeter Wave Portal

- Walk-through – stop 2 seconds
- Detects metals, and non-metals (ceramics, wood, plastic, etc.)
- Liquids and gels
- Paper and coin currency
- Safe radio waves
- Non-ionizing (not x-ray)
- Low power
- Fast: 300 – 600 people per hour

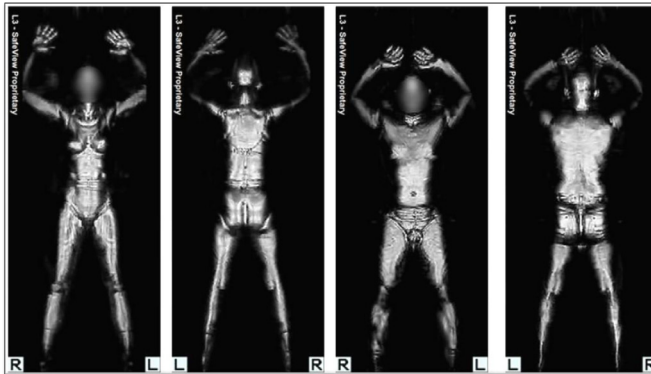


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Millimeter-wave Images from the L-3 ProVision[®] system



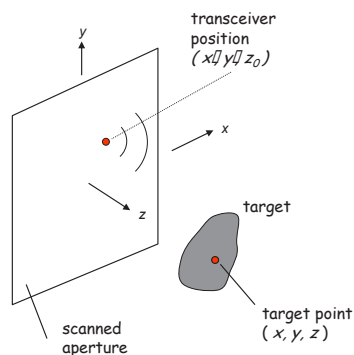
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Holographic Millimeter-wave Imaging Technique

- ▶ Transmit antenna emits diverging (spherical) wave
- ▶ Receiver records amplitude and phase of scattered wavefront
- ▶ Transmitter/receiver, or transceiver, is scanned over a two-dimensional planar aperture and swept over a wide frequency bandwidth
- ▶ 3-D image formed using mathematical focusing
 - Holographic, wavefront reconstruction
 - Fourier transform based - efficient

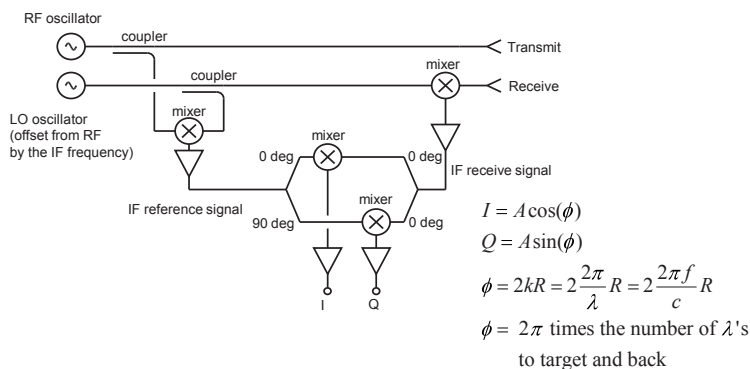


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Millimeter-wave Transceiver (Heterodyne)



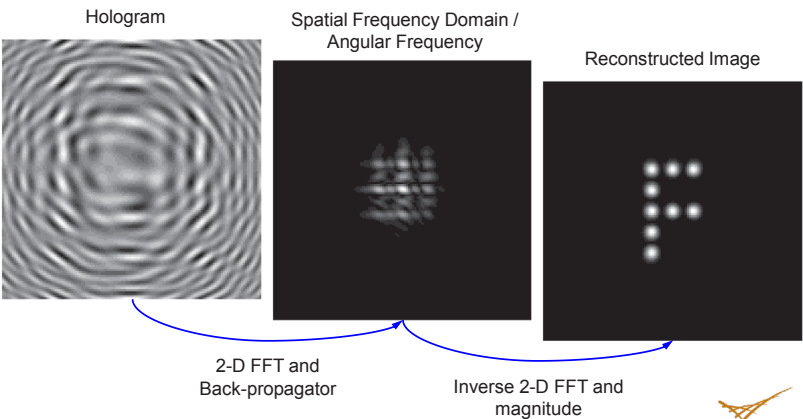
Measures phase and amplitude of scattered wavefront with high sensitivity



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Holographic Image Reconstruction

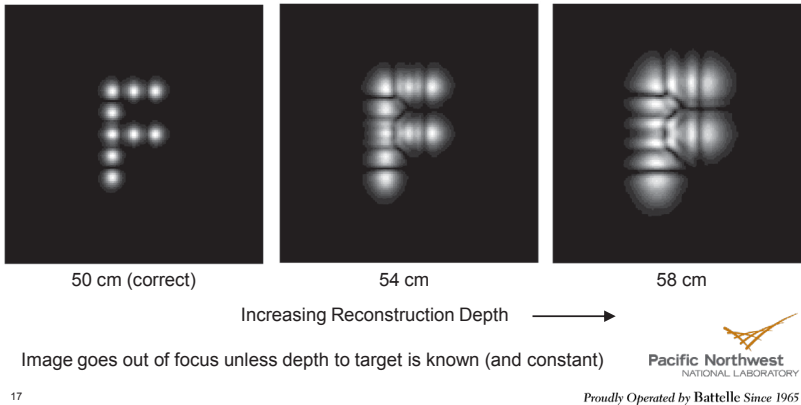


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Holographic Reconstruction □ Depth of Focus

- ▶ A depth must be specified for single frequency holographic image reconstruction



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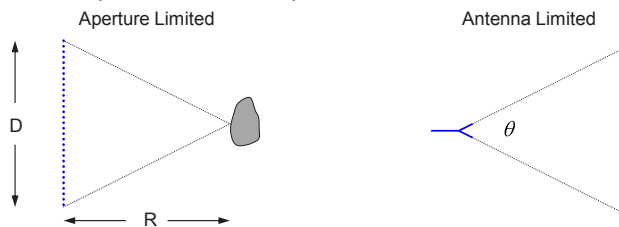
Wideband 3-D Image Reconstruction

- ▶ Limitations of single frequency holographic imaging
 - Cannot measure the range to the target and therefore the correct depth of focus is unknown
 - Images of objects that have a range of depths cannot be in complete focus, i.e. only portions of the image will be focus
- ▶ Recording the amplitude and phase of the wavefront over a range of frequencies can provide fully 3-D imaging
- ▶ 3-D Algorithm
 - 2-D Spatial Fourier Transforms decompose wavefronts into plane waves at known angles
 - Interpolation onto uniform 3-D spatial frequency domain grid
 - Phase term back-propagates the plane wave to the object's plane
 - 3-D Spatial Inverse Fourier Transform converts back to spatial domain
 - Maximum value projection typically shown – full 3-D information available

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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)



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



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Range Resolution

- ▶ Range resolution is determined by the bandwidth of the system
- ▶ The distance between two distinct targets must be sufficiently large so that one additional cycle is generated in the I or Q waveforms during the sweep

$$\delta_r = \frac{c}{2B}$$

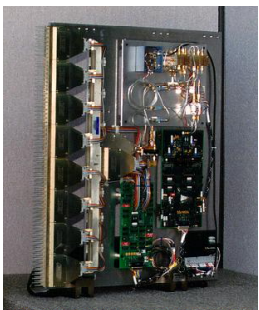
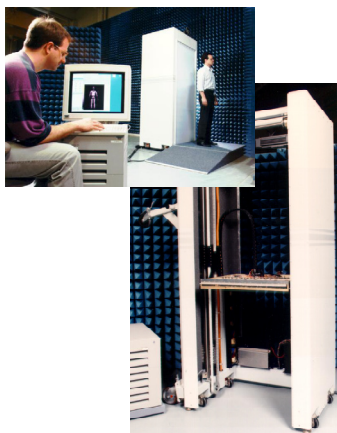
- ▶ For example, a bandwidth of 10 GHz (e.g. 10-20 GHz operation) results in a range resolution of 1.5 cm



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Prototype Wideband Imaging System



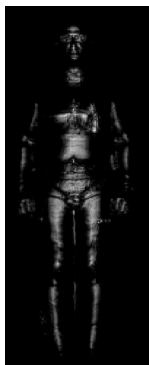
- K-a band switched linear array
- 27 - 33 GHz
- 128 elements
- Pin-diode switching
- 5.7 mm sampling
- 0.73 meter aperture

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Comparison of Wideband and Narrow-band Millimeter-wave Images



Wideband images of man at 27 - 33 GHz



Narrowband images of man at 35 GHz

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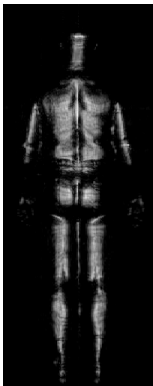
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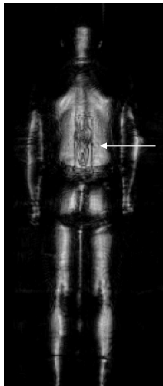
Wideband Image of a Man with Concealed
RDX Plastic Explosive (27 □ 33 GHz)



Optical - plastic
explosive



No explosive



Concealed explosive



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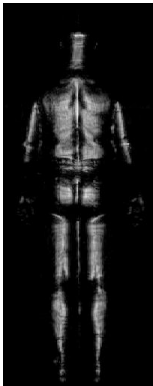
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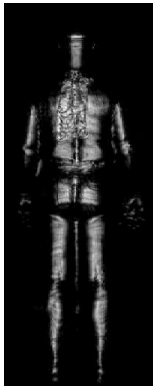
Wideband Images of Man with Plastic
Explosive Simulant (27 □ 33 GHz)



Optical - duct putty
explosive simulacrum



No explosive



Concealed explosive



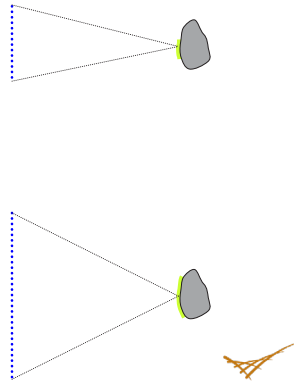
Pacific Northwest
NATIONAL LABORATORY

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24

Wide Angle Illumination

- ▶ Wide-angle illumination is critical
 - Lateral resolution is proportional to $1/\sin(\theta)$
 - Many targets are smooth compared to the wavelength in the microwave and millimeter-wave frequency ranges
 - Specular reflection will prevent scattered wavefront from returning to the transceiver
- ▶ Technique does not have inherent blind spots – images reflectivity, which can be low in the backscattered direction

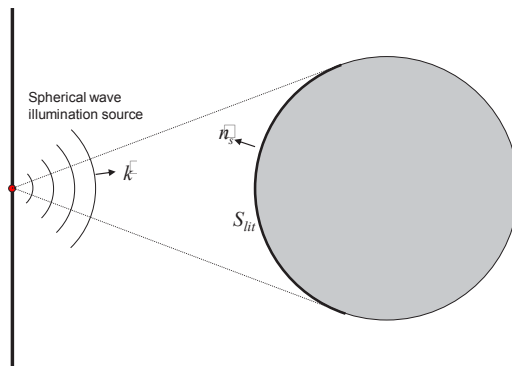


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Physical Optics Scattering from a Cylinder

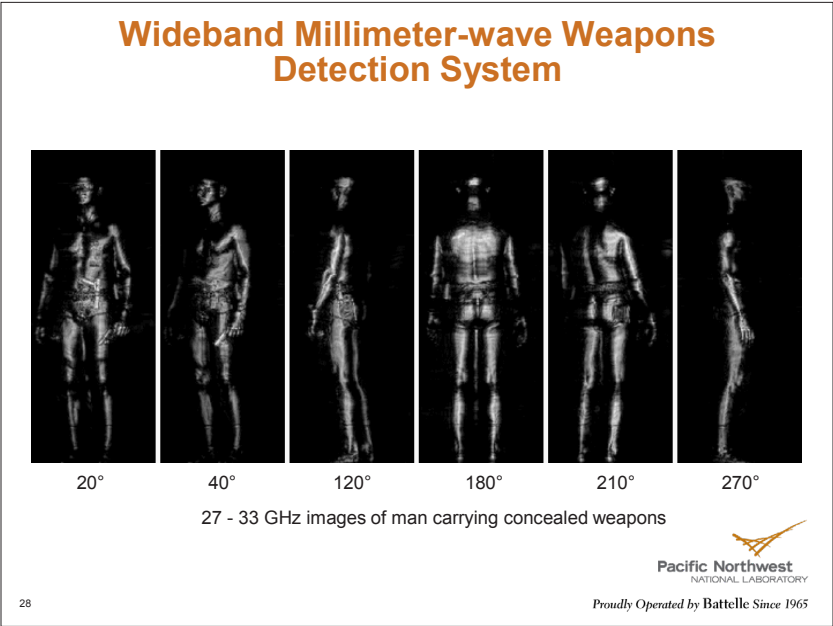
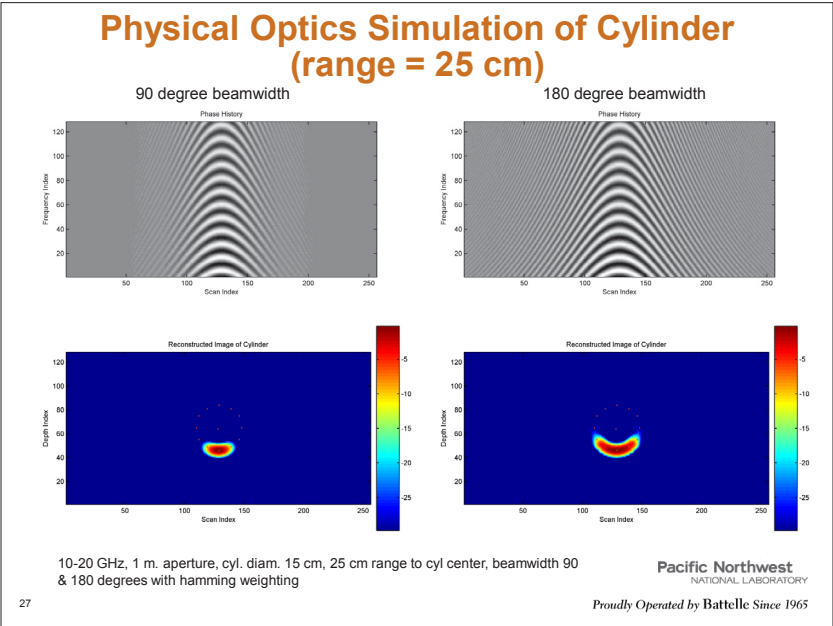


$$\vec{E}^s(\vec{r}) = \frac{jkZ_0}{4\pi} \iint_{S_{Ht}} \vec{k} \times \vec{k} \times (2\vec{n}_s \times \vec{H}^i) \frac{e^{-jk|\vec{r}-\vec{r}'|}}{|\vec{r}-\vec{r}'|} dS$$

Pacific Northwest
NATIONAL LABORATORY

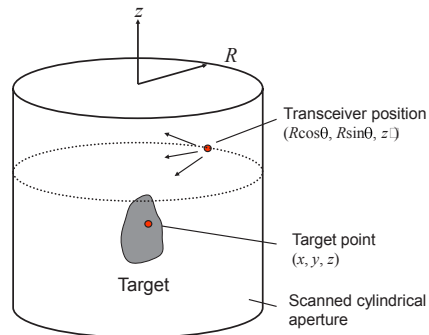
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26



Cylindrical Imaging Technique

- ▶ Novel wideband image reconstruction algorithm has been developed which allows for fully focused 3-D imagery from a single cylindrical data set
- ▶ Reconstruction algorithm based almost entirely on Fourier Transforms which are implemented efficiently using the FFT algorithm
- ▶ Algorithm is readily separated into parallel instructions for parallel processing computers
- ▶ Viewing angle may be rotated about the subject to form a 3-D video animation of the resulting image data



Wideband reflection data gathered over a 2D cylindrical aperture

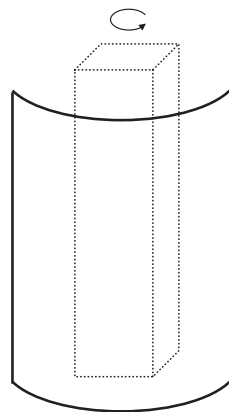
Pacific Northwest
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Rotating Target 3-D Reconstruction

- ▶ Reconstruction (x, y, z) volume rotates with angular arc segment
 - 90 deg. arcs typical
 - Maximum value projection typically displayed
- ▶ Images are combined to form a video animation of the rotating target
- ▶ Bandwidth of millimeter-wave illumination is important
 - Depth of field (focusing)
 - Additional exploitation of depth (combined cylindrical imaging technique)



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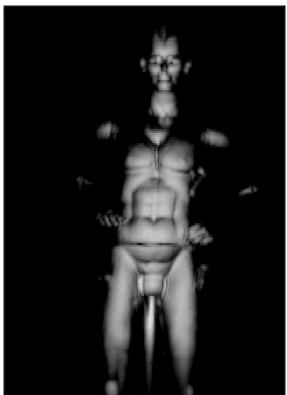
Proudly Operated by Battelle Since 1965

30

Cylindrical Imaging Results at 10 □ 20 GHz



Optical – 3 glass vials



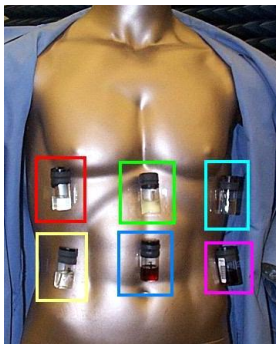
10 – 20 GHz



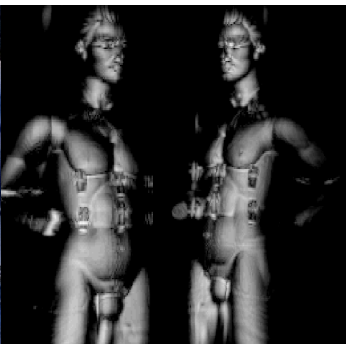
Proudly Operated by Battelle Since 1965

31

Ka Band Images of Mannequin and Concealed Glass Vials



Optical



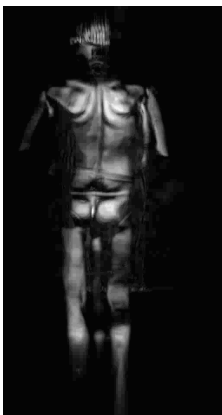
22 – 33 GHz Images



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32

Cylindrical Imaging (24 - 40 GHz)

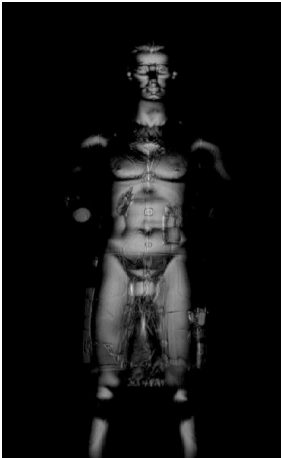


Cylindrical

33

Cylindrical Holographic Radar Imaging Results (40 □ 60 GHz)

Mannequin with Concealed Threats



34

Conclusion

- ▶ Active mm-wave imaging is effective for security screening
 - Cylindrical portal imaging technology is becoming widely deployed
 - Excellent illumination properties due to the 360 degree (or wide angle) illumination
 - Allows inspection from multiple viewing angles
 - High-resolution
 - Excellent clothing penetration at in the lower mm-wave band
 - Scanning is rapid (several seconds), with throughput of over 400 people/hour possible
 - Cost effective
 - 3-D imaging provides additional information
 - Preserves focus (depth of field)
 - Allows exploitation of depth information or layered reflections for additional target detection techniques
- ▶ Standoff imaging is being explored using sub-mm imaging

19.5 Michael Fleisher, L-3 Communications: Commercial products and algorithmic needs — Millimeter Wave

**communications**
Security & Detection Systems

**L-3 Communications
Security & Detection Systems**

ProVision ☐

ProVision ☐ **ATD**
(Automatic Threat Detection)



This presentation consists of L-3 Communications Corporation general capabilities information that does not contain controlled technical data as defined within the International Traffic in Arms (ITAR) Part 120.10 or Export Administration Regulations (EAR) Part 734.7-11.

Agenda

- Checkpoint Challenges
- ProVision, ProVision **ATD**
 - ☐ Highlights
 - ☐ How ProVision Works
- Summary

How ProVision Works?



L3 Proprietary

L-3 Passenger Security Screening Solution
ProVision[®] and ProVision[®] ATD - Key Features Summary

	ProVision [®]	ProVision [®] ATD (ATD = Automatic Threat Detection)
Category	High Resolution Imaging System	Non-Imaging System
Regulator Approval	TSA Qualified	Currently under evaluation by regulators
Safety	Harmless Radio Waves Non-Ionizing	Harmless Radio Waves Non-Ionizing
Privacy Data Protection	No Data Storage Multiple Levels of Privacy Protection	Eliminates Privacy and Data Protection concerns [Image-Free]
Detection	Operator Analysis	Operator Assist OR Fully automated
Throughput	Aviation : 250 pph	Expected: >350 pph
Cost of ownership	Operators and Image Analysts	Operators, but No need for Analysts

4

Security & Detection Systems

ProVision Highlights**Address ALL Passenger Screening Considerations****Passengers Perspective****• Health & Safety**☐ **Active Millimeter Wave (MMW) Technology = Harmless radio waves**

- About 10,000 times **less** power than common household RF devices
- **NOT** X-ray technology

• Privacy & Data Protection☐ **ProVision**

- Shows a 3-D silhouette, which is not stored
- Options for image blurring, remote viewing and gender-specific viewing
- No data storage; Secured access

☐ **ProVision ATD (NON-IMAGING SYSTEM)**

- Eliminates Privacy & Data Protection concerns.

• Convenience

- ☐ **One pose only:** Passenger assumes one position and does NOT have to rotate.
- ☐ **Less than 2 second scan time**

Airport/Regulator Perspective**• Security/Detection**☐ **High resolution provides visibility of ANY material: Low and high density, reflective and non-reflective materials:**

- Metal, powders, plastics, liquids, gels, very thin sheet and bulk explosives

☐ **ProVision - TSA Qualified**☐ **ProVision ATD**

- Under Evaluation by regulators;
- Operational in several airports in Europe

• Throughput

- ☐ **~200** ☐ **400 people per hour**, depending on operational mode and configuration
- ☐ **Less than 2 second scan time**

• Operational Cost

- ☐ **Flexible configurations**

**ProVision ATD (Automatic Threat Detection)**

Non-imaging system
Ultimate Solution to Privacy Concerns

Automatic Threat Detection Benefits

- **Machine-based detection: No human factor**
- **Enhanced privacy with mannequin image**
 - *No System Image*
- **Improved throughput**
 - *No Analysis Time*
 - *Directed searches*
- **Ease of use**
 - *Minimal training*
- **Operational cost savings**
 - *No additional security personnel*



L3 Proprietary

Automatic Threat Detection ConOps

- Two Options Available:
 - **Auto Assist** helps remote analysts to identify the presence and location of concealed objects
 - Potential threats are highlighted with a red outlined box around the area of interest and displayed to the image analyst
 - Analyst verifies the areas of interest, which are then displayed to the operator as a mannequin with red boxes highlighting the region(s) of interest
 - **Auto Detect** identifies areas of interest automatically □ no images generated and no analyst required
 - Areas of interest are displayed to the operator as a mannequin with red boxes highlighting the region(s) of interest

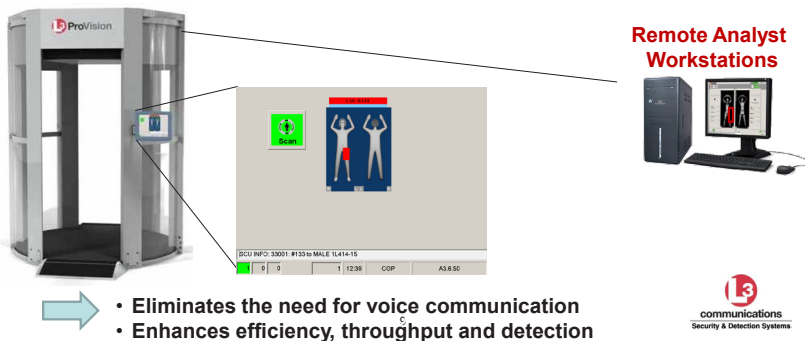


L-3 Proprietary

Option 1: Auto Assist

Auto Assist helps remote analysts identify the presence and location of concealed objects:

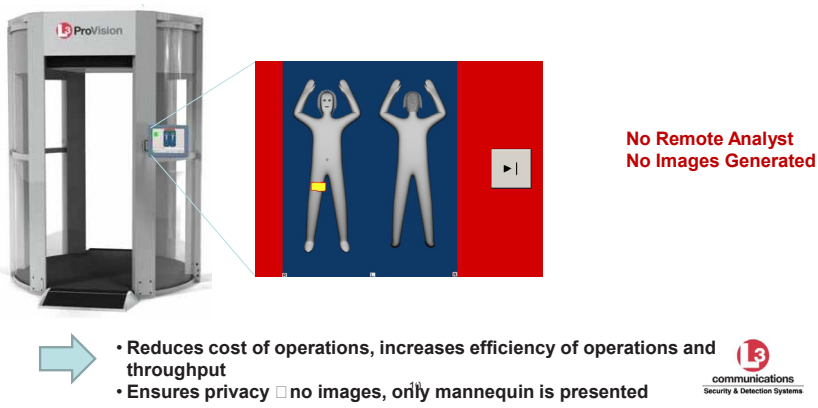
- ☐ Potential threats are highlighted to the analyst with a red outlined box on the image
- ☐ Analyst reviews the areas of interest and marks/confirm the suspected objects
- ☐ Analyst assessment is displayed to the operator as a mannequin with red boxe(s) highlighting the region(s) of interest



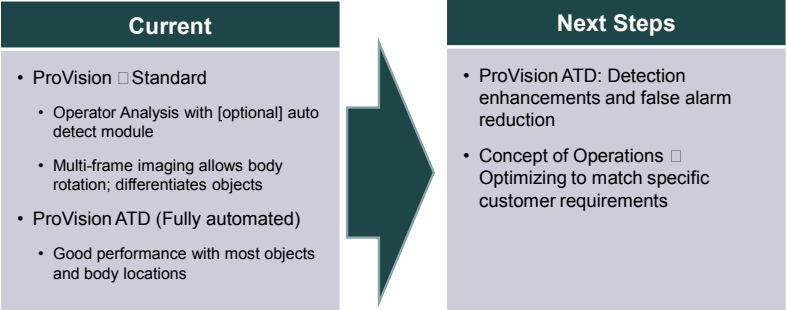
Option 2: ProVision *ATD*

Image-free solution to identify presence and location of concealed objects:

- ☐ Areas of interest are displayed to the operator as a mannequin with yellow boxe(s) highlighting the region(s) of interest



Vision: Upgradeable Path



L-3 Proprietary



Thank You!



19.6 Markus Schiefele, American Science and Engineering: X-ray backscatter

SmartCheckHT ☐
The AIT from AS&E

Dr. Markus Schiefele, 4-27-2010

AMERICAN SCIENCE AND ENGINEERING, INC.


AS&E




SmartCheck in a Nutshell

AS&E

- Personal Screening System from AS&E (X-Ray based)
- Uses patented Z ☐ Backscatter® technique
- Two Versions available:
 - ☐ Single Sided
 - ☐ Double Sided (SmartCheckHT)
- Transmission Image available on HT System
- X-Ray Dose per scan equivalent to ~2min @ 30,000ft



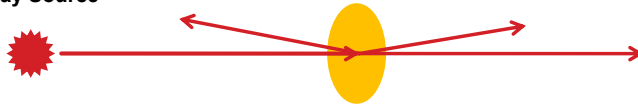
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X-Ray Interaction with Matter



X-Ray Source

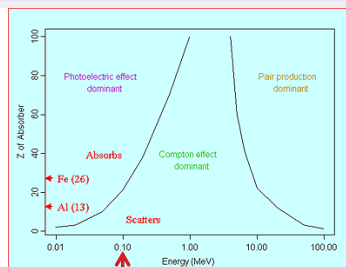
Specimen



- Transmission
- Backscatter (Compton Effect)
- Forward Scatter
- Photoelectric Effect

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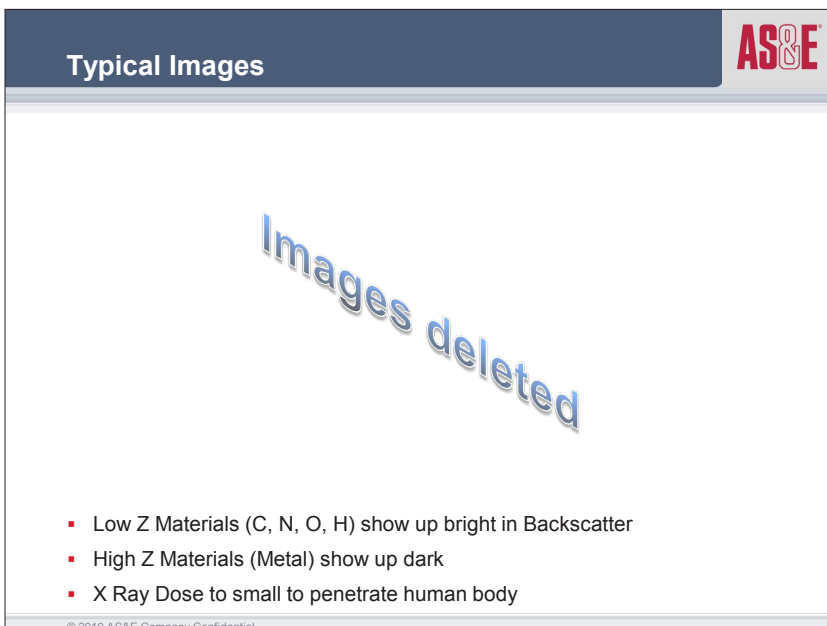
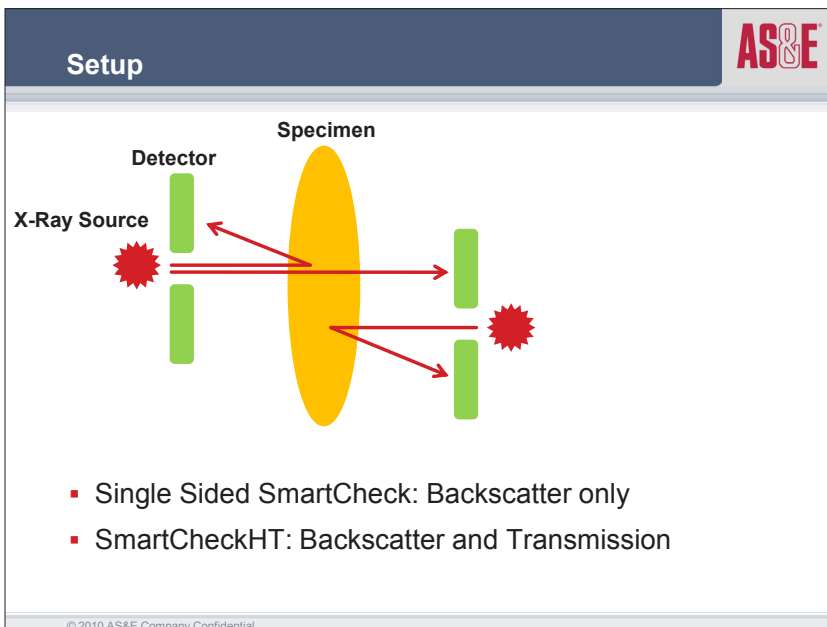
Dominant Effect




SmartCheck

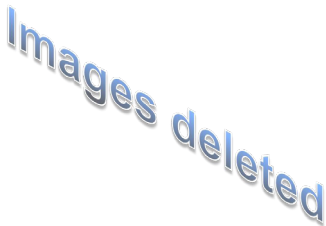
- Dominant Effect depends on atomic number Z and X Ray energy
 - ☐ Low Z : Backscatter dominant
 - ☐ High Z : Photo Effect dominant

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Why Transmission?






- Metal Threats on the side of a person show very well in the Transmission Image

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Challenges



- Only one Chance
 - One Sensor, One Image
- Privacy
 - Sensor Images can not be freely displayed
- High Throughput, unforgiving for errors

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Challenges ☐ Continued

AS&E

- Body features can look a lot like threats!

Images deleted

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Challenges ☐ Continued

AS&E

- Threats can blend in well with the human body

Images deleted

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The last slide

AS&E

- Thank you for your attention!
- Questions?

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19.7 Pia Dreiseitel, Smiths Detection: Millimeter wave

smiths detection
bringing technology to life

People screening at Smiths Detection

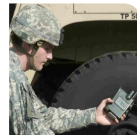
Opportunities for advanced algorithm development

April, 2010

Pia Dreiseitel, Smiths Detection Wiesbaden



www.smithsdetection.com



© 2010 by Smiths Detection: Proprietary Data

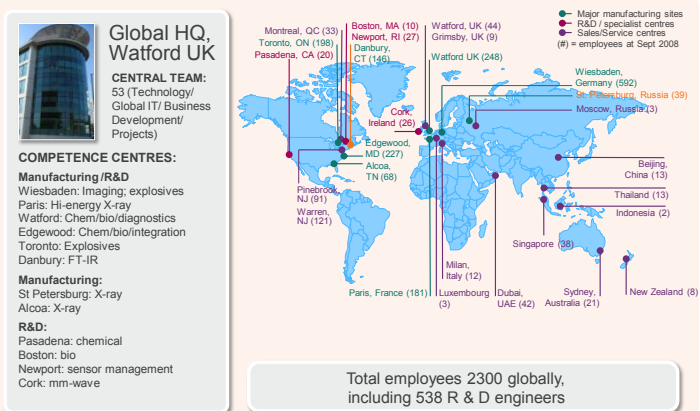
Outline

- Smiths Detection overview – who we are and what we do
- People screening at Smiths
 - Using millimeter waves – eqo
 - Using X-ray – B-Scan
 - Using trace detection – Sentinel
 - Using multi-threat technologies
- Challenges with auto detection in people screening versus baggage screening
- Collaboration models with Smiths

smiths detection

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Smiths Detection has true global presence



smiths detection

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Smiths has a broad range of technologies for different markets

 Technologies	Chemical		Biological	Rad/Nuc	Explosives		
	IMS/ trace	FTIR (Chem ident.)	PCR/ (bio)	Hi-energy X-ray Spectrometry	X-ray ind. hi-energy	mm-wave Backscatter	IMS/ trace
Markets							
Transportation	■					■	
Ports & Borders	■			■			■
Critical Infra.	■	■	■		■	■	
Military	■		■				■
Emergency Response	■	■	■				■

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Security and Inspection

Wide range of technologies


Millimetre wave


Checkpoint X-Ray


Explosives Detection System


Sensor management


Cargo X-Ray


Explosives Trace Detection

Searching for: explosives, weapons & contraband in a wide range of markets


Airport Security


Critical Infrastructure


Ports & Borders

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People screening at Smiths – eqo

High Resolution Image
excellent detection

Full Motion Image
live video image display

Rapid Processing
real time evaluation for high throughput



Minimal Footprint
open plan operation & easy integration

No Moving Parts
low service & maintenance

Privacy Solutions
Remote image view, filters, data delete

smiths detection

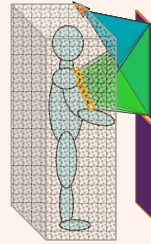
6
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249

People screening at Smiths – eqo

How It Works

- Active system
- Energy signal introduced to person
- Active volume/surface scanned with detectors
- Reflected Signal detected and analyzed



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People screening at Smiths – B-SCAN

Transmission x-ray

Single View Systems*BS 16HR-FB (dose $\leq 2.0 \mu\text{Sv} / \text{scan}$)*

- Excellent Transmission image at medium dose
- Currently used in prisons

BS 16HR-LD (dose $\leq 0.1 \mu\text{Sv} / \text{scan}$)

- New variant for normal people screening
- Prototypes under development/build for evaluation
- Low dose complies with US exposure standards for "normal use" at checkpoints

Dual View System*BS 16HR-DV (dose $\leq 4.5 \mu\text{Sv} / \text{scan}$)*

- Excellent Transmission images at medium dose
- Adds high resolution view of torso to primary view



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People screening at Smiths

Trace detection – Sentinel

- Detection of explosives and drugs
- Only traces necessary
- Very specific

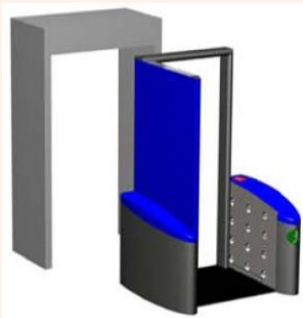


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People screening at Smiths

Using multi-threat technologies
e.g. mm-Wave combined with
shoe scanner



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Challenges with auto detection in people screening versus baggage screening

Challenges with auto detection in people screening versus baggage screening

Differences

- Dual-energy X-ray or tomographic baggage scanners offer material information.
- Narrow band mm-wave scanners offer grey scale images.
- Depth image is provided by some scanners.
- Different vendors have very different technological approaches
→ probably new algorithms have to be developed for each system
- Suitcases contain almost anything that fits in.
- The human body has similarities → detection of anomalies possible for ATR.

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Real World Examples – Checked Baggage Items

Some data: Images of Checked Baggage

- Checked Baggage has few restrictions
- Dense packed clothes plus metallic items
- Lots of large electronics, tools, etc..
- More background clutter due to more reinforcement



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Real World Examples – WBI

Some data: Image of WBI

- Almost no objects allowed on body
- Human body shows similarities
- Items allowed on person
 - Medical devices
 - Jewelry
 - Religious adornments
- “Unique” clothing items
- Casts/prosthetics?

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Standards

Standards developments are clearly needed

- Imaging quality standards
 - Well established in conventional x-ray systems
 - Common testing “persons” are not yet defined.
- Data format standards
- ATR testing standards
 - Test set contains many people → extremely cost intensive
- ATR detection requirements
 - Need to be somewhat abstract to cover various technologies

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And finally ... an idea for more public acceptance ...



Source: www.twitter.com/DerBulo

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19.8 Gerard Hanley, Rapiscan: X-ray backscatter



Rapiscan[®]
systems
An OSI Systems Company



BAGGAGE AND PARCEL INSPECTION



HOLD BAGGAGE SCREENING



CARGO AND VEHICLE INSPECTION



PEOPLE SCREENING

**Secure 1000
Personnel Screening
Systems for
ALERT Workshop**
27 April 2010



www.rapiscansystems.com ONE COMPANY - TOTAL SECURITY

Confidential and Proprietary Information

Advanced Imaging Technology



**TSA Begins Deploying
150 Advanced Imaging Technology
Machines at Airports Nationwide**
[Click Here >>](#)



Imaging Technology





PEOPLE SCREENING

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Secure 1000 Single Pose

- Comprehensive Threat Detection
- Optimized Checkpoint Throughput
- TSA Qualified

RAPISCAN SECURE 1000 SINGLE POSE



RAPISCAN SECURE 1000 SINGLE POSE

The Secure 1000 Single Pose combines unparalleled threat detection with optimized throughput.

The Secure 1000 Single Pose uses backscatter technology as well as Rapiscan proprietary image processing software and an operator-friendly interface to rapidly and comprehensively screen passengers for a wide range of potential threats including liquids, concealed weapons, explosives, narcotics, concealed currency and weapons.

Secure 1000 Single Pose Highlights:

- Fast and Best Screening for Comprehensive Threat Detection:** The Secure Single Pose generates a front and back view simultaneously, which increases threat spots and potential opportunities for concealment, thereby increasing checkpoint security.
- Advanced Imaging Detects Range of Threats:** The Secure 1000 Single Pose can detect small objects and threats concealed on passengers. It can detect organic and inorganic threats, metals and non-metallic objects, liquids, explosives, narcotics, plastic explosives, narcotics, metals, concealed weapons, etc.
- Single Pose Configuration Streamlines Checkpoint Operations:** Because the Secure 1000 Single Pose requires only one pose with no additional movement by the passenger, a full scan can be completed in seconds, thereby accelerating checkpoint operations and increasing passenger satisfaction.
- TSA Qualified:** The US TSA has tested, evaluated and qualified the Secure 1000 Single Pose for aviation checkpoints. The Secure 1000 Single Pose complies with U.S. and international health, safety and privacy requirements.

Rapiscan
systems
An OSI Systems Company

www.rapiscansystems.com

ONE COMPANY - TOTAL SECURITY



RAPISCAN SECURE 1000 PRODUCT LINE FREQUENTLY ASKED QUESTIONS REGARDING HEALTH AND SAFETY

How Much X-ray Radiation Exposure Is Generated by the Secure 1000?

The amount of x-ray energy generated by the Secure 1000 is very low, much less than that of a standard airport baggage scanner.

Secure 1000 is designed to be used in a way that minimizes exposure to the operator.

Is a person allowed to be in the Secure 1000?

It is recommended that a person be positioned in the Secure 1000 to be scanned.

Is it safe to be in the Secure 1000?

Yes, it is safe to be in the Secure 1000.

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PEOPLE SCREENING

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An OSI Systems Company

Secure 1000 Near-History

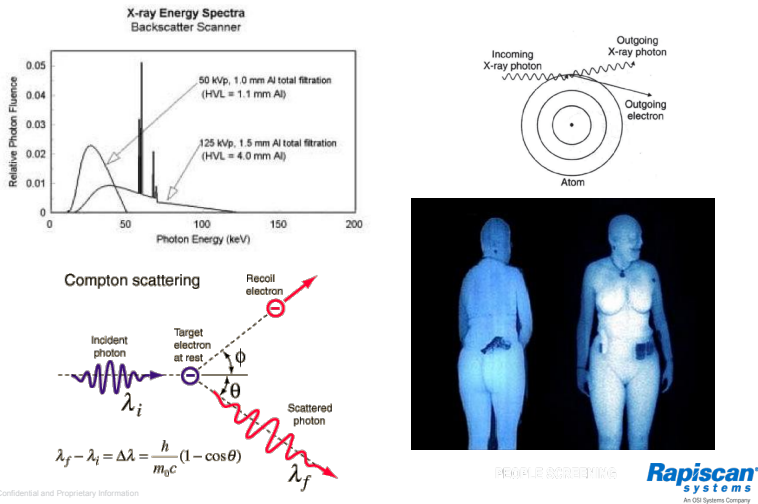
- October 2009
 - TSA order for 150 Secure 1000 Single Pose
- December 25th 2009
 - Mr. Underpants Bomber
- December 26th 2009
 - Focus on Operational Effectiveness
- February 2010
 - EPIC (Electronic Privacy Information Center) increases privacy concerns
 - Fast Track to ATR

Confidential and Proprietary Information

PEOPLE SCREENING

Rapiscan
systems
An OSI Systems Company

Backscatter X-ray Technology



How Passenger Screening Works - Today

- Passenger enters the scan area
 - Instructed to pose with arms above head
 - Inspection (Scan) is complete in 7 seconds
- Remote operator inspects scan and communicates decision to onsite operator
- Passenger is cleared to destination
- **Total time = 10-20 seconds**

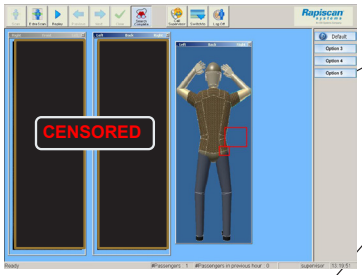


Confidential and Proprietary Information

PEOPLE SCREENING
Rapiscan
systems
An OSI Systems Company

How Passenger Screening Works - Today

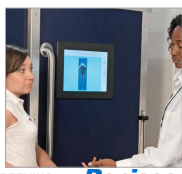

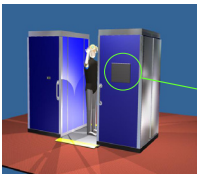
Scan Performed Images displayed for remote operator



System operator can easily identify search locations on **SEARCH DUMMY** for alarm resolution while preserving privacy

ONLY SEARCH DUMMY displayed on system


Privacy maintained



Confidential and Proprietary Information

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Passenger Screening Options - ClearPass



ClearPass Image Sorter




Manual Image Analysis

ClearPass Operator Assist

ClearPass ATR

Full Privacy

Manpower
Pd
Pfa (ATR)
Pfa (Final)



Confidential and Proprietary Information

PEOPLE SCREENING **Rapiscan** systems An OSI Systems Company

Secure 1000 Single Pose Overview

- The Secure 1000 is ideally suited to the detection of ALL threat items (metallic and non-metallic) concealed on a person that are of interest at aviation security checkpoints.
- System is well suited as a technology integration platform, taking advantage of a stationary passenger
 - Biometrics
 - Iris/ facial recognition
 - Additional sensors ☐ shoe screening
 - Transmission X-ray
 - Quadrupole Resonance
 - Explosive Trace Detection
 - Alarm resolution sensors
 - Directed THz spectroscopy

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Configurations

- Technology is applicable to Stationary Screening (Posed) or Transit Screening (Walk-by) configurations
- Posed (Stationary Person)
 - Single Pose vs. Single View
 - Capital Cost vs. Operational Cost
 - Throughput vs. Footprint
 - Primary Screening vs. Secondary Screening
- Walk-by (Person Transits System)
 - Covert vs. Overt (PBIED)
 - Integration opportunities for additional sensors

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Contact Information

- Questions, comments or information on collaborative opportunities

Gerard Hanley
Manager of Advanced Detection
Rapiscan Systems Inc.,
2805 Columbia Street
Torrance, CA 90503
Ph: (310) 349-2618
email: ghanley@rapiscansystems.com


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19.9 Iztok Koren, Brijot: Millimeter wave


Brijot® Whole Body Imaging



**Automated Passive
Millimeter-Wave Processing
for People Screening**

Iztok Koren, Ph.D.

April 27, 2010



Whole Body Imaging

Acknowledgements

- Bob Daly
- Zili Weng
- Lu Turzanski

Whole Body Imaging

Passive Millimeter-Wave (PMMW) System

- **Passive:** The system does not employ an active scene illuminator—no safety concerns for the subject being screened whatsoever (including pregnant women and people with pacemakers).
- **Millimeter wave:** The system senses energy in the millimeter-wave region of the spectrum.

Whole Body Imaging

PMMW Imaging

Radiometric temperature of an object in a scene:

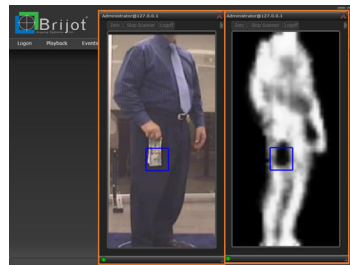
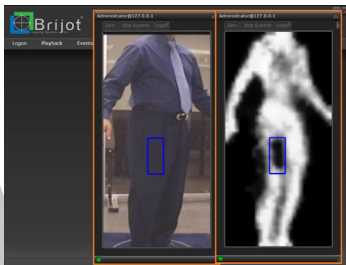
$$T = \rho * T_1 + \varepsilon * T_2 + \tau * T_3$$

where ρ , ε , and τ stand for object reflectivity, emissivity, and transmissivity, respectively; and T_1 , T_2 , and T_3 correspond to temperatures of illumination, object, and background, respectively.

Whole Body Imaging

PMMW Imaging (cont'd)

Sufficient contrast is needed for a particular object of interest (OOI) to be detected.



Whole Body Imaging

Brijot® MobileScan™

- Battery-operated portable PMMW checkpoint solution.
- Frame rate up to 12 fps.
- Imaging on a laptop connected to the system.



Whole Body Imaging

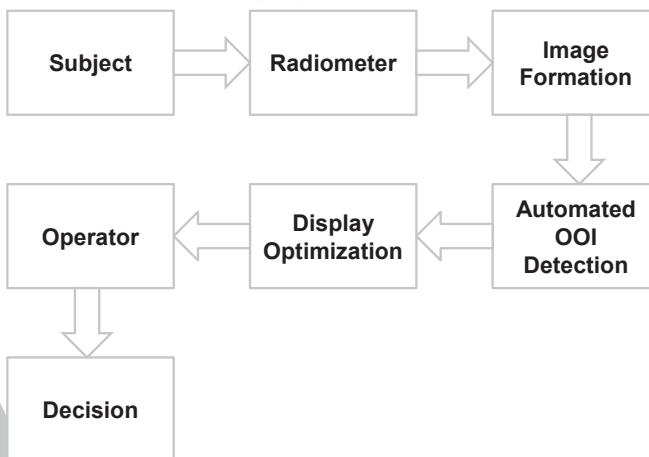
Automated PMMW Processing Goals

- 1) Automated OOI detection.
- 2) Supplying good quality PMMW images to the operator.

Note that with high enough a probability of detection (P_d) at low enough a probability of false alarm (P_{fa}) 1) could eliminate the need for 2).

Whole Body Imaging

PMMW Screening System Model



Whole Body Imaging

Radiometer

Noise equivalent temperature difference (NETD):

$$\text{NETD} = \frac{\text{output noise standard deviation}}{\text{thermal sensitivity}}$$

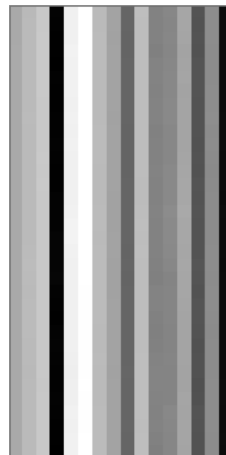
Lower NETD translates into better image contrast.

Building sensors with low NETD is a challenge.

Whole Body Imaging

Image Formation

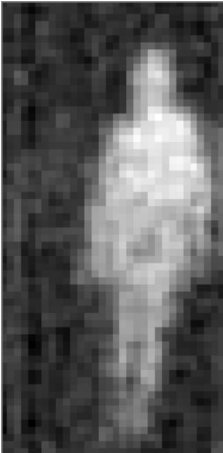
Output from a 16-channel radiometer with flapping-mirror scanner, 125 ms sweep time, and subject standing in the field of view 7 ft from the system.

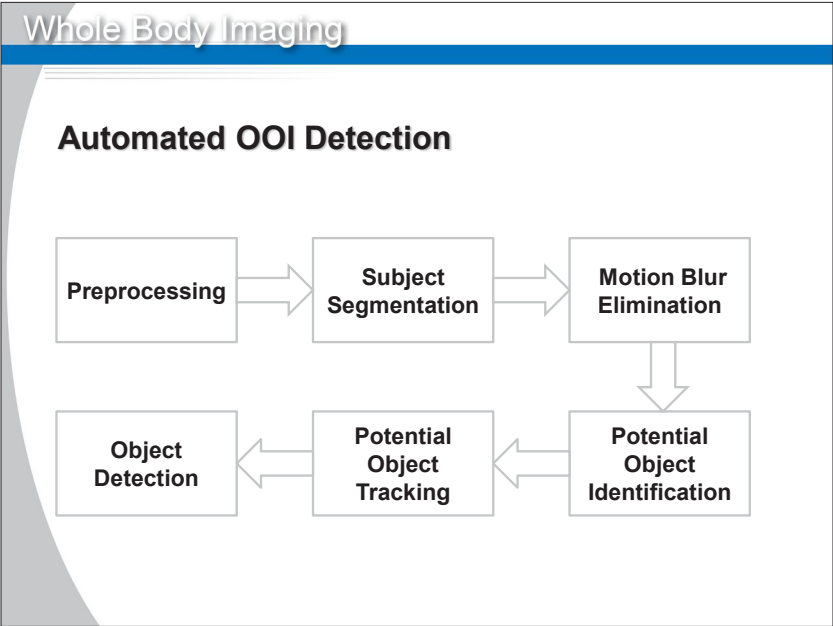


Whole Body Imaging

Image Formation (cont'd)

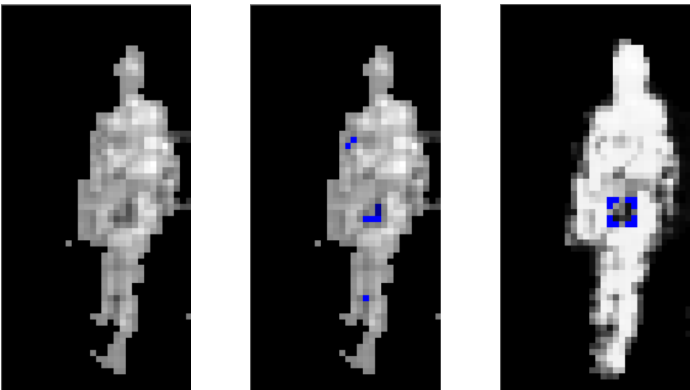
PMMW frame after channel equalization and increase in sampling density.






Whole Body Imaging

Automated OOI Detection (cont'd)



Whole Body Imaging

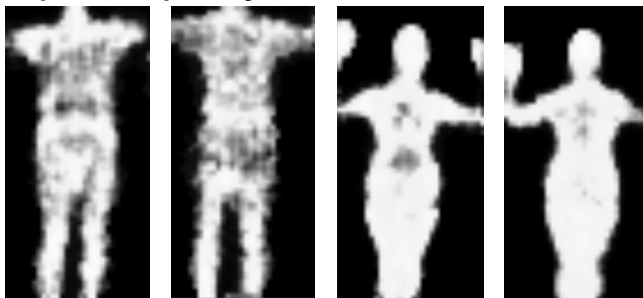
Automated OOI Detection (cont'd 2)



Whole Body Imaging

Privacy Issues

Images reveal no anatomical details and do not violate personal privacy.



Whole Body Imaging

Brijot® SafeScreen™

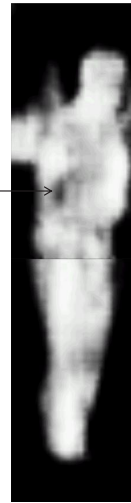
- Fully integrated security screening checkpoint.
- No safety concerns (PMMW technology).
- Despite higher resolution than MobileScan™, no privacy issues.



Whole Body Imaging

Brijot® SafeScreen™ (cont'd)

Both Automated OOI Detection and Display Optimization are still under development.



Whole Body Imaging

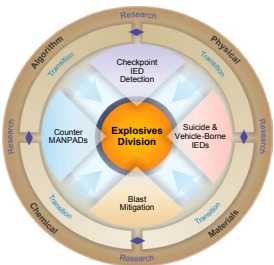
Conclusion

- Improvement opportunities exist for practically all system components.
- Bringing the performance of automated detection algorithms to the level of human operators (even without any other system improvements!) would arguably make the largest impact.

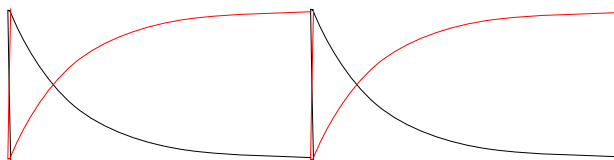
19.10 Ted Grant, Department of Homeland Security: The integrated check point

Integrated Checkpoint:
Algorithm Opportunities for Developers

Ted Grant
Department of Homeland Security
Science & Technology Directorate



Homeland
Security



Homeland
Security

Necessity for Innovation

- Cutting-edge AIT Automatic Detection capabilities sought
 - ☐ *Privacy*
 - ☐ *Efficiency*
 - ☐ *Uniform performance*
- Level playing field
 - ☐ *Recent requests for information demonstrate efforts related to ATR algorithm development outside of AIT Original Equipment Manufacturers (OEMs)*
 - ☐ *Large and small developers from industry and academia are encouraged to submit to DHS*



Homeland
Security

ATR, ATD

- Short Term Goal: Automatic Detection
 - ☐ *Detect anomalies*
 - ☐ *Passengers should be fully divested*
 - ☐ *wallet or bomb, shouldn't be there*
- Long Term Goal: Automatic Target Recognition
 - ☐ *Characterize targets*
 - ☐ *Allow benign objects to pass*



Homeland
Security

Algorithm Business Opportunities

- TSA: [Very] Short term
 - ☐ <12 Months
 - ☐ Partner with System Vendors
- S&T Transition Programs: Short Term
 - ☐ 12 ☐ 36 months
 - ☐ Direct contracts, e.g., BAA
- S&T Basic Research Program: Long Term
 - ☐ 3 year plus



Homeland
Security

Algorithm Integration Opportunities

- Embedded
 - ☐ Algorithm provided to vendors as part of partnership or as GFE
 - ☐ Hosted on existing processors
- Additional Processor, Direct Connect
 - ☐ Algorithm provided
 - ☐ Additional processor(s)
- Integrated Checkpoint
 - ☐ Standardized interfaces, framework



Homeland
Security

Constraints

- Focus on existing, deployable hardware
- Operational Reality
 - ☐ *Throughput*
 - ☐ *Personnel- Quantity and quality*
 - ☐ *False alarm consequences*
- Procurement System
- Competitive disclosures
- Security



Homeland
Security

Vendor Partnerships

- TSA is looking to partner AIT OEMs with AIT developers for best performance
 - ☐ *Facilitates transition of ATR software*
 - ☐ *Fosters collaborative working environment*



Homeland
Security

BAA Submission Options

- Long-Range Broad Agency Announcement (LRBAA)
 - ☐ *Ongoing window of opportunity to submit white papers/proposals based on go/no-go decisions*
 - ☐ *Subject to availability of funding*
- Targeted BAAs
 - ☐ *Short windows of opportunity subject to downselect*
 - Current BAA window is closed, more will follow
 - ☐ *Funding set aside for effort*
 - ☐ *Anticipated 12-month periods of performance*
 - ☐ *Opportunities for follow-on work*
- BAA information is located at <https://baa.st.dhs.gov/>



Homeland
Security

Follow-On Work

- Vendors that are selected for development efforts may be given opportunity to continue work via follow-on contracts
 - ☐ *Follow-on subject to performance and available funding*



Homeland
Security

Innovative Licensing

- The goal for use of ATR software is most flexible use by TSA and further development by S&T
- S&T will work with vendors to strike best agreement between Government-purpose rights and Intellectual Property rights



Homeland
Security

Incentives

- DHS anticipates incentives for improved performance over time
 - ☐ *Incentives determined by rate improvements are developed*
 - ☐ *Metrics used to determine incentives include improvement of Pd and Pfa, ease of transition into deployed systems, improvement of human factors, overall cost of ownership*



Homeland
Security



Homeland
Security

**19.11 Michael Barrientos, Department of Homeland Security:
Automated Algorithms for Integrated Checkpoint Program**

Automated Algorithms for Integrated Checkpoint Program



**Homeland
Security**

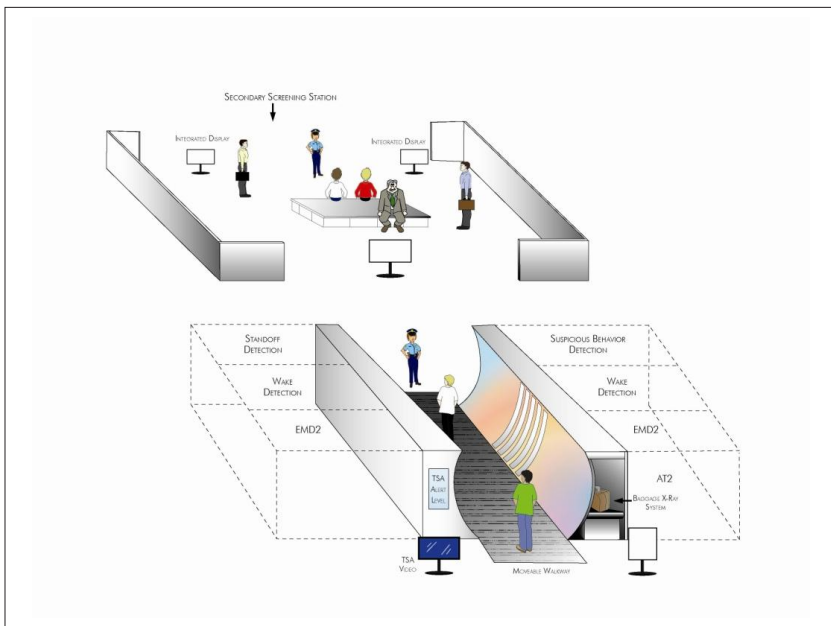
Michael Barrientos
ALERT Workshop
April 2010

The integration of vendor systems requires
the development of algorithms
for current checkpoint capability

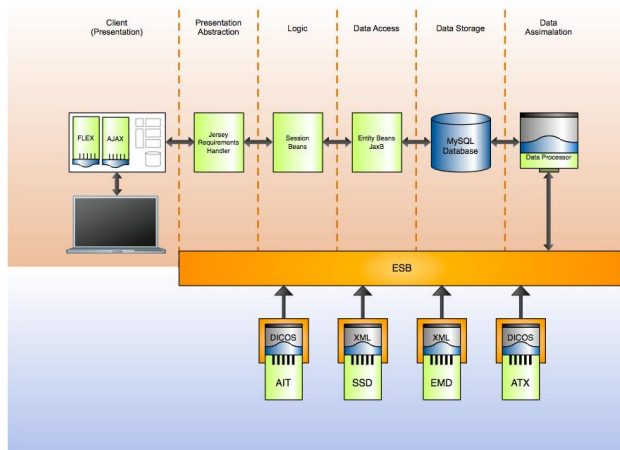
- Stove-pipe systems
- Screens for each individual systems with no standardization between vendor solutions
- Access to information only at system itself
- Information passing via word of mouth

The Integrated Checkpoint Program (ICP) aims to combine checkpoint systems to improve the current process

- Create an open architecture solution to the checkpoint
 - ☐ Standards-based
 - ☐ Amalgamation of applicable systems and data elements
 - ☐ Future connectivity of hardware technologies
- Enable the following:
 - ☐ Rapid response to and detection of evolving threats
 - ☐ Increased passenger throughput
 - ☐ Improved passenger experience
 - ☐ Timely and broad accessibility of data elements
 - ☐ Decision analysis capability
 - ☐ Reduced total ownership cost of checkpoint



ICP will centrally perform data processing



ICP integrates checkpoint technology data to gain better detection (more from what we have)

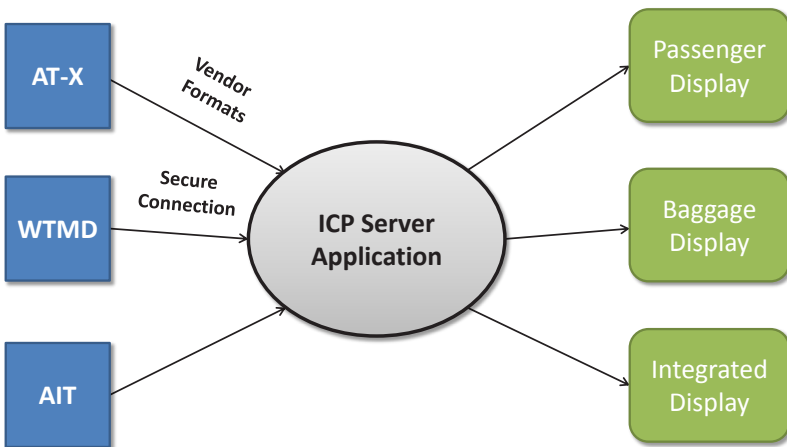
• Short Term

- ☐ Decrease training costs due to common user interfaces
- ☐ Consolidate and store checkpoint data for future analysis
- ☐ Enable more efficient & accurate stream of data (i.e., bag/passenger statistics) at and between airports/regions
- ☐ Allow for the availability of TSO efficiency measurement
- ☐ Provide remote data monitoring by TSO management
- ☐ Reduce new technology integration time based on data standards developed

• Long Term

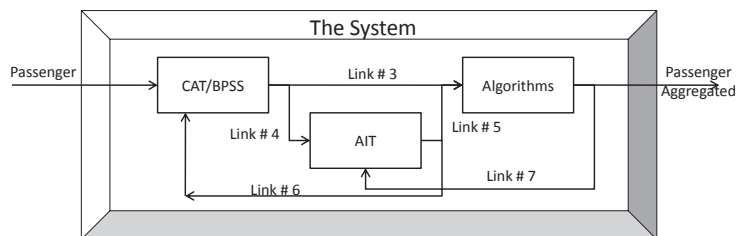
- ☐ Link all airport sensors and databases to allow for threat detection at any location within the airport rather than only at the checkpoint
- ☐ Foster common algorithm development for checkpoint systems based on common sensor data outputs
- ☐ Offer real-time threat alerts across airports and regions based on threat identification
- ☐ Connect to national remote data review center for all checkpoints

The use of algorithms in the ICP architecture looks to reduce the TSO from the detection loop



An algorithm (Ref # 1) has the ability to make the "Whole" greater than the "Sum of its Parts"

The Whole (System) $\equiv \sum_{j=1}^n \text{Parts}_j \text{ (Subsystems)}_j + \text{Delta (Links)}$



Ref # 1 -- Adapted from John A. Thomas, Senior VP of Booz Allen Hamilton [taken from Allen Fairbairn remarks, Chief Systems Engineer of the Chunnel Project]

Current incremental efforts?

- Developing ICP system/software architecture
- Coordination with stakeholders (government, commercial, academia)
- Development of ICP test bed
- Involved with DICOS standard group

Future Incremental efforts?

- Continued Coordination with Stakeholders
- Correlation/ Passenger Tracking
- Data Source Integration
- Fusion
- Algorithm Integration

19.12 Carl Crawford, Csuptwo: CT segmentation grand challenge (ADSA02) update

CT Segmentation Grand Challenge (ADSA02) Update

Carl R. Crawford
Csuptwo

Workshops

- Support DHS objective to get 3rd party involvement
- Limited to advanced algorithm development for explosive detection

ADSA01

- **Algorithm Development for Security Applications Workshop (ADSA)**
- April 2009
- Limited to checkpoint
 - Passenger (AIT, shoe screeners, etc...) screening
 - Screening of divested objects
 - Screening of hand luggage
- Key outcome: execute grand challenges

3

Grand Challenges

- Translate problem into unclassified space
- Provide with minimal restrictions
 - Requirements
 - Data sets
 - Acceptance criteria
 - Funding
 - Mentorship

5

Grand Challenges

- Translate problem into unclassified space
- Provide with minimal restrictions
 - Requirements
 - Data sets
 - Acceptance criteria
 - Funding
 - Mentorship

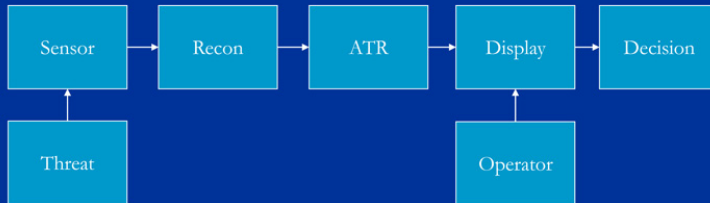
5

Applicable Topics

- System simulation
- Reconstruction and processing of sensor data,
- Automated threat recognition
 - Image segmentation
 - Classification
- Fusion
- Improved operator performance
- Concept of operations

6

Generalized Model



Boxes may mean different things to different modalities.
Some modalities may not have all boxes.
Multiple systems may be fused.

7

Applicable Applications

- Checked baggage
- Checkpoint
 - Personnel
 - Divested objects
- Cargo
- Standoff
 - Persons
 - Vehicles
 - etc...

8

Applicable Modalities

- X-ray CT
- Transmission x-ray
 - Single and multi-view
 - Single and dual energy
- MMW, XBS, MRI, NQR
- Etc.

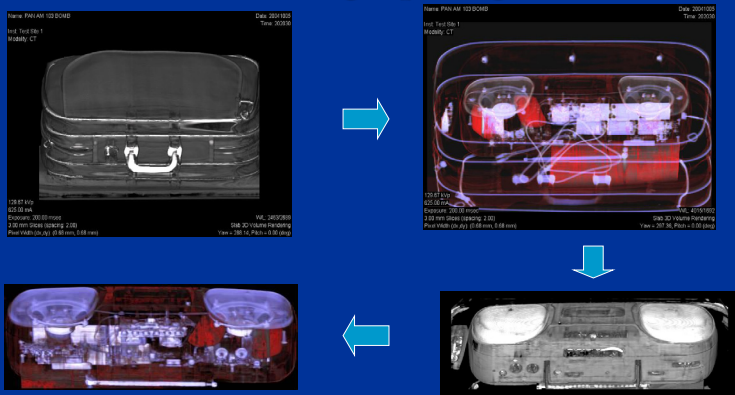
9

CT Application

- Reconstruction improvements would have greatest impact
 - Present reconstruction based on medical that emphasizes pixel-based detection
 - Could be optimized for threat detection
 - Improvements can be better measured with ATR
- ATR improvements
 - Better characteristics (mass, density, Z_{eff})
 - Overcome aggregation, splitting, CT artifacts

10

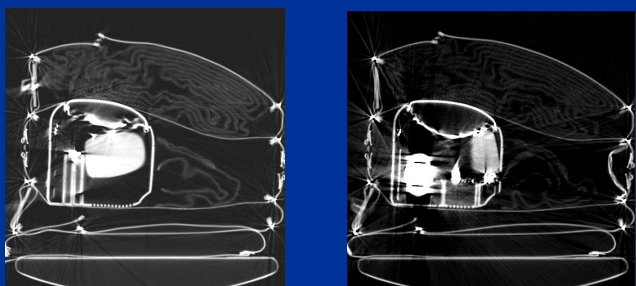
3D Rendering and Virtual Bag Opening



Images provided by Telesecurity Sciences and derived from scans on a Imatron medical CT scanner. Images were not generated on TSA-owned machines.

11

Cross-Sectional Images



Workshop goal: 3rd party development of segmentation algorithms to find explosives in volumetric CT data

Images provided by Telesecurity Sciences and derived from scans on a Imatron medical CT scanner. Images were not generated on TSA-owned machines.

12

ADSA02

- Focus: implementing grand challenges
- October 2009

13

Final Reports

- ftp://ftp.censsis.neu.edu/ADSA/ADSA01_final_report.pdf
- ftp://ftp.censsis.neu.edu/ADSA02/ASDA02_final_report.pdf

14

Segmentation GC Status

- Specs exist for CT scanner for scanning
- Negotiating with three companies to use medical CT scanner
 - Image and raw/corrected data
- DHS funding
- Objects of interest decided
- Sample segmentation and scoring programs written
- Semi-automatic outlining of object of interest for answer key written
- Expect to kickoff in ~2 months

15

19.13 Masashi Yamaguchi, Rensselaer Polytechnic Institute: Terahertz

ADSA Workshop 3:
Application to Advanced Imaging Technology

THz wave technology for security applications

Masashi Yamaguchi
Center for THz Research, Rensselaer
Polytechnic Institute, Troy, NY 12180



Conclusions.


- Spectroscopic imaging is necessary for chemical identification beyond anomaly detection (for local/ or full body scan.)
- THz sensor should be fuse with other imaging technique either X-ray back scattering/MMW imaging.

Where are we now ?

THz sensor can do following.

- Spectral imaging in the lab condition.
- Intense (1MV/cm) and broad band (>10 THz) THz pulse is available for THz spectroscopy for explosive detection.
- Real-time: < 1 sec operation at stand off distance (3 m).
(BomDetec system supported by DHS.)
- Multiple sensor system need to be developed for the faster scan.


19.14 Richard Bijjani, Reveal Imaging: Fused technologies



Fused Technologies

Scott MacIntosh
 Michael Litchfield
 Richard Bijjani
 Elan Scheinman

Innovate. Detect. Safeguard.



Fusion, beyond the hype

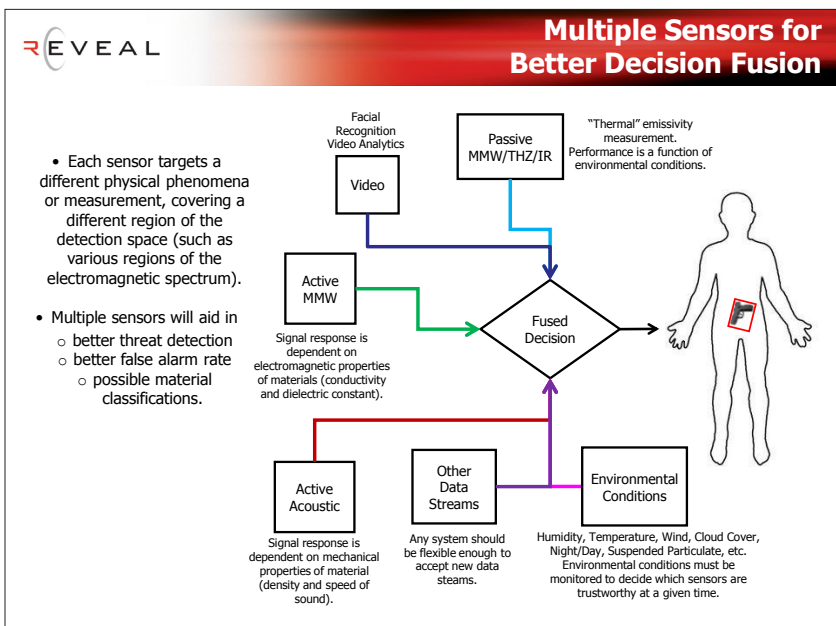
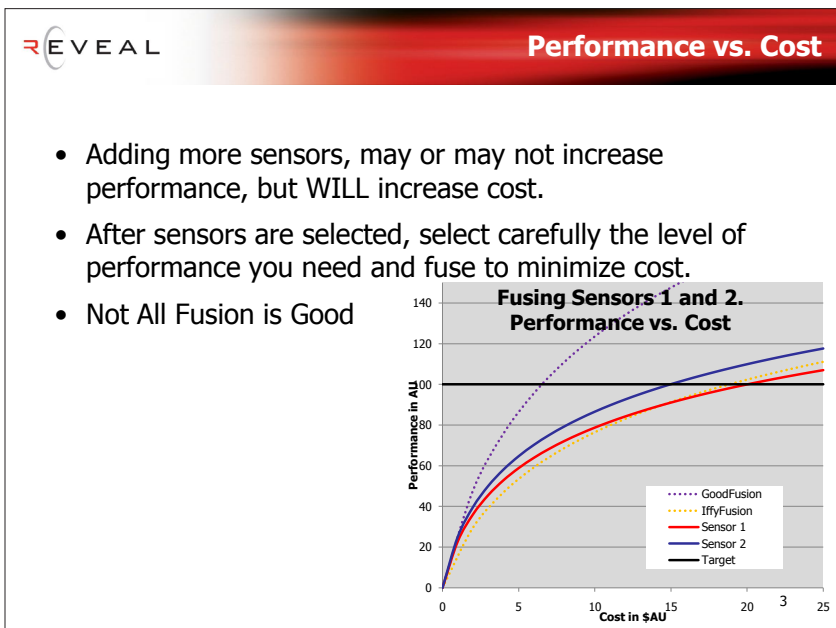
~~Buy my Sensor, It'll solve ALL of your problems!~~

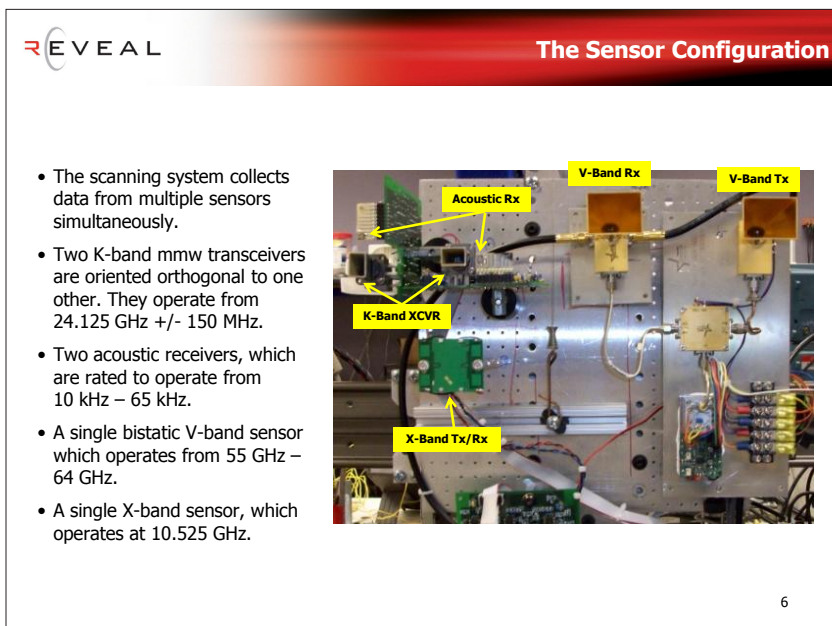
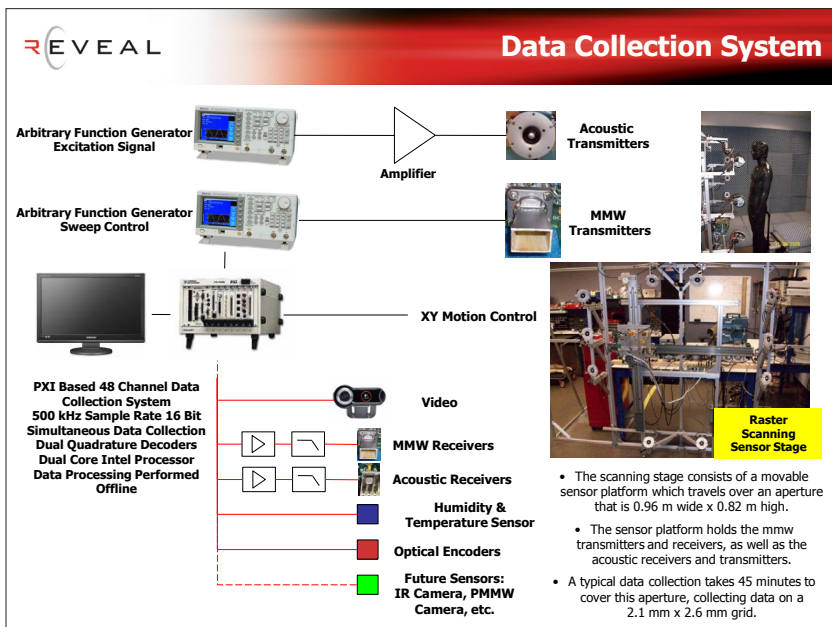
- No Silver Bullet
- Combination of orthogonal sensors required

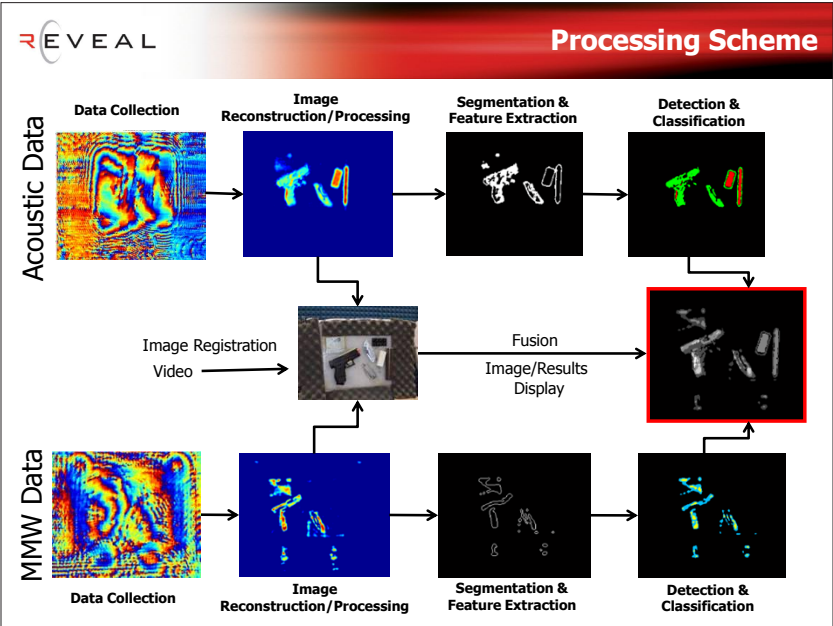
But

- What sensors?
- At what Cost?
- How do you decide which ones to use?
 - What is the fundamental science behind each?
 - How to prove orthogonality?
- Method of fusion?
 - Data Fusion
 - Decision Fusion
 - Master/Slave or Mutual Directional Information

2





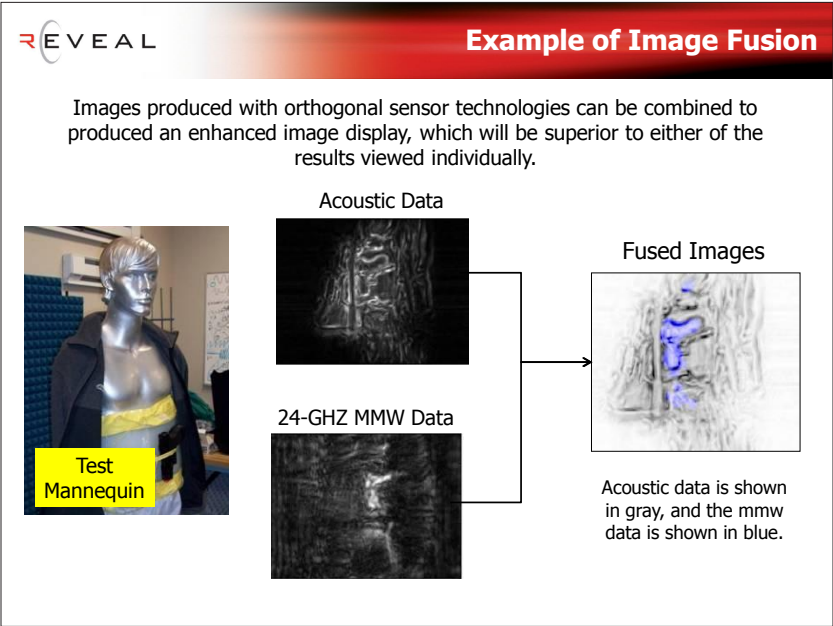
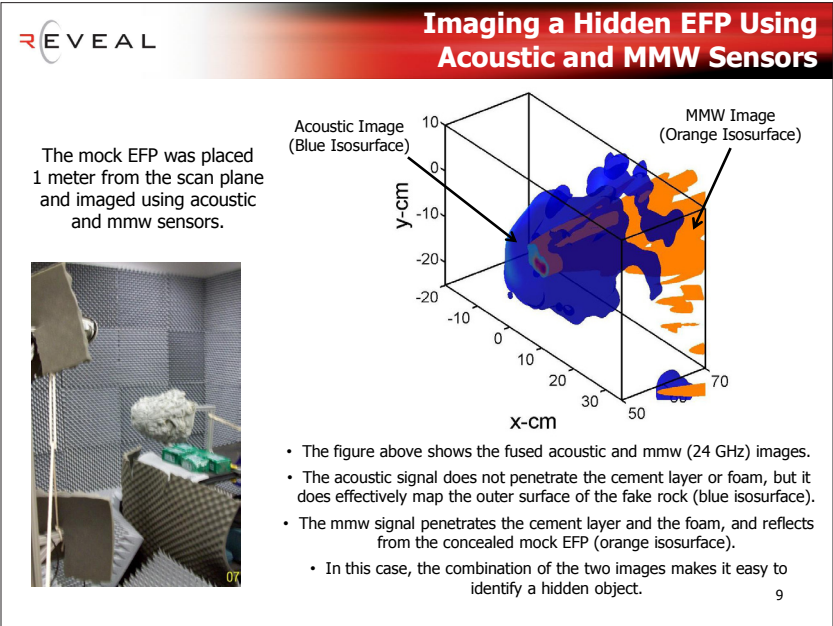


REVEAL **Construction of a Mock EFP**

- A mock Explosively Formed Projectile (EFP) was constructed using a 5" diameter aluminum tube with a shaped copper plate embedded on one end.
- The mock EFP was then covered with foam and a thin layer of concrete, and then painted with faux rock finish to simulate a rock's appearance.

The construction process is shown in three stages:

- A bare 5" diameter aluminum tube with a shaped copper plate embedded on one end.
- The tube covered with foam.
- The final mock EFP, covered with a thin layer of concrete and painted with faux rock finish to simulate a rock's appearance.





Decision Sensor Fusion

- Use both mmW and Acoustic sensors to scan and resolve anomalies detected in primary system
- If a shield alarm due to water (example, diaper, adult diaper, feminine napkin, etc), rely exclusively on Acoustic signature
- Otherwise fuse both signals for alarm Resolution

11



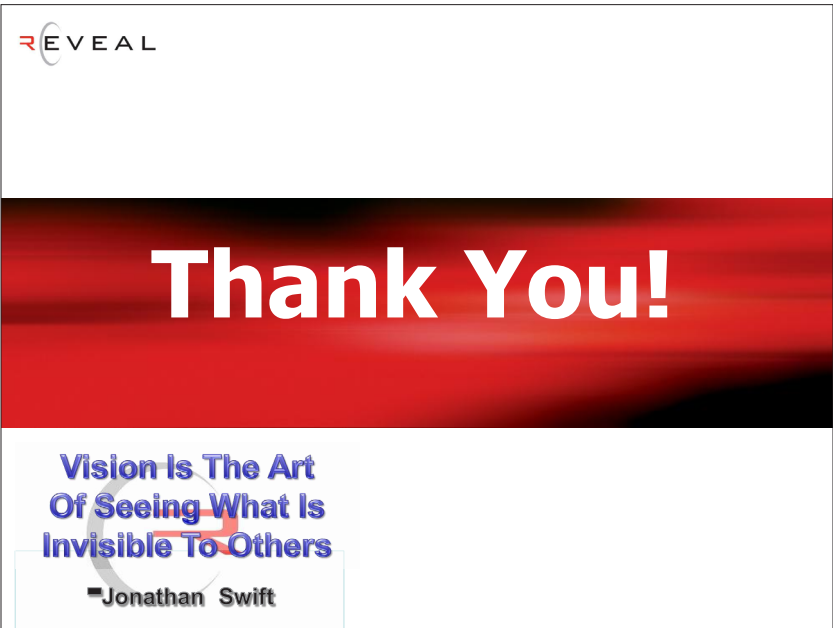
Challenges

Goal: Create physical screening solutions that allow our customers to move more people, more quickly, more securely

The whole is more than the sum of parts- sometimes

Before you build (or try to sell) do your homework and get a clear understanding of the problem. Design a solution for the problem at hand, don't take your solution and look for a problem

We are EAGER to identify / develop / partner / acquire / co-develop / license □



19.15 Mike Watkins, Pacific Northwest National Laboratory: Infrared

Transient Infrared Imaging

*An Opportunity for Enhancing
Automated Threat Recognition ?*

Mike Watkins
National Security Directorate
Pacific Northwest National Laboratory

DHS Advanced Imaging Technology Workshop
Northeastern University, Boston, MA
April 28, 2010



Outline

- ▶ Infrared Radiometry
- ▶ Generic process for generating thermal images
- ▶ Active / Passive ?
- ▶ The Orthogonal Proposition
- ▶ Examples for successful applications
- ▶ R&D opportunities



R&D Challenges

- ▶ Develop detailed heat transfer model
 - Currently semi-qualitative
- ▶ Potential to enhance signature discovery by using environmental sensors
- ▶ Complementary to through-clothing methodologies such as mm-wave and backscatter x-ray
- ▶ Opportunity to leverage designed or imposed environmental transients
- ▶ Compare automated dT/dx and dT/dt to human image interpretation



Spectrum

xxxx - Wave Soup □ □ .. ?

	Microwave	Millimeter-Wave	Sub-mm / Terahertz	Far IR	IR	Visible - UV	
Wavelength	10 cm	10 mm	1 mm	0.1 mm	10 μm	1 μm	0.1 μm
Frequency	3 GHz	30 GHz	300 GHz	3 THz	30 THz	300 THz	3000 THz

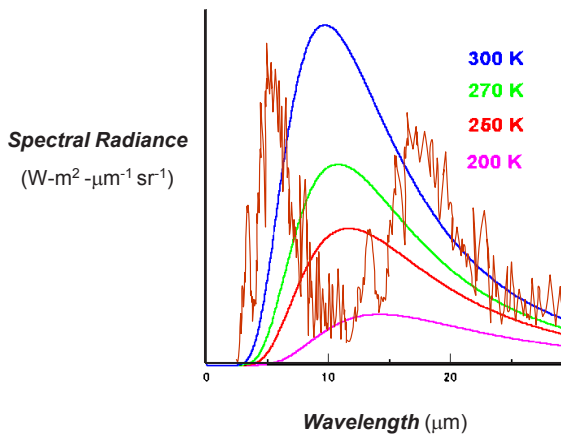
LWIR ----- 8-12 μ m

MWIR ----- 3-5 μ m

SWIR ----- 1-3 μ m



Source Characteristics



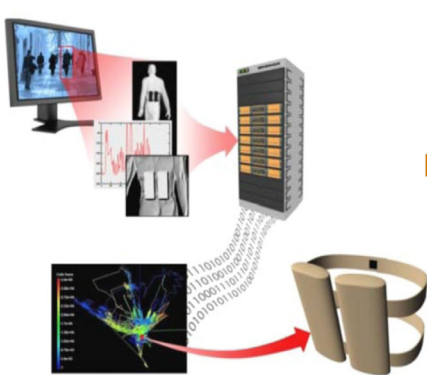
Pacific Northwest
NATIONAL LABORATORY

Advantages and Challenges

- ▶ Remote with long range
- ▶ Rapid □ video frame rates
- ▶ 2D □ High spatial resolution
- ▶ Demonstrated ability to provide 3D information
- ▶ IR bands
 - Available within atmospheric transmission window
 - Do not transmit through common clothing
- ▶ Data interpretation is not trivial
 - Sensitive to bulk property variations
 - Sensitive to surface properties and orientation
- ▶ Historical threat detection tends to be and qualitative/subjective
- ▶ R&D in spectral exploitation is vigorous

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NATIONAL LABORATORY

Algorithm Challenge




$T_{ij}(t,x,y)$

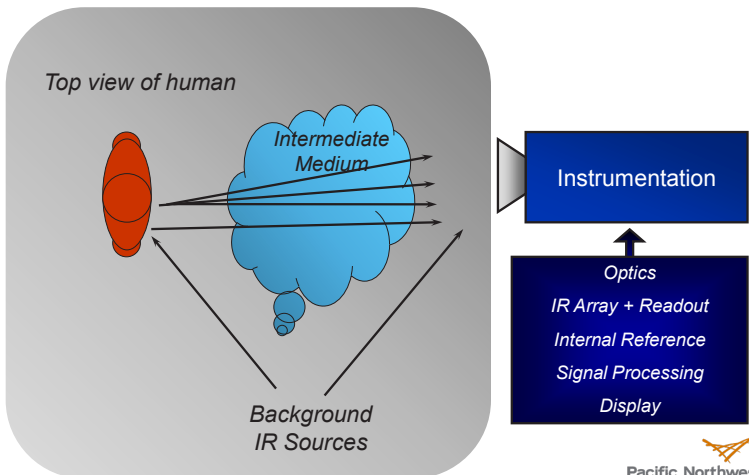
↓

► **Dynamic BC problem**

- Materials
- Geometry
- Source/loss terms



Generation of Thermal Images




Top view of human

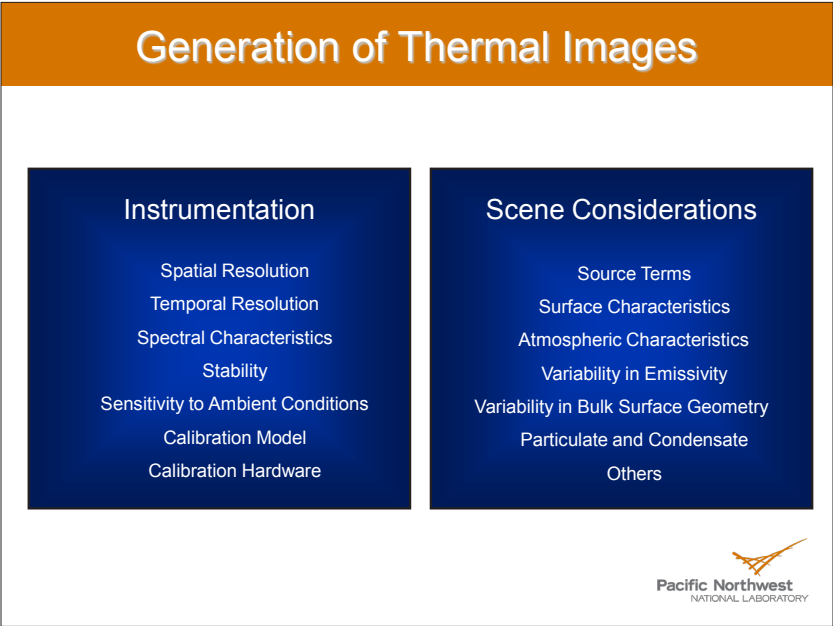
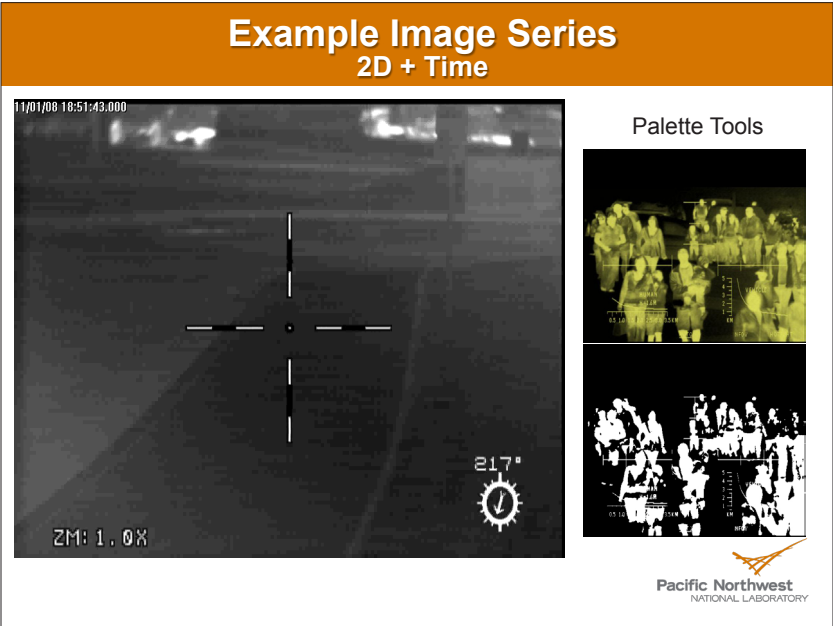
Intermediate Medium

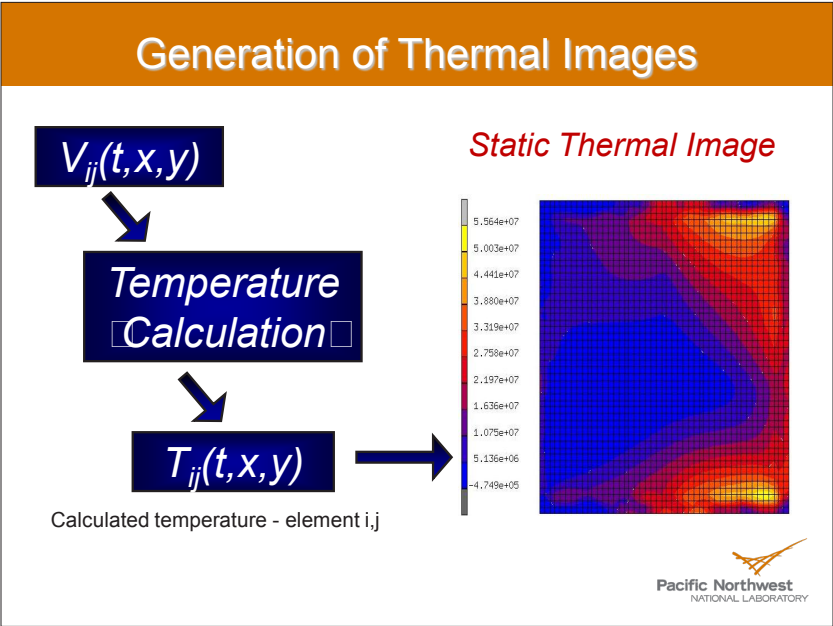
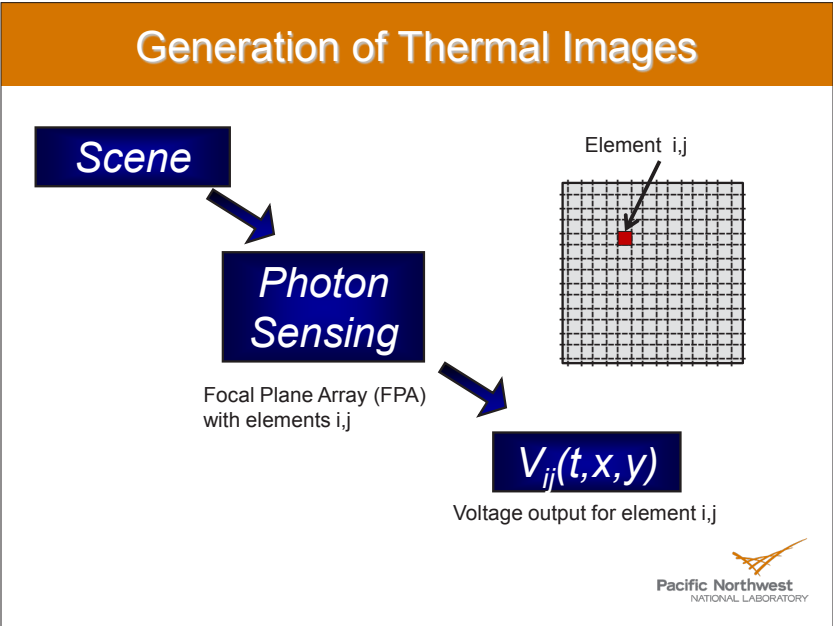
Background IR Sources

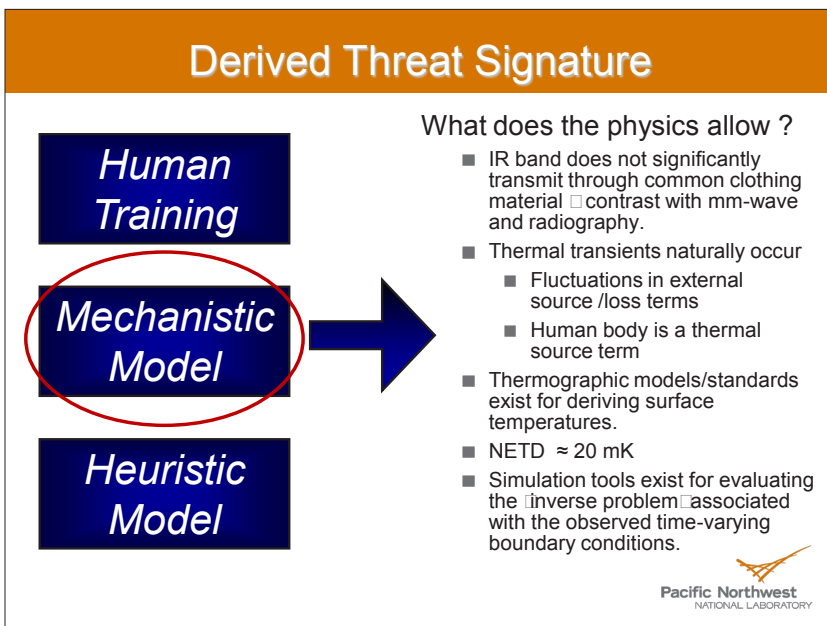
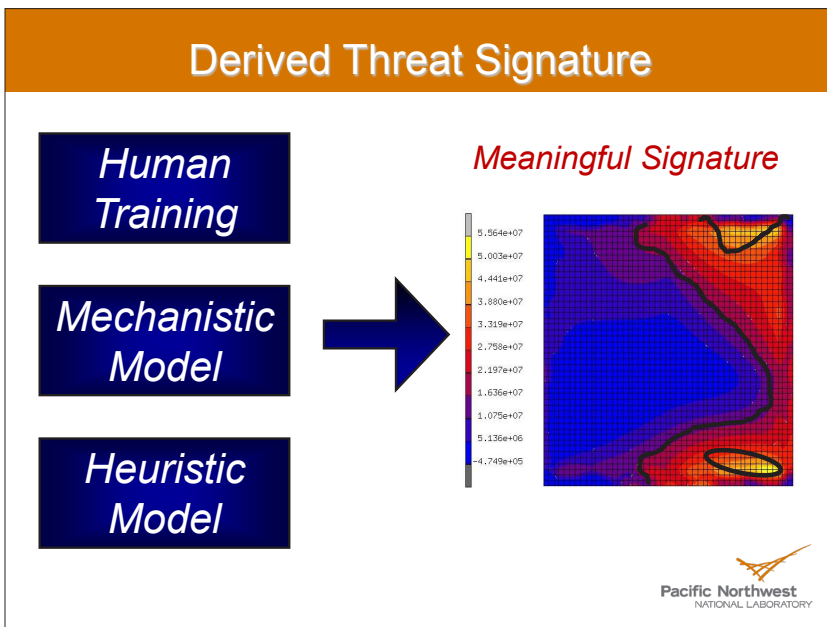
Instrumentation

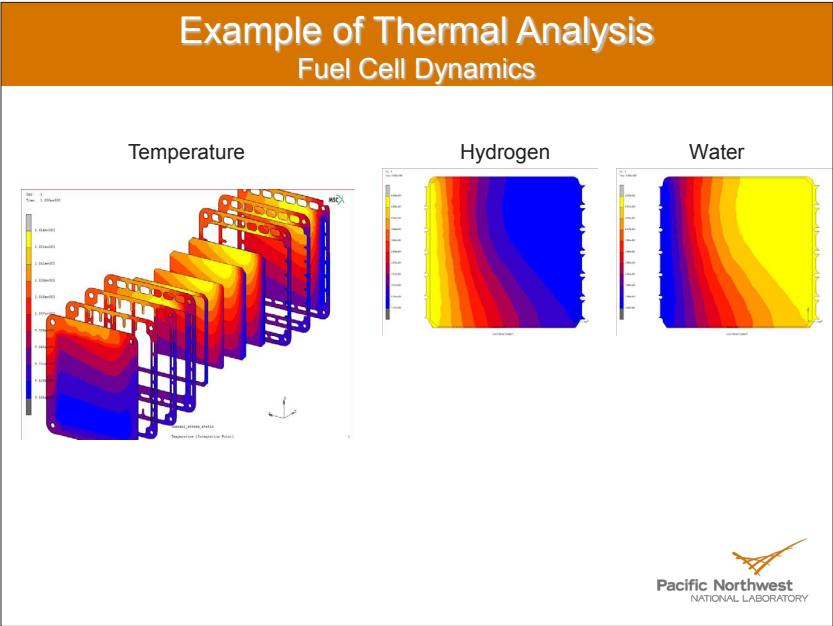
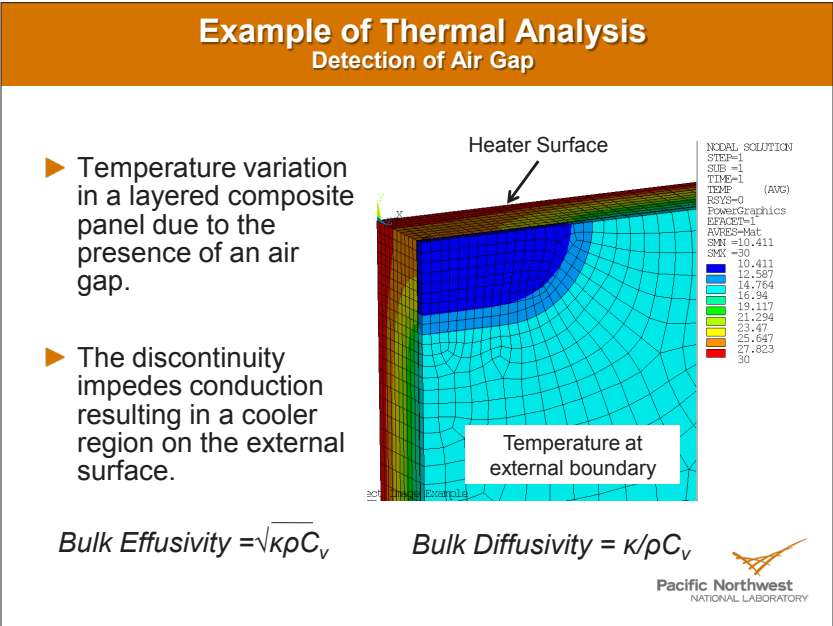
Optics
IR Array + Readout
Internal Reference
Signal Processing
Display

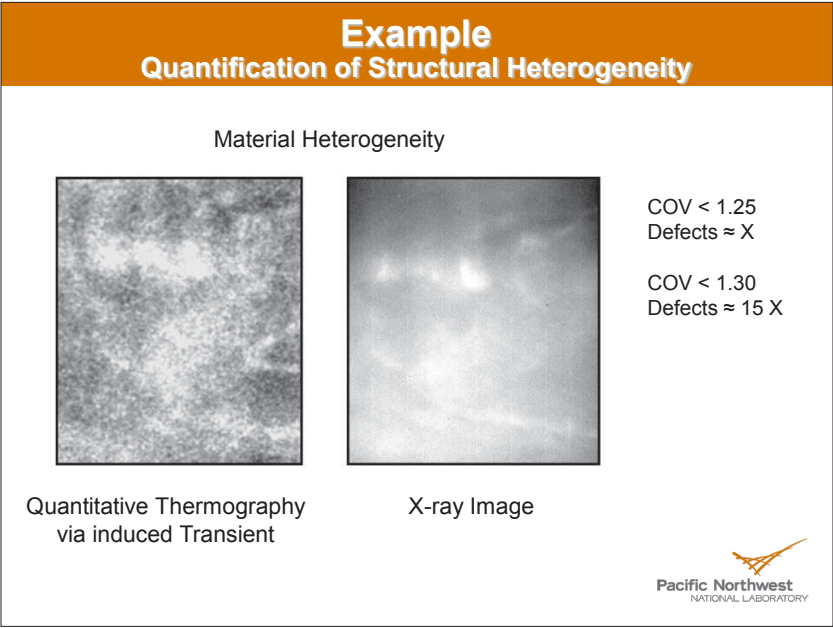
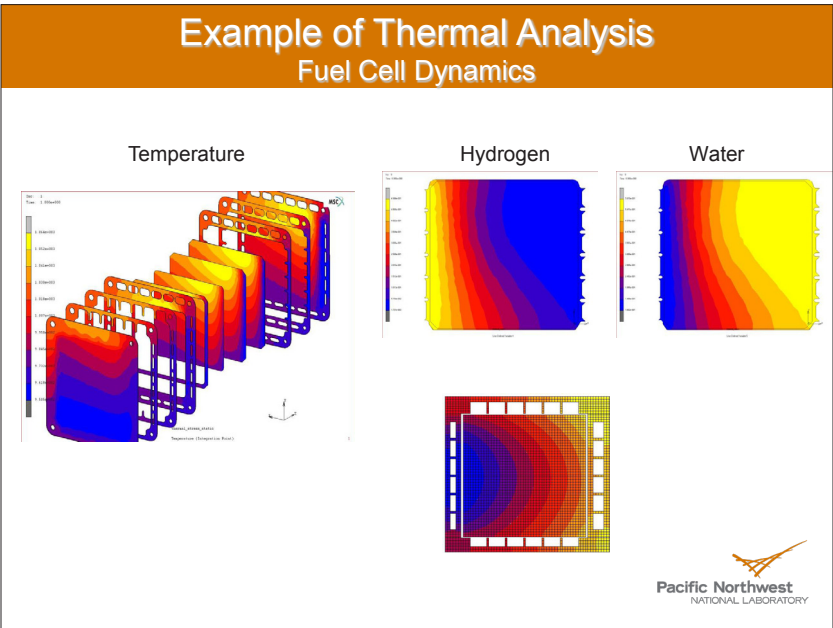


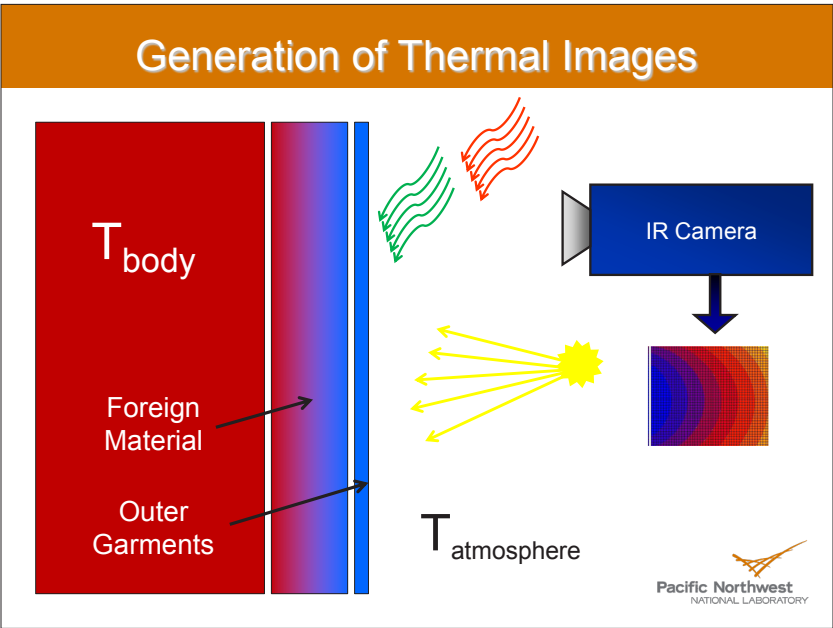
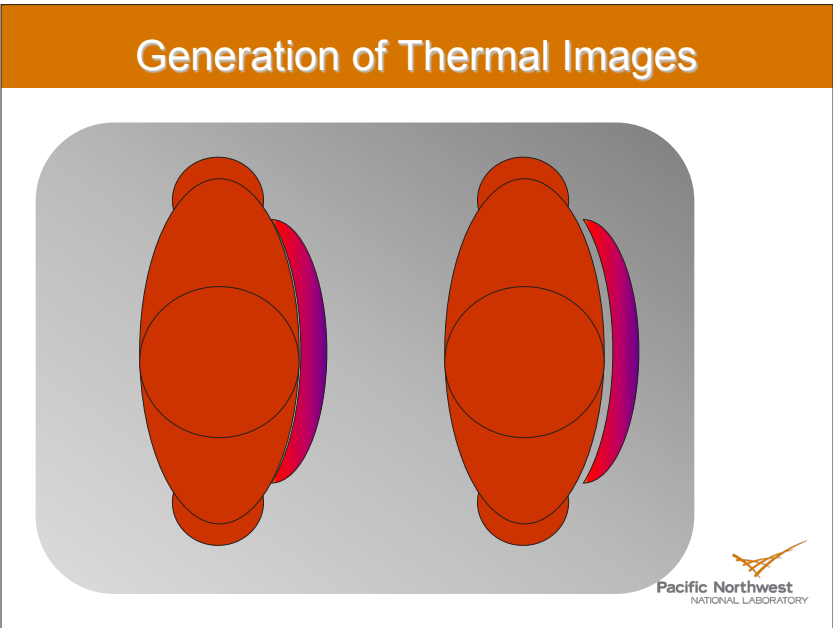












R&D Challenges

- ▶ Develop detailed heat transfer model.
 - Currently semi-qualitative
- ▶ Potential to enhance signature discovery by using environmental sensors.
- ▶ Complementary to through-clothing methodologies such as mm-wave and backscatter x-ray.
- ▶ Opportunity to leverage designed or imposed environmental transients.
- ▶ Compare automated dT/dx and dT/dt to human.

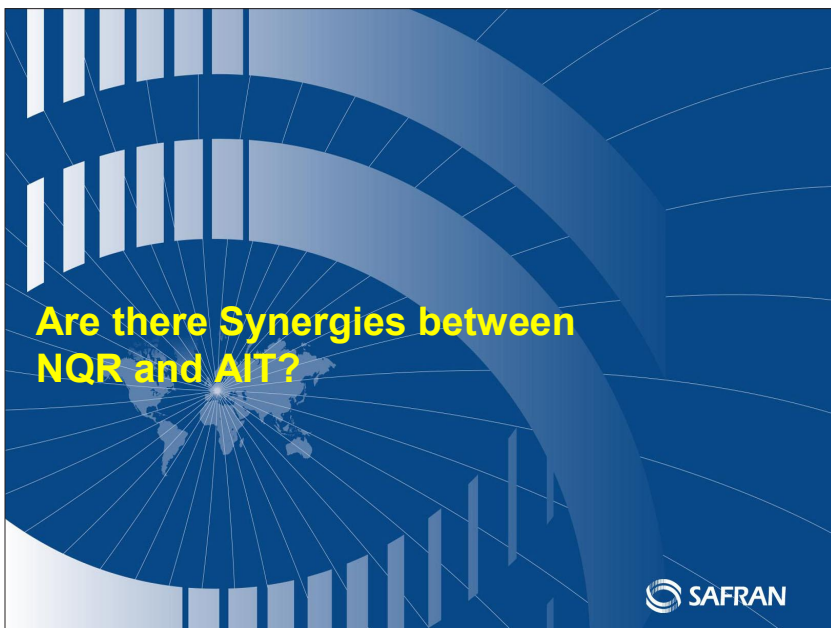


Other Examples

- ▶ Voids in walls
- ▶ Mine detection
- ▶ Missing layers of composites
- ▶ Delimitations
- ▶ Moisture content
- ▶ Corrosion
- ▶ Others



19.16 Chris Crowley, Morpho Detection: Quadrupole Resonance



■ Fusion: AIT => NQR

1) AIT Whole Body can *clear* most of body:

NQR for targeted Spot Checks=>
Surface Coils = Better □ Fill Factor □

2) AIT Concealments = ~body temp:
Narrower NQR temp band=better
performance & longer □ list □

■ Fusion: NQR => AIT

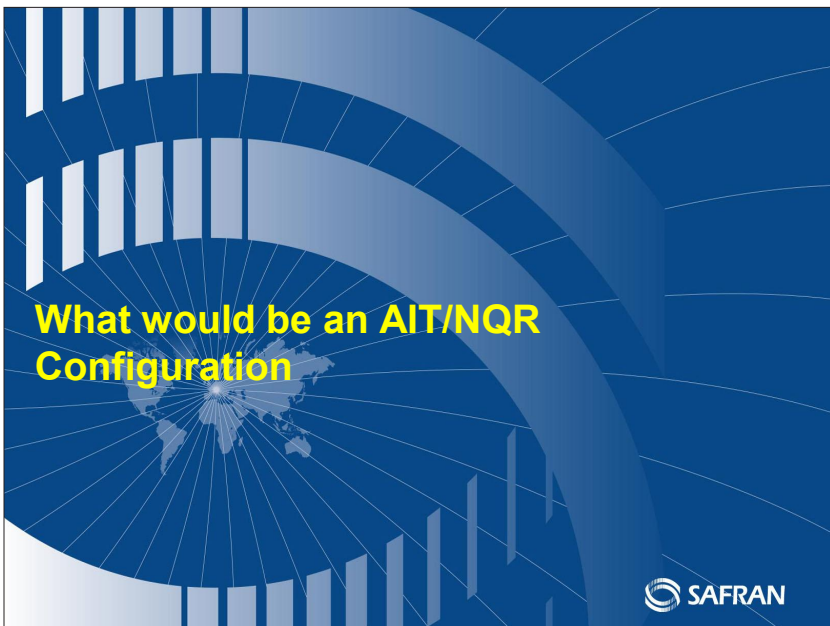
NQR Can See:

Optically obscured concealments

Internal Concealments

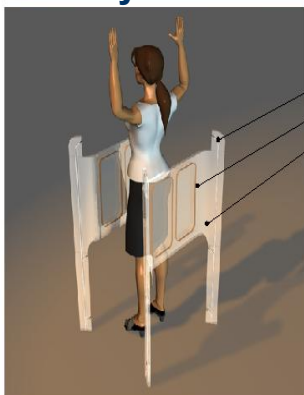
Primary or Secondary Spot checks

2



■ ■ ■ Question: Primary or Secondary?

Primary AIT Add-on?



AIT-Directed Secondary
Anomaly Resolution?



4



ALERT 2010: NQR for AIT

**Christopher Crowley, Ph.D.
Morpho Detection Inc.
San Diego, CA**



■ ■ ■ Background

Nuclear Quadrupole Resonance (NQR)

Like MRI, NQR Safely penetrates tissue:

□ Sees Insides □

Bulk spectroscopic threat detection:

No imaging, no anomaly detection

Finite □ list □ of materials

False Alarm mechanisms exist

=>Candidate for Fusion in a □ System of Systems □

6

 **Morpho Detection**
SAFRAN Group

**Historical perspective: NQR
Body scanning**

 **SAFRAN**

■ ■ ■ Handheld NQR Wand (~2000)

**Adapted from
Landmine Detector**

**Superficial Detection
(e.g. colostomy bag?)**

**Operated in
Open Environment**

**Active Electronic
Cancellation of
RFI**



8

 **Morpho Detection**
SAFRAN Group

■ ■ ■ NQR Portal (~2002)

**Whole Body,
Head-to-toe Scan**

**TSWG sponsor
(non-aviation)**

**Inside/Outside
Detection**

Passive RFI Shielding

Tested TSL, INRL, ISA



9

 **Morpho Detection**
SAFRAN Group

■ ■ ■ **NQR Shoe Scanner (~2004)**

**Targeted Extremity
(Shoe) Scanner**

Passive RFI Shielding

**Added ITMS
Trace Detection:
New Vapor-mode**

Tested TSL



10

 **Morpho Detection**
SAFRAN Group

**How Could NQR Be configured to
Complement AIT?**

 **SAFRAN**

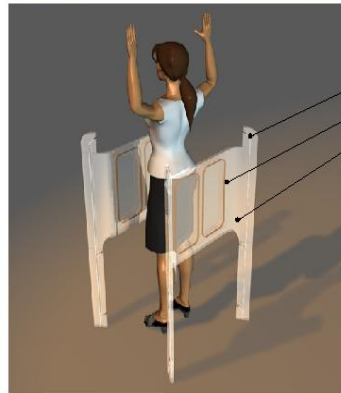
■ NQR Pelvis Scanner

Primary:
Targeted Pelvis
& Body Cavity
NQR Scanner

Passive RFI Shielding

Inside AIT?
Simultaneous Scan?
Interference:

AIT=>NQR
NQR=>AIT



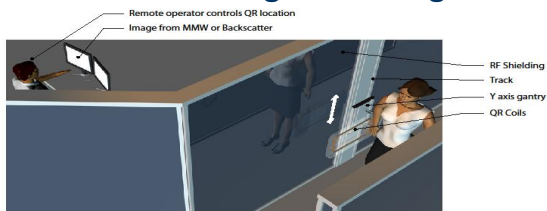
12



■ NQR Wand: Gantry Mounted

Secondary:
AIT-guided Anomaly Resolution
Surgical Sites?
Embedded Threats?

Passive RFI Shielding: Wandering Station



13




NQR Wand: Hand Held

Optional ITMS Integration



The diagram shows a mechanical assembly with various components. A yellow tube connects the assembly to a handheld device. A blue arrow points from the text 'Collection Tube to Wand' to the yellow tube. A cyan arrow points from the text 'MDI MobileTrace' to a component in the assembly. Another cyan arrow points from the text 'High Volume Vapor Pump' to a cylindrical component on the left.



A photograph of a handheld black rectangular device with a green light and a yellow tube attached to its side. A hand is holding the device.

Collection Tube to Wand

MDI MobileTrace

High Volume Vapor Pump

14

 **Morpho Detection**
SAFRAN Group

317

19.17 David Sheen, Pacific Northwest National Laboratory: ATR for millimeter wave



**Automated Threat Recognition for
Millimeter-wave Imaging**

David Sheen, Paul Keller, and Doug McMakin

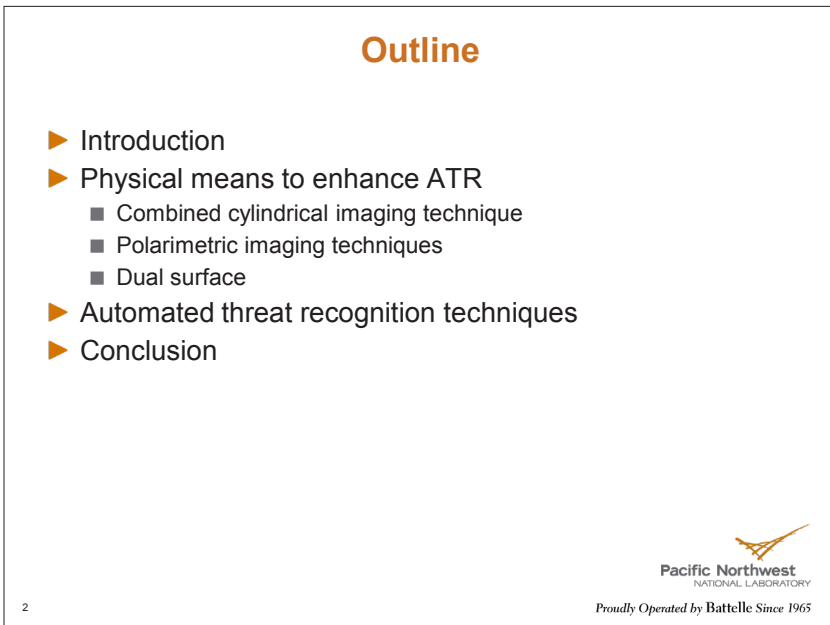
April 27-28, 2010

Algorithm Development for Security Applications (ADSA) Workshop
Sponsored by ALERT / DHS

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NATIONAL LABORATORY

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1



Outline

- ▶ Introduction
- ▶ Physical means to enhance ATR
 - Combined cylindrical imaging technique
 - Polarimetric imaging techniques
 - Dual surface
- ▶ Automated threat recognition techniques
- ▶ Conclusion

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Terrorist Threats

- ▶ Explosives
- ▶ Suicide vests
- ▶ Weapons
 - Guns
 - Knives
 - Etc.
- ▶ Nuclear, biological, or chemical materials carried in sealed containers



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Current Screening / Privacy Policies

- ▶ Passengers' faces are blurred
- ▶ Images will be deleted immediately once viewed
- ▶ Images never stored, transmitted or printed (the passenger imaging units have zero storage capability)
- ▶ No line-of-sight with person under surveillance
- ▶ No association of millimeter-wave imagery with person



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Privacy Algorithms for ATR

- ▶ Goal □ automatic detection of concealed threats
- ▶ Algorithm approaches
 - Physical techniques
 - Software techniques
- ▶ Operational disclosure rules augment algorithm performance (checkpoint)
- ▶ More information improves algorithm performance
 - More image frames (averaging)
 - Enhanced coverage (viewing perspective)
 - Higher frequency (lateral resolution)
 - Wider bandwidth (range resolution)

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Approach to ATR

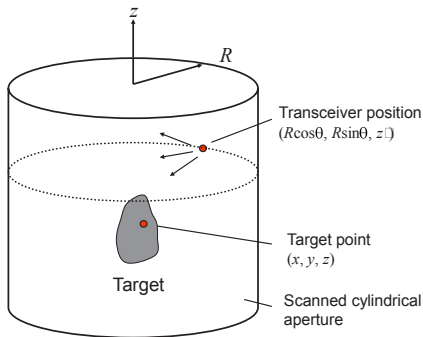
- ▶ Goal:
 - Find concealed weapons or explosives on individuals during security screening while maintaining privacy rights
- ▶ Exploit these to find objects
 - Intensity
 - Depth
 - Polarization
 - Views from multiple angles
 - Unique features of the object
- ▶ Techniques
 - Image processing techniques
 - Artificial Neural Networks (ANNs)

6

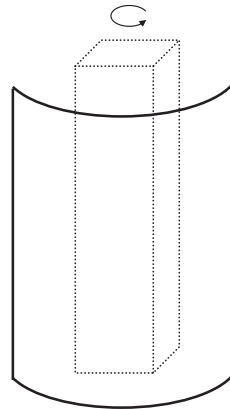


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Rotating Target Cylindrical Reconstruction Technique



Wideband reflection data gathered over a 2D cylindrical aperture



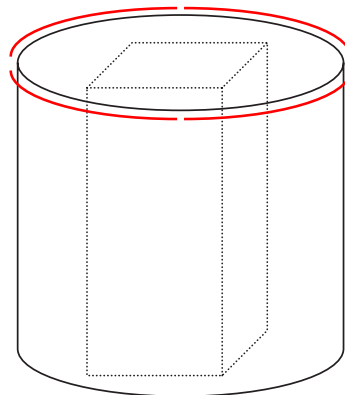
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Combined Cylindrical 3-D Reconstruction

- ▶ Reconstruction angular segment rotates with respect to fixed (x, y, z) volume
- ▶ *Rotating Illumination* modification to standard *Rotating Target* cylindrical reconstruction
- ▶ 3D (x, y, z) images are combined from 8 overlapping 90 degree arc segments to form complete reconstruction
- ▶ Bandwidth of millimeter-wave illumination should be as wide as possible for depth resolution comparable to lateral resolution



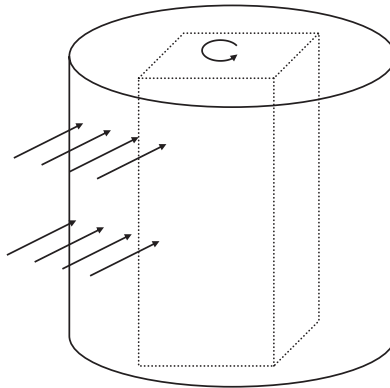
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Rendering the Combined 3-D Image

- ▶ The combined 3-D image is rendered by projecting through the data set at discrete angles over the full 360 degree angular range
- ▶ The back surface is hidden by attenuating the projected rays proportionally to each voxel's intensity



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Combined 3D Cylindrical Imaging - Advantages

- ▶ Only eight 3-D image reconstructions are required to form a complete animation with any number of frames
- ▶ Rendered views of the combined image have much more complete illumination than single-view images (single view images lose information due to specular reflection)
- ▶ Optimized use of depth resolution may allow for improved automated threat recognition (ATR) algorithm development by accenting objects which appear off the body and other techniques

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Cylindrical Imaging Results (24 - 40 GHz)



Cylindrical



Combined Cylindrical



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Circular Polarization □ Reflection Properties

- ▶ Single (or odd numbered) reflection from smooth surface (e.g. flat plate or sphere) has its rotational handedness reversed (e.g. RHCP becomes LHCP)
- ▶ Double (or even numbered) reflection has its rotational handedness preserved (e.g. RHCP remains RHCP)
- ▶ These properties may enhance detection of concealed items and reduce body features in the images

RHCP
→
←
LHCP

Single
Reflector

RHCP
→
←
RHCP

LHCP



Corner
Reflector

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Mannequin with Concealed Weapons



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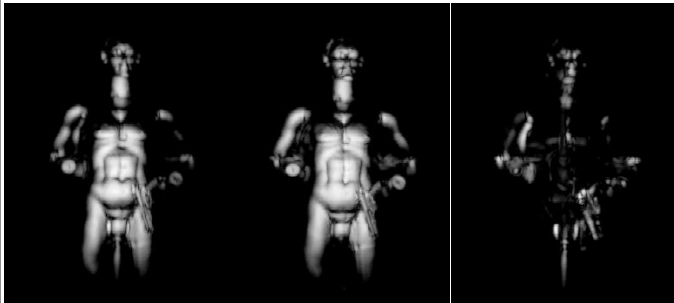
13

Mannequin with Concealed Handgun and Simulated Explosive

HH Polarization

RL Polarization

RR Polarization



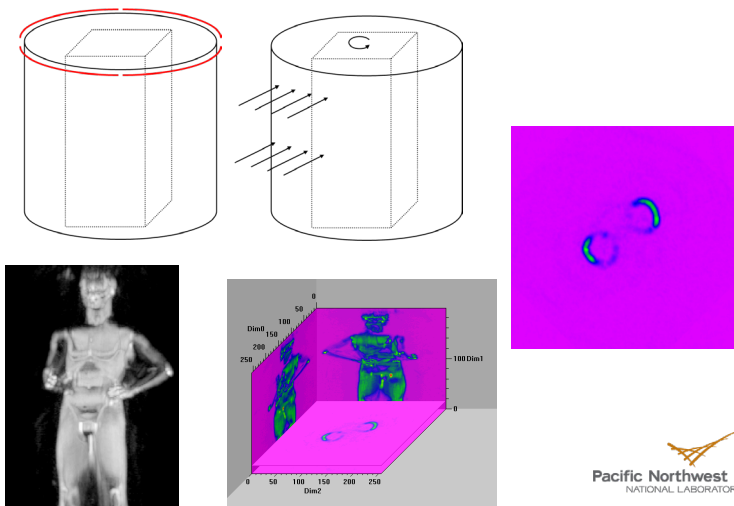
Full Cylindrical Scan/Reconstruction
10 □ 20 GHz

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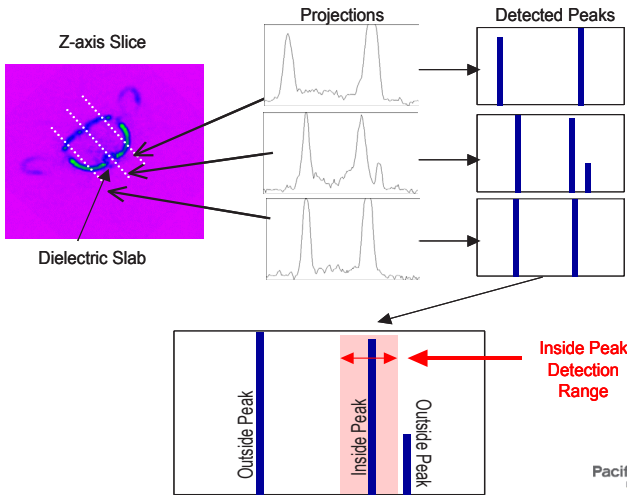
Combined Cylindrical Imaging Technique



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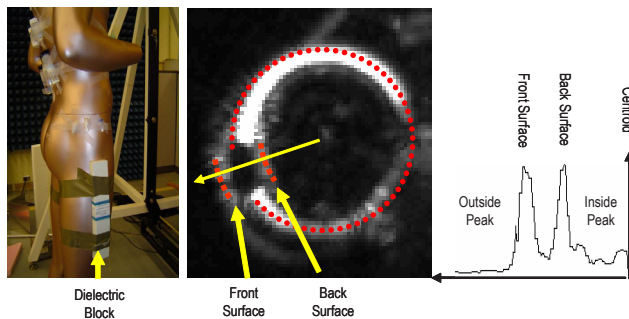
Basic View of Dual Surface Dielectric Depth Detector



16

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Dual Surface Dielectric Depth Detection Preliminary Results



17

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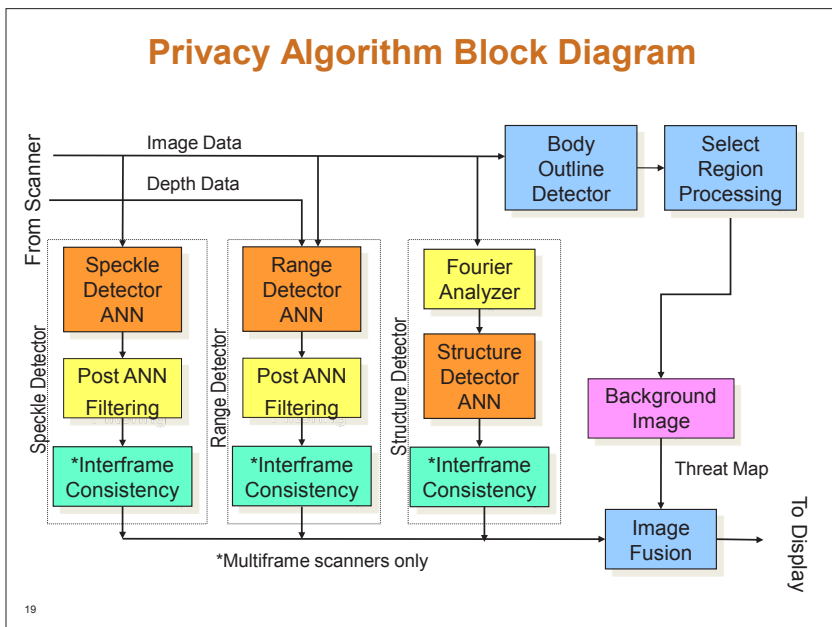
Automated Threat Detection Techniques Developed with ANNs

- ▶ ANNs that exploit speckle in images
 - Detects plastics and other dielectrics
 - IEEE Carnahan Security Conference □ Madrid (October 1999)
 - IEEE Aerospace Magazine (February 2000)
- ▶ Pulse coupled neural networks for object segmentation
 - Not successful
 - SPIE AeroSense Conference □ Orlando (April 2000)
- ▶ ANNs that use depth information
 - Detects certain objects based on surface profiles
 - US Patent #7,365,672
 - European Patent Office, Mexican Patent Office
- ▶ ANNs that employ spatial frequency information
 - Detects sharp edges indicative of manmade structure
 - US Patent #6,876,322
 - WCCI/IJCNN □ Vancouver (July 2006)

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Speckle Detector for Dielectric Objects

► Approach:

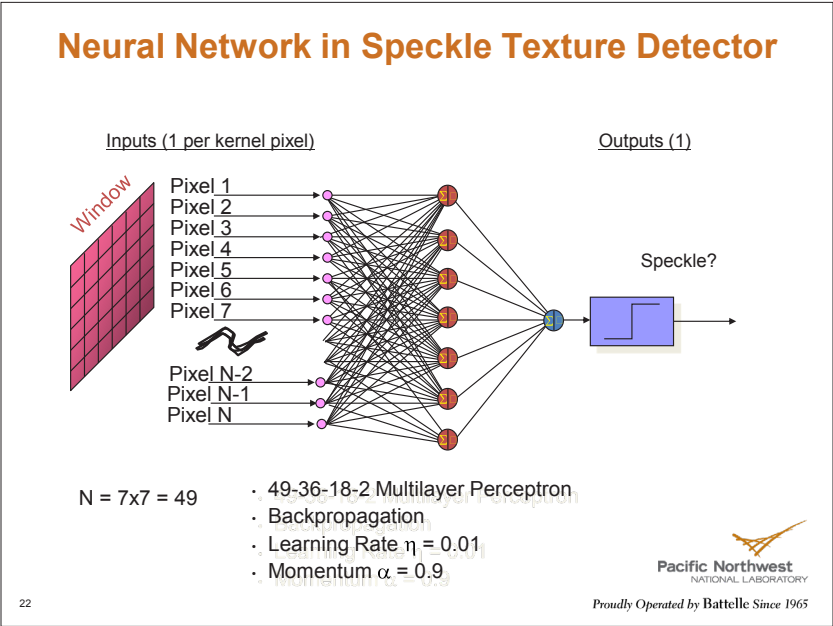
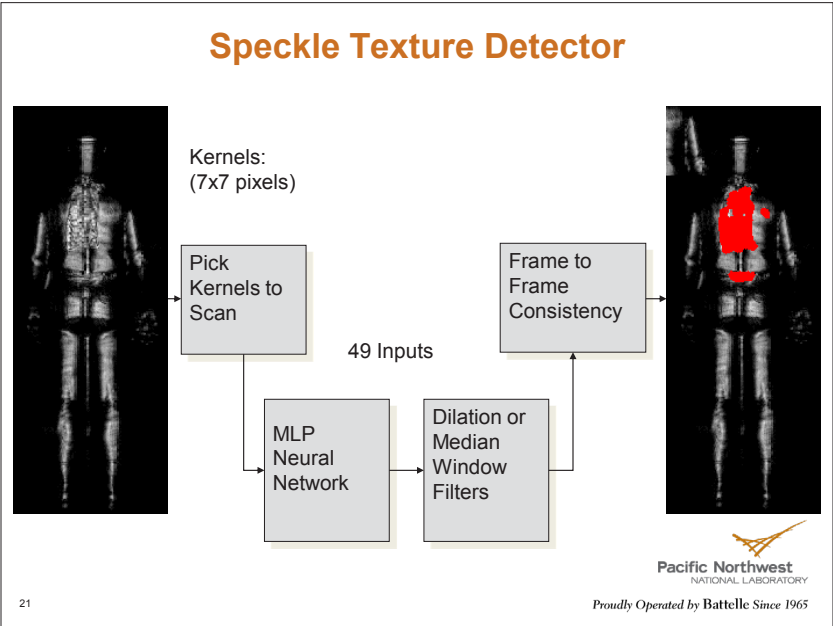
- Plastic objects produce speckle in the millimeter wave images. Speckle is the result of interference between multiple reflections and has a granular appearance.
- A multi-layer perceptron (MLP) neural network with dilation and median window filters detects presence of speckle indicating probable plastic in image

► Goal:

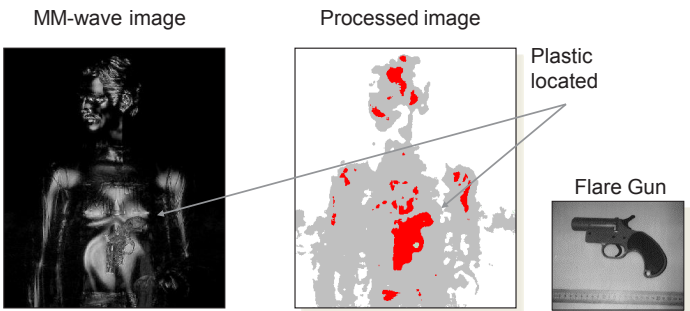
- Highlight speckle in images which is indicative of plastic (e.g., plastic guns, plastic explosives)

► Data Sets:

- SeaTac data and new scanner with new simulants



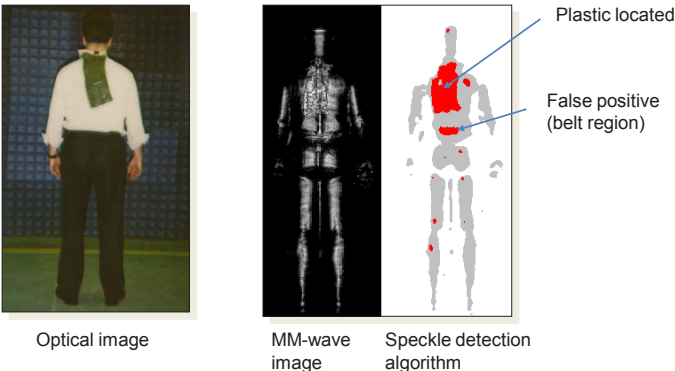
Speckle Texture Detection Results with Plastic Flare Gun



23


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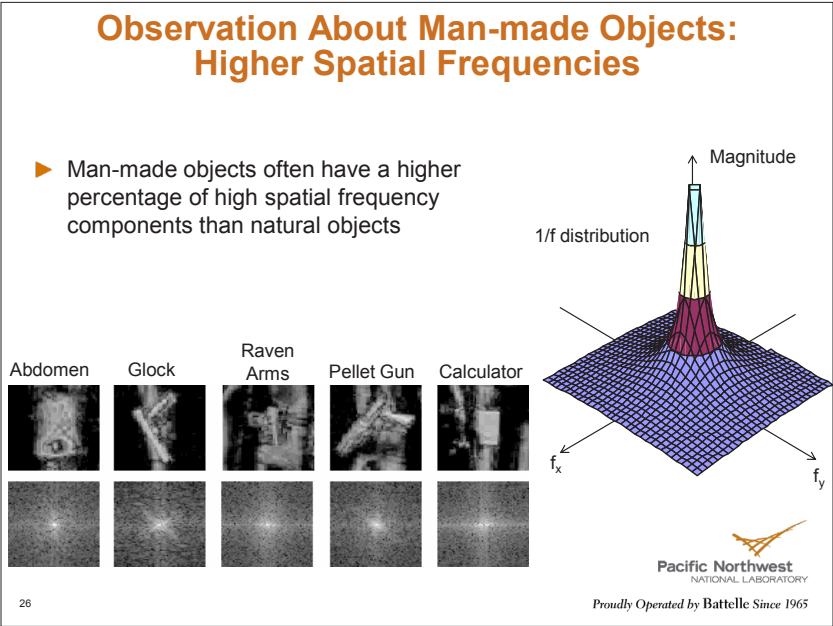
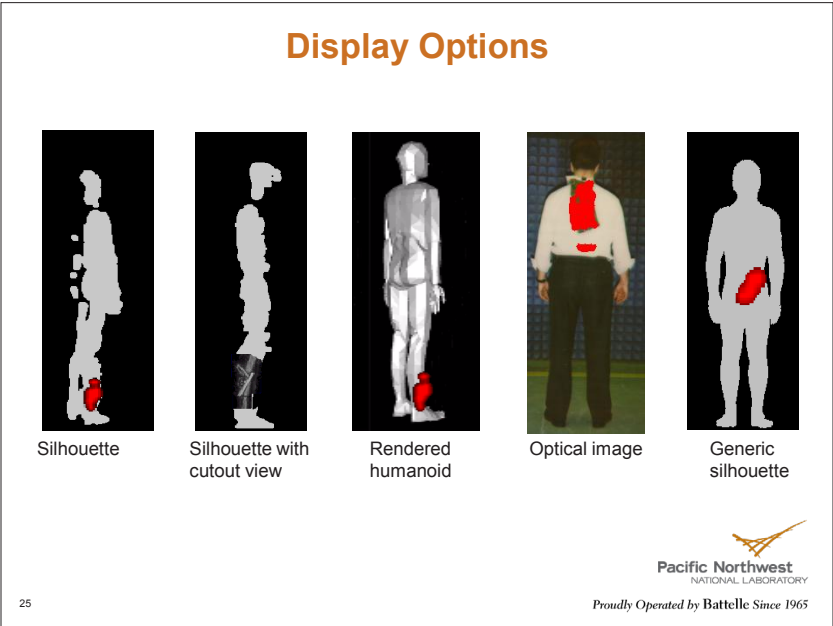
Speckle Texture Detection Results on Simulated Plastic Explosive

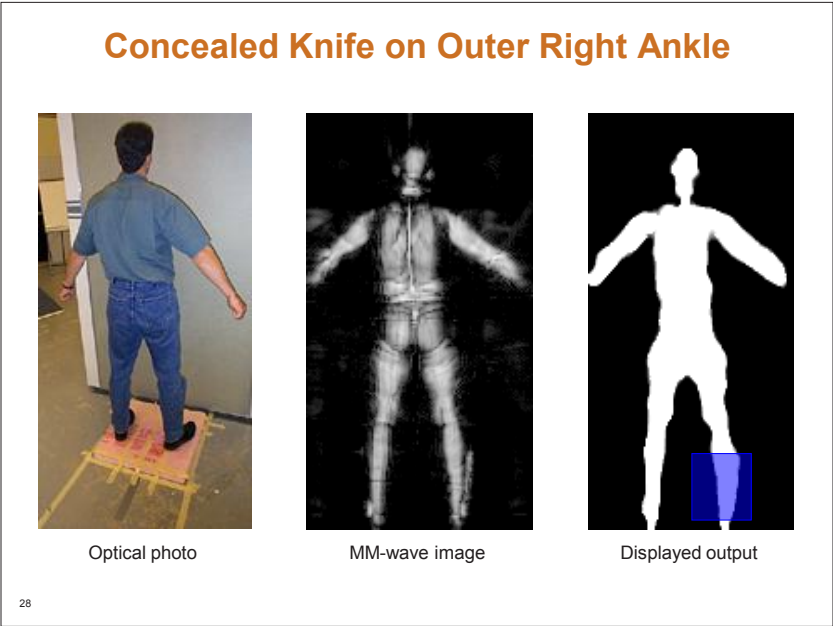
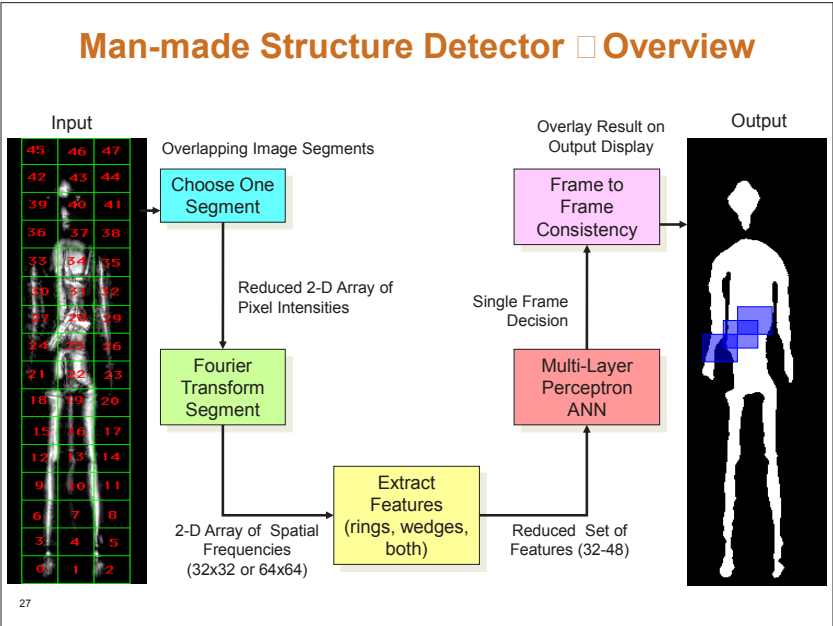


- ▶ Filters remove stray hits and small areas (dilation, median, window)
- ▶ Frame to frame consistency also reduces false positives

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Conclusions / Recommendations

- ▶ Millimeter-wave imaging systems are being deployed at major airports in the US for both primary and secondary screening
- ▶ ATR techniques
 - Speckle detector works well for dielectric threats
 - Structure detector detects many man-made devices
 - PCNN results disappointing and not useful for this type of imagery
 - Dual surface dielectric depth detector is a promising new technique for ATR in 3-D mm-wave images
 - Large set of algorithms may be required
- ▶ Recommendations
 - Imaging system improvements
 - Increase resolution
 - Increase coverage (extra sensors?)
 - 3-D information can be enhanced and more widely exploited

19.18 Thomas Sebastian, GE Global Research Center: ATR for millimeter wave and x-ray backscatter

ATR Algorithms

Thomas Sebastian
GE Global Research

Jointly with Morpho Detection Inc (MDI)

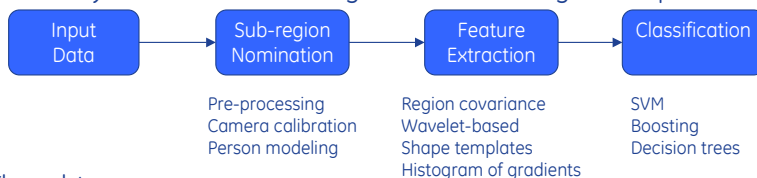


imagination at work

ATR Algorithm Overview

Consists of 3 main steps

- Nominate image sub-regions based on prior/domain information
- Extract feature descriptor for each image sub-region
- Classify feature vectors using machine learning techniques



Thoughts

- ATR development need to account for physics of underlying imagery
- Need to have enough data to capture the *variability*
- Use domain-specific information whenever possible
- Multimodal data (Video+MMW, Video+IR – person detection)



imagination at work

Visualization and Computer Vision Lab
GE Global Research

2

GRC ATR Overview

- Leverages experiences in other applications
 - Pipeline defect recognition (Magnetic flux and Ultrasound)
 - CT lung cancer detection
 - Video person detection
- GRC experiences with MMW ATR
 - Video + QinetiQ iSPO30 MMW
 - Safeview SafeScout MWW imagery analysis



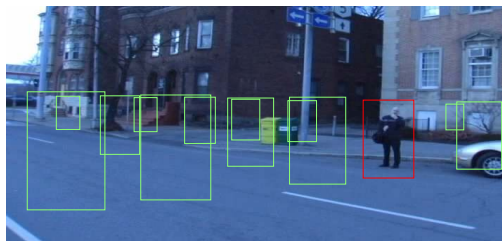
3
Visualization and Computer Vision Lab
GE Global Research

Person Detection in Video

Goal: Detect people in moving cameras (e.g. mounted on a car or robot)

We cannot rely on motion cues

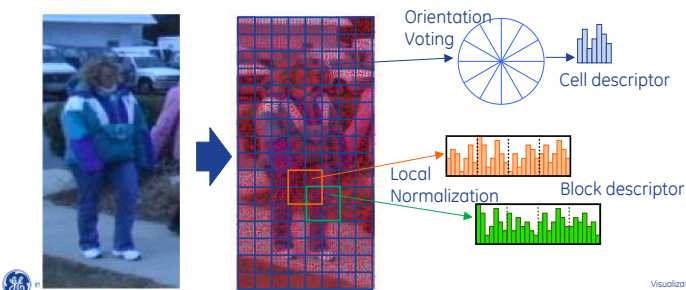
Use camera calibration (gives size of people in images) to select regions where to look



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Person Detection in Video

- Features have to be invariant to lighting changes, viewpoint changes, appearance variations due to clothing and dynamic pose of people
- Capture the local object shape and appearance
- Commonly used features are based on image gradients, blob-based region features, region covariance features, histogram of oriented gradients



Person Detection in Video

Training data: Several thousand positive (person) and negative (non-person) images



Robust detection needs data that captures the underlying variability

Person Detection in Video - Results



Wooded

Urban



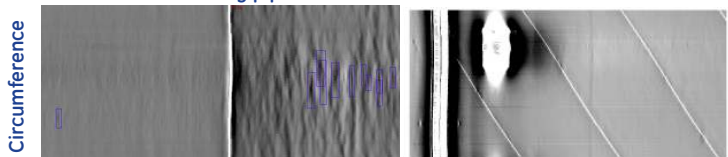
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Defect Detection – Pipeline Inspection

Goal: Detect corrosion and other metal loss defects



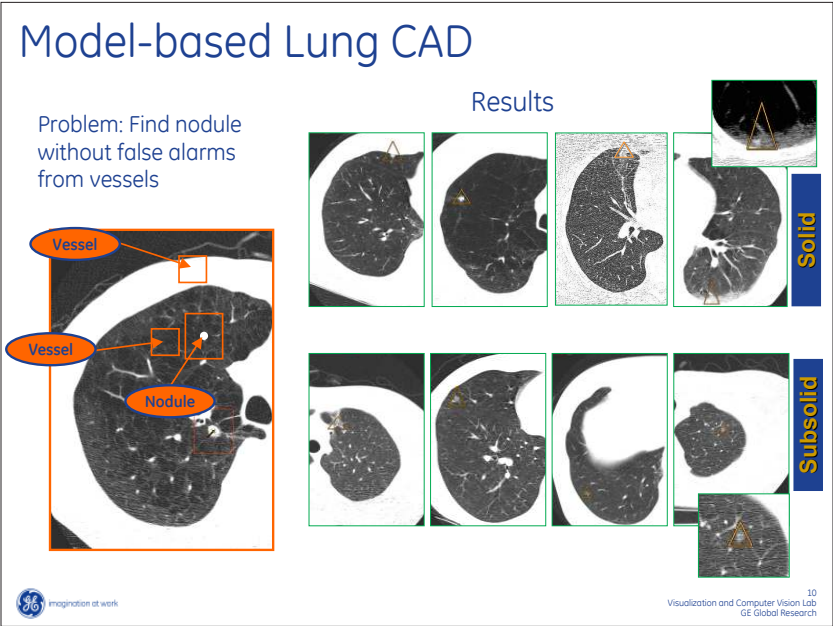
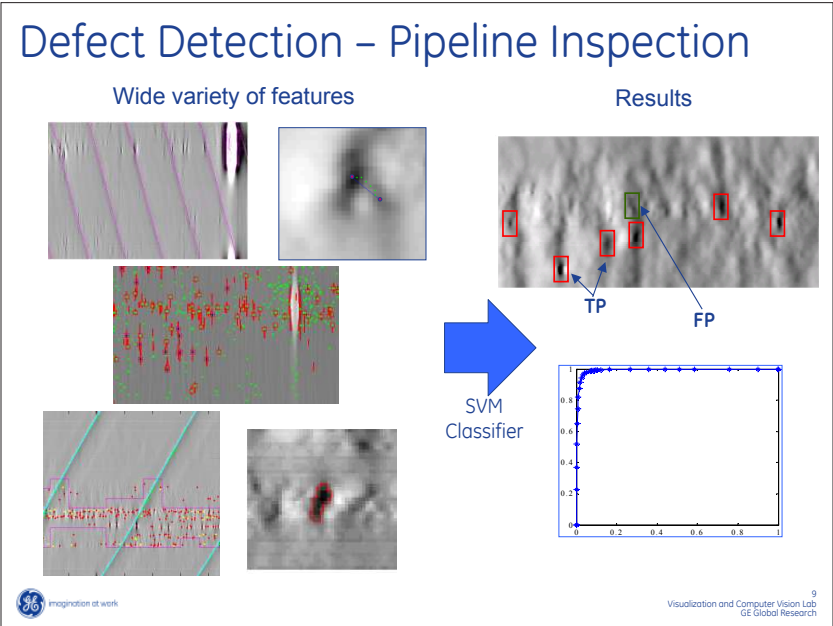
Key challenge: Wide variations in data
Along pipeline



- 1000+ miles of data @ sample / 3mm
- 2.5M+ labeled defects



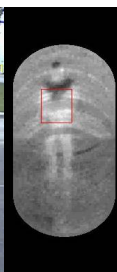
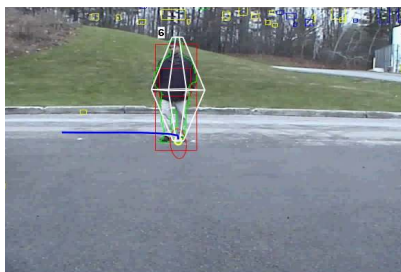
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iSPO-30™ Demo – GE Global Research



QinetiQ iSPO-30™ MMW Sensor
Provided to GRC by TSWG



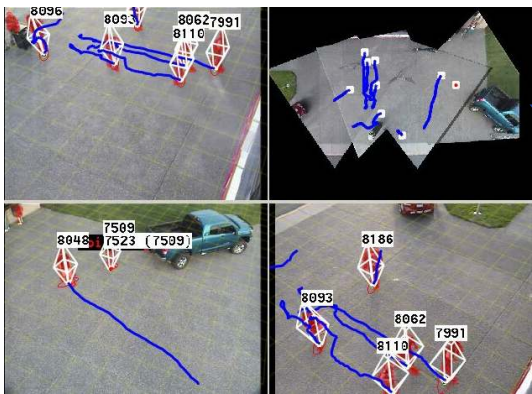
Automated video person detection, tracking and
model fitting used to get relevant MMW data



Imagination at work

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GE Site-wide Tracking at DHS STIDP



Synthesized
One-World View

- GE is a recognized leader in multi-camera person tracking
- GE deployed video site-wide tracking and event detection system Toyota Center, Kennewick WA (DHS STIDP 2008)




Imagination at work


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Person Detection – Crowds


WFOV




PTZ



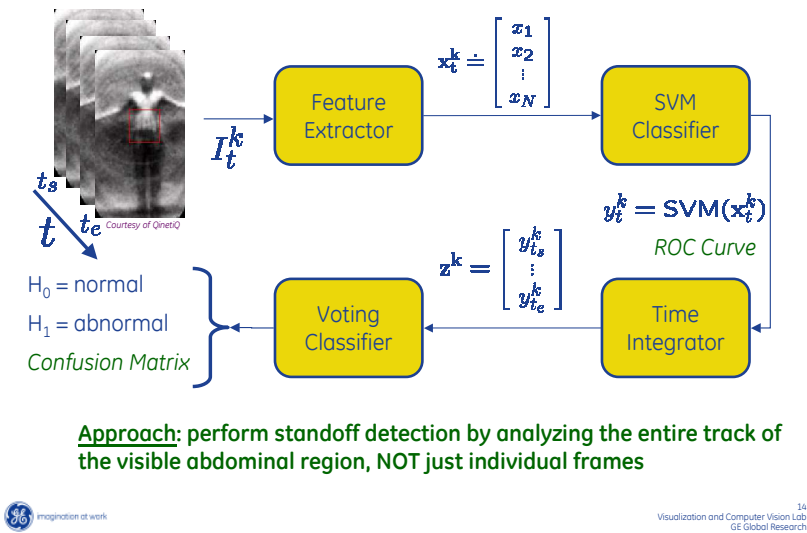
Detection and tracking of people is used to aim the PTZ camera and capture high-resolution data

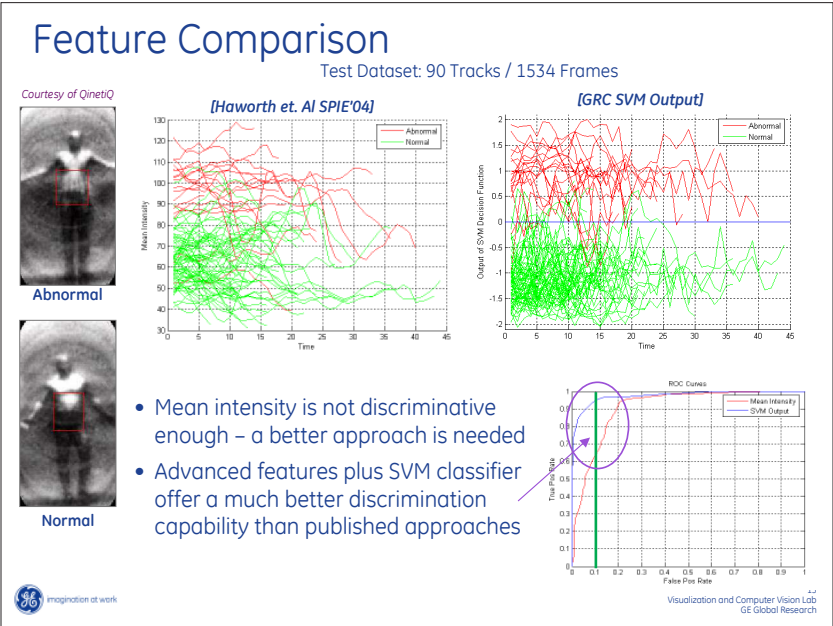



Imagination at work

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MMW Threat Detection System Overview





Safeview Image Analysis

Preliminary investigation based on images captured using screen-shots

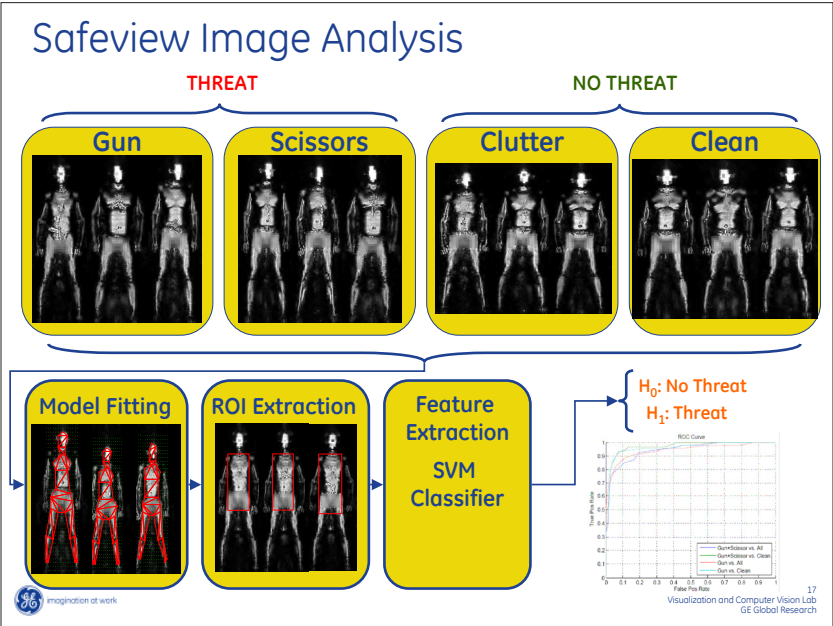
Similar threat detection algorithm

1. Automatic extraction of the region of interest (ROI)
2. Feature design and extraction
3. Classification with machine learning techniques

SafeScout™ MMW Portal

SafeScout™ MMW Portal GUI

Visualization and Computer Vision Lab
GE Global Research



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Tel: (518) 387-4413



19.19 Visvanathan Ramesh, Siemens Corporate Research: Video tracking of divested objects

Corporate Technology

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Video Analytics for Checkpoint Screening

Presented by : Dr. Visvanathan Ramesh, Siemens Corporate Research, a division of Siemens Corporation, Princeton, NJ.

Email: visvanathan.ramesh@siemens.com

Contributors: Dr. Claus Bahlmann, Dr. Vasu Parameswaran, Dr. Yanghai Tsin, Dr. Vinay Shet, Dr. Maneesh Singh, and numerous other collaborators.

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Multi-Sensor Solution for Screening

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Conveyor Transports

Objects/Packages

Multi-camera Vision System for Screening

Video Analytics Platform & Plugins

Data & Logs

Communication to remote facility

Functions:

- 1) Multi-camera systems for person & divested items detection, tracking, re-identification
- 2) Logging, visualization & Remote communication

User Interface, Information access & Visualization

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Secure Screening via Video Analytics**SIEMENS**

- **Problem:** Effective screening of persons in airports require the ability to:
 - Track persons being screened
 - Associate persons with their divested items
 - Identify Anomalous Events – e.g. person leaving an item, or picking up someone else's items
- **Current Process:** error-prone, human-intensive, manual (cumbersome for both passengers as well as security personnel).
- **Need:** Automation is highly desired to address enhanced security while increasing throughput and comfort for passengers.
- **Potential Solution:** Advanced video analytics to:
 - acquire visual descriptors of persons, their bags and their association through the use of sets of cameras
 - re-identify persons and their respective bags after they go through metal-detector/screening portal.
 - Catalogue bags identified as potential for further screening and display along with the person identification (pictures) for effective intervention.
 - Alert operators about potential items left behind and/or event anomalies.

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<Dr. V. Ramesh/C. Bahlmann>,
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© Siemens AG, CT/SCR**Secure Screening Solution Technology:****SIEMENS**

- Core Component Technologies/Subsystems of interest:
 - Face detection, tracking, matching.
 - Person descriptor (height, weight, appearance) Extraction,
 - Object detection, tracking, descriptor construction and matching\
 - Video analytics for person/bag association
 - Event analysis for anomaly detection
 - High-level reasoning for situational awareness
 - Advanced Human Machine Interface for effective intervention.
- Common framework for Sensor Data Fusion and Cognition
- System Engineering Tools for Sensor Placement, Performance Prediction, etc.

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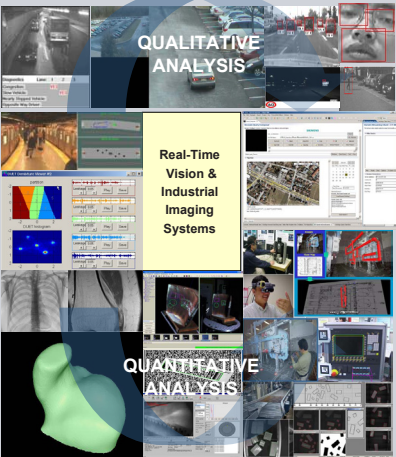
Video Monitoring Technology Landscape & Trends

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QUALITATIVE ANALYSIS

Real-Time Vision & Industrial Imaging Systems

QUANTITATIVE ANALYSIS



- Continued Increase in HW capabilities
- Advances in Sensing – higher resolution, dynamic range, smart, embedded, distributed, novel sensors
- Advances in Analysis tools – Statistical learning, Data fusion
- Systems Engineering and Analysis of complex systems
- Advanced Multimedia management & search tools
- Push to understand semantics from images/video and combination of sensor data
- Human-like cognitive architectures

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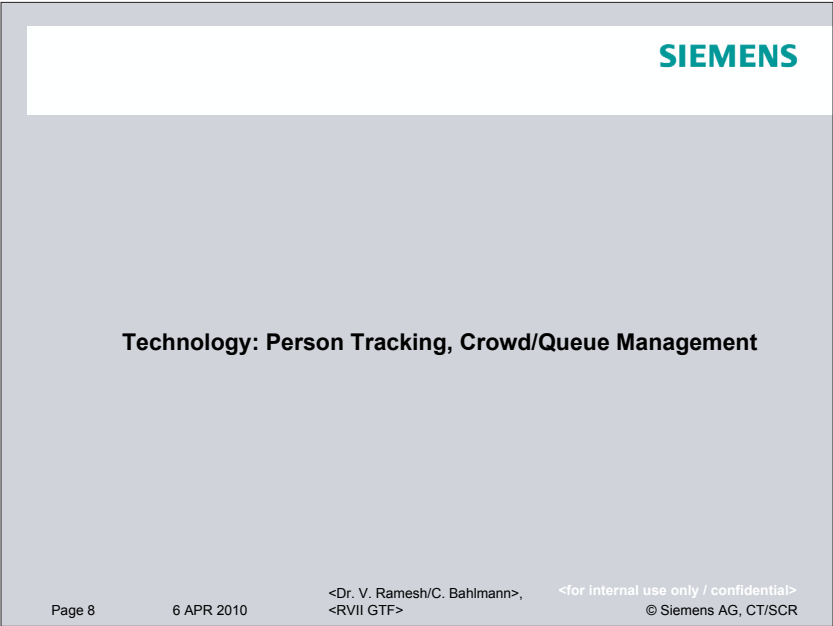
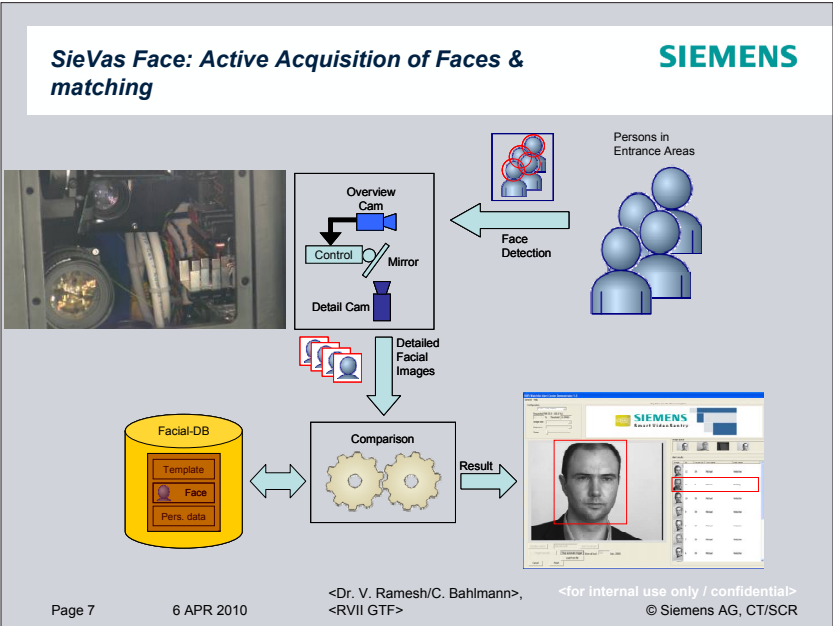
Technology: “Capture of Person Biometric Features”

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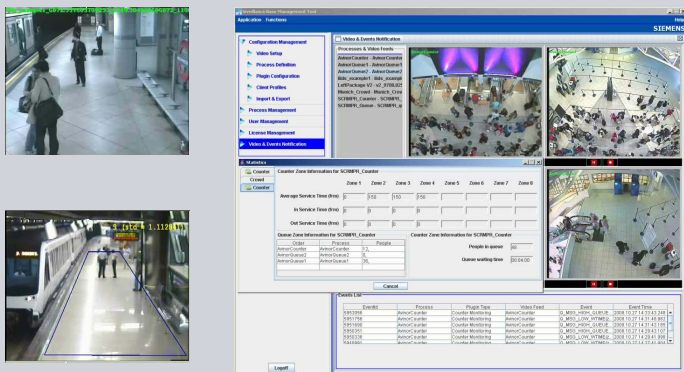
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344



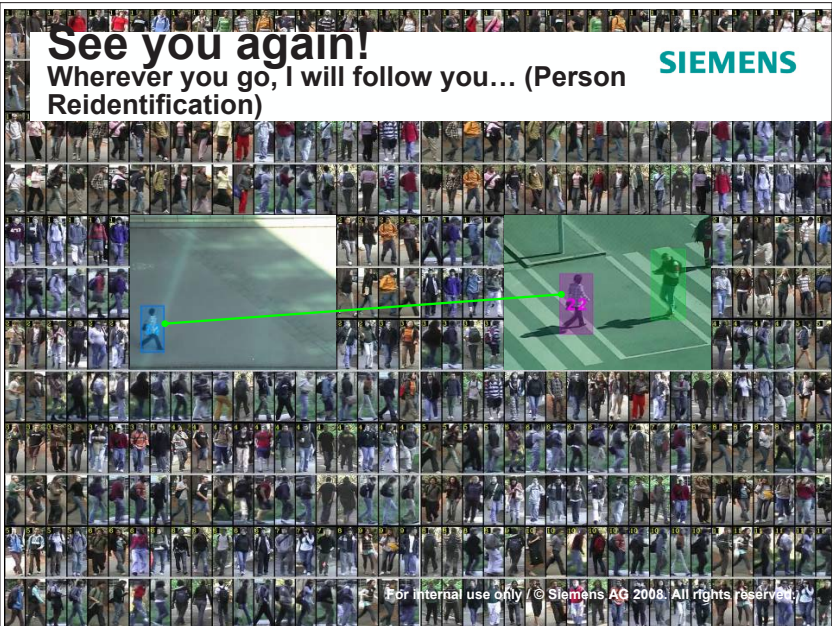
Technologies for Person, Tracking, Event Analysis
& Crowd, Queue Management

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Technology: Person Re-identification



Screening – Matching by Appearance

- **Re-identification** of persons by overall appearance („Soft-Biometrics“), e.g. clothing, movement pattern
- Ensure **efficient interactive search** functionality
- Leverage existing CCTV infrastructures

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Technology: Model Based Object Re-identification

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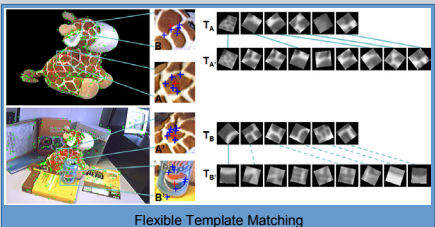
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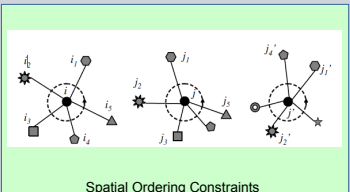
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Object Detection and Matching Using 2D Spatial
Ordering Constraints

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Flexible Template Matching



Spatial Ordering Constraints



Rigid Object Detection



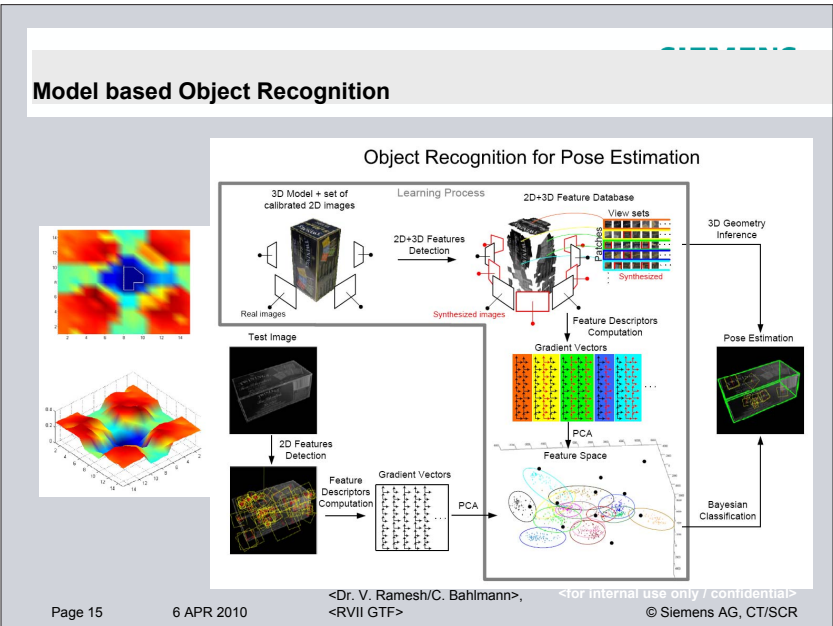
Non-Rigid Object Detection

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Technology/Platform: Common Framework for Visual Cognition

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Video Analysis for Security & Transportation



- Application-specific design configurations depends largely on:
 - the task,
 - requirements, and
 - domain context (i.e. world knowledge)
- Framework can leverage mental processing models in psychology and cognitive science.

"Common Visual Cognition Framework" to address: Predictability, Scalability, Modularity and Extensibility

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Summary & Conclusions:**SIEMENS**

- Integrated Sensing, Data Analytics and Reasoning Solutions can help greatly enhance:
 - throughput, comfort, quality of travel experience of passengers and
 - improved security.
- Advanced video analytic capabilities that may be used to:
 - acquire visual descriptors of persons, their bags and their association through the use of sets of cameras
 - re-identify persons and their respective bags after they go through metal-detector/screening portal.
 - Catalogue bags identified as potential for further screening and display along with the person identification (pictures) for effective intervention.
 - Alert operators about potential items left behind and/or event anomalies.
- Performance of video analytics is still not at a stage where complete automation is feasible
- Judicious integration of sensors, algorithms, and system engineering can enable high performance solutions to be realized.

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Future Challenges:**SIEMENS**

- Modular component technologies for basic technologies in vision and audio such as: detection, localization, tracking, identification, pattern classification, pose estimation, 3D reconstruction, and video/audio interpretation
- Domain modeling for application spaces can enable effective re-use
- Model-based Systems engineering & Analysis more mature: Statistical characterizations of total systems (composed of estimation schemes applied in sequence, open-loop and in closed-loop (with feedback)) and quantification of limits of systems → **“Challenge is in scaling up the methodology to address performance quantification of distributed sensing, communication, control and large scale search systems”**

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Key Research Topics

- More active research is on
 - "Multi-modal Fusion" – Systematic fusion of Vision with other sensors
 - "Pattern Models and Grammars for Recognition" – Bridging Model-based vs Data driven methods
 - "Cognition & Situational Understanding"
 - Advanced Systems Engineering - "Systematic use of Knowledge bases and Models to drive selection of appropriate tools for Data Analysis"
 - "Scalable Search & Mining tools"
 - "Better HMI + Automated Data Analytics Integration" – e.g. Cognitive Engineering, radical search tools using EEG + Vision systems integration (C3Vision – Columbia U.)
 - "Active & Real-time Control", etc.





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Thank you for your time!





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19.21 Lauren Porr, Department of Homeland Security: Concept of operations for using sensors

Concept of Operations for Advanced Imaging Technology



Homeland
Security

What should the AIT CONOPS consist of?

- Ideally, the CONOPS should:
 - ☐ Describe how AIT fits into the Common Operating Picture (Checkpoint)
 - ☐ Indicate interoperability with other systems in the Checkpoint
 - ☐ Give a realistic picture of how an operator will typically use the system
- Factors to consider:
 - ☐ Flow of passengers
 - ☐ Throughput
 - ☐ Space required
 - ☐ Discrimination of passengers for further search

How to implement the CONOPS?








- The CONOPS should be drafted early in the development/qualification process in coordination with requirements development
- Receive feedback from testing entity to refine documented processes
- Involve Transportation Security Officers (TSOs) in process to assure understanding at working level
- Factors to consider:
 - ☐ Current requirements
 - ☐ Effect of new systems in checkpoint lanes
 - ☐ Results from testing
 - ☐ Availability of TSOs

What is the path forward?

- (0-12 months) Write CONOPS to accommodate new AITs into checkpoint lanes as well
- (12-18 months) Incorporate ATR into CONOPS
- (18+ months) Merge AIT CONOPS into Integrated Checkpoint CONOPS


19.22 Carey Rappaport, Northeastern University/ALERT: Modeling of sensors, probe interactions with targets, and clutter sources

ADSA III Workshop -- Advanced Imaging Technology for Whole Body Imaging










Modeling of Sensors, Probes, Clutter Sources

Carey Rappaport
ECE / ALERT
Northeastern University



Boston, MA, April 28, 2010



Appendix 5

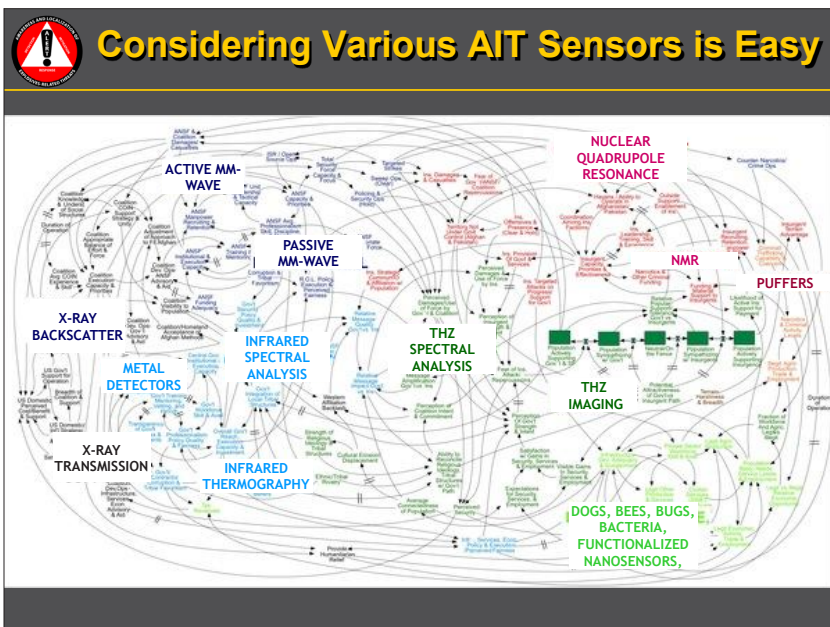
Derivation of Unified Mathematical Theory (con'd)

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180r^2s1 216a1r^2s1 72a1^2r^2s1 864r^2s1 432a1r^2s1 3s1^2 3a1s1^2 12a1^2s1^2 6a1^3s1^2 27del s1^2 72r^2s1^2 72a1r^2s1^2
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a1^2s1s2 36r^2s1s2 72a1r^2s1s2 3s1^2s2 12a1s1^2s2 3a1^2s1^2s2 3s2^2 3a1s2^2 72r^2s2^2 3a1s1s2^2 2s2^2,^2
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4, . 2 a1 12r^2 s1 a1s1 s2, 3, 1 s1, 1 2a1 12a1r^2 a1s1 s2 a1s2,...

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Slide 845 of 845



Definitions

- Sensors** □ Antennas, emitters, coils, transducers, including receiving elements
- Background** □ Expected nominal scene
- Probe interactions** □ Scattering, reflection, absorption, resonant coupling, nonlinear coupling □
- Target signal** □ response from intended object of interest
- Clutter** □ organized or self-correlated non-target signal
- Anomaly** □ low occurrence shape, signature, or response



Wave-Based Computational Modeling

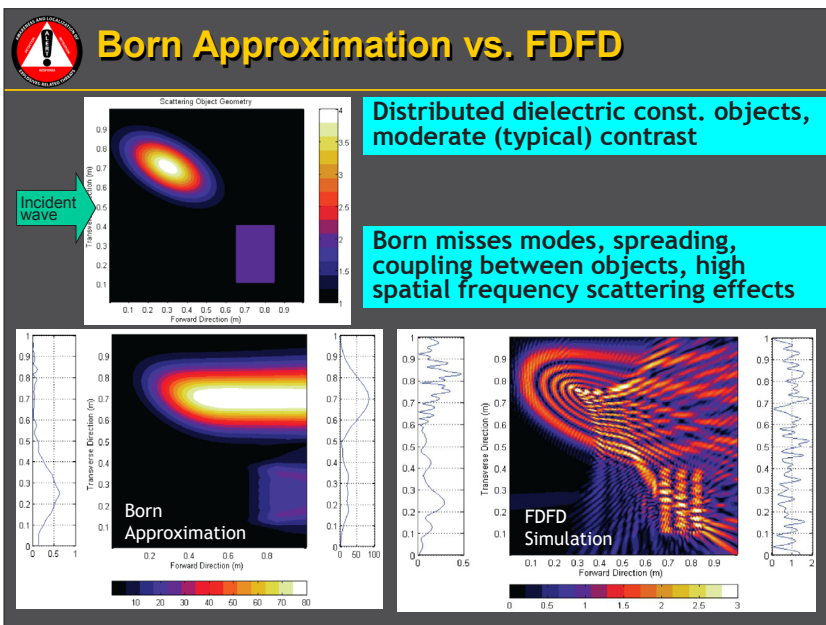
Reasons for modeling


- Quickly simulate scattering: realistic targets / backgrounds
- Identify target features and clutter characteristics
- Provide a basis for sensor array geometry synthesis
- Provide a forward model for inverse scattering analysis



Snapshot of Waves Interacting with Scatterers





 **Millimeter-Wave Radar Modeling**

Background Structure

- Skin/flesh: well-characterized lossy but penetrable dielectric
 - Insignificant penetration for cavity or implant sensing
- Smoothly varying surface
 - Convex and concave (between legs) regions
 - Glancing incidence (shoulders, buttocks) regions
- Very large scatterer $\sim 50 \square 150 \lambda$
- Mutual interaction among parts of body and between body and targets
- Specular reflections indicate large smooth surfaces (but also smooth man-made objects)



Millimeter-Wave Radar Modeling

Clutter Sources

- Folds in flesh
- Clothing
 - Metal / leather items or attachments
 - Wrinkled fabric
- Harmless concealed objects
 - Jewelry
 - Bandages
 - Medical items



Millimeter-Wave Radar Modeling

Probe Interactions

- Broad beam illumination
 - Reconstruction based on Fourier Inversion
 - Synthetic / real focused aperture
 - No mutual interaction
- Focused beam □ localized probing in 3D
 - Real 2D aperture
 - Does not take advantage of strong specular reflection
 - May miss features on side of subject (glancing incidence)



Millimeter-Wave Radar Modeling

Target Signals / Anomalies

- Unusual shapes
 - Non-biological media
 - Boundaries of similar dielectric media
- Specular reflections
 - Missing from expected regions
 - Arriving from unexpected regions
- Delayed time pulse return due to multiple wave bounces
- Resonant responses



X-Ray Backscatter Modeling

Background Structure

- Skin/flesh: well-characterized
 - Backscatter doesn't penetrate enough for cavity sensing
 - Transmission shows internal features
 - Model tissue attenuation to predict depth
- High resolution imaging



X-Ray Backscatter Modeling

Clutter Sources

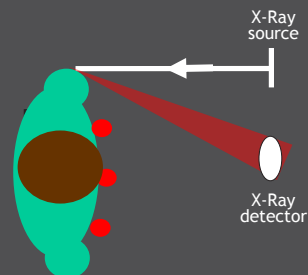
- Folds in flesh
- Clothing
- Harmless concealed objects
 - Jewelry
 - Bandages
 - Medical items



X-Ray Backscatter Modeling

Probe Interactions

- Spot illumination
 - Ray-based back projection reconstruction
 - Model non-ideal pencil beam?
 - Minimal mutual interaction between probed features
 - Shadowing by strong absorbers
- Limited depth information
 - Only view from front or back
 - Makes objects on sides hard to distinguish
 - Rotating subject or curved detector?





X-Ray Backscatter Modeling

Target Signals / Anomalies

- Unusual shapes
 - High Z material
 - Boundaries of dissimilar media
- Model attenuation of foreign objects to predict thickness
 - Compensate for shadowing
- Model pixel responses to determine best resolution



THz Modeling

Background Structure

- Skin/flesh: well-characterized lossy impenetrable dielectric
 - Insignificant penetration for cavity or implant sensing
 - Wet/metallic layers block THz
- High resolution transmission imaging (but not for WBI)
- Localized point-by-point probing
- Spectral response gives material characteristics



THz Modeling

Clutter Sources

- Anything with water or polar molecules
- Clothing
 - Metal items or attachments
 - Wrinkled fabric?
- Harmless concealed objects
 - Jewelry
 - Bandages
 - Medical items



IR Thermography Modeling

Background Structure

- Quantitative heat transfer model
- Model environment and associate its perturbation to observed signal
- Non-equilibrium spatial and temporal temperature distribution



NQR Modeling

Background Structure

- Spectral response gives unique chemical characteristics
- Readily penetrates tissue
- Sensitivity depends on ROI size, distance from sensor coils



NQR Modeling

Clutter Sources


- Variation with temperature
- Metal objects



Summary

- Modeling provides feasibility analysis
- Allows control of parameters
- Must capture all relevant problem aspects
 - Target characteristics
 - Background characteristics
 - Clutter characteristics
- Gives framework for performance optimization
 - Must know what deficiencies are
 - Must know what can be changed

19.23 Eric Miller, Tufts University: Reconstruction algorithms





Tufts
UNIVERSITY

School of
Engineering

Algorithmic Needs: Reconstruction

Eric Miller
Prof. ECE, Tufts University
elmiller@ece.tufts.edu





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Reconstruction

- Four components
 - Parameter of interest (reflectivity, Z , absorption, Compton coefficient, photo-electric coefficient,...)
 - Data
 - Model relating the two encompassing both the underlying physics and the specifics of the sensor
 - Prior information
- Algorithm for converting data and prior information into an estimate of the parameter
 - Closed-form like filtered back projection, beamforming, SAR-type processing etc correct for very specific modalities and geometries
 - Iterative methods much more flexible and capable of handling fusion (joint inversion) in a rigorous manner





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Opportunities in WBI

- Many modalities could potentially be amenable to these methods
 - MM wave almost certainly
 - Spectroscopy likely
 - IR, THz, Thermography maybe
- How useful would be these methods?

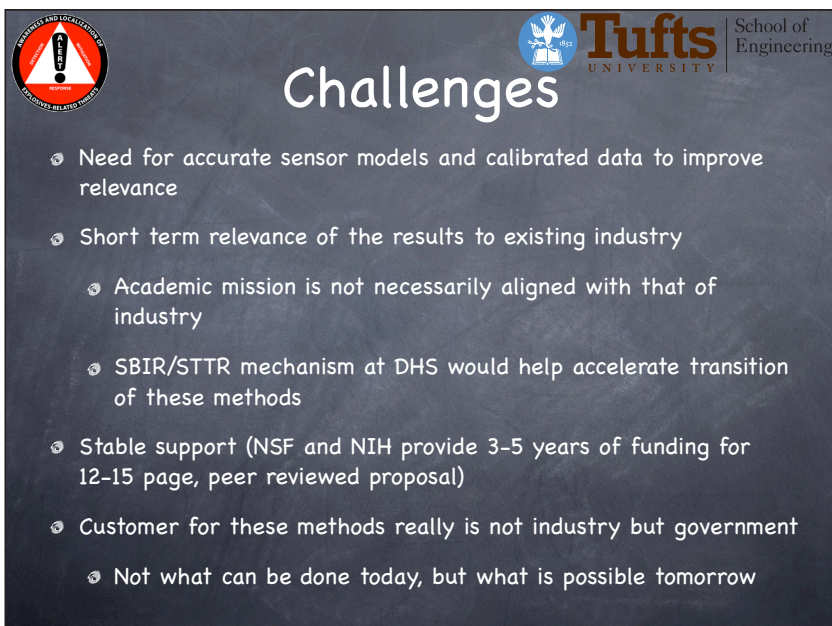


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Utility


- Exploration of state-of-the-art processing methods and reconstruction schemes (compressive and sparse sensing, inverse scattering, hyperspectral analysis, micro-local methods, ...)
- Potential mechanism for unified approach to threat detection and characterization as well as physics-based fusion (state of the art in geophysics)
- Better determination of information content in the data
- Trained engineers and scientists for consumption by industry



Challenges




- Need for accurate sensor models and calibrated data to improve relevance
- Short term relevance of the results to existing industry
 - Academic mission is not necessarily aligned with that of industry
 - SBIR/STTR mechanism at DHS would help accelerate transition of these methods
- Stable support (NSF and NIH provide 3-5 years of funding for 12-15 page, peer reviewed proposal)
- Customer for these methods really is not industry but government
 - Not what can be done today, but what is possible tomorrow

19.24 Jeff Jortner, Sandia National Laboratory: Automated threat recognition (ATR)





Why ATR ?

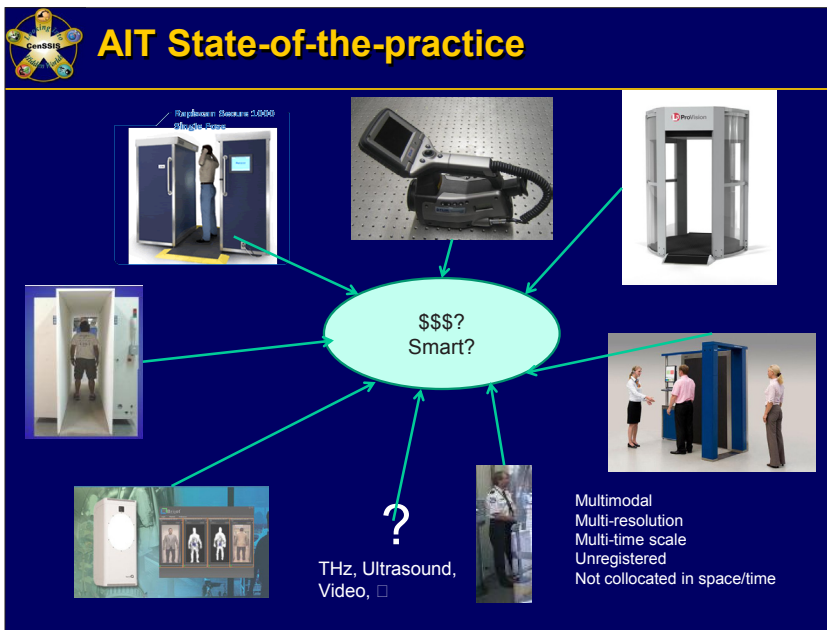
- Privacy
- Performance
- Throughput
- Data Fusion



ATR Issues

- ☐ Automatic vs. Assist
- ☐ Simplified display
 - Easier for TSO
 - Do you lose information
- ☐ CONOPS dependencies
- ☐ Access to vendor algorithms
- ☐ Data for training
- ☐ Data standards
 - DICOS for AIT just begun
- ☐ Standard nomenclature



19.25 David Castañón, Boston University: Sensor and data fusion of multi-sensor systems, including adaptive processing

Observations

- **Current Systems are fusion based, adaptive**
 - Single modalities + extensive sequential human intervention
 - Unclear performance, costs: throughput, specificity, personnel, □
- **Are there better architectures/conops?**
 - Increased automation, throughput, accuracy, total cost
 - Probably □ but no clear systems trades available
- **Big gaps: what is the potential performance payoff?**
 - Experimental gap: hard to assemble diverse instrumentation
 - Theoretical gap: limited joint simulation
 - Security: limited access to mission-specific data/parameters
 - Algorithms: without data, models, missions?
- **Moving Forward: enable system studies and fusion concept exploration and maturation**

19.26 Rick Moore, Northeastern University/ALERT: Advanced display including privacy filters

AIT Workshop April 26-27
Display Technologies/Issues

DHS Science & Technologies

Richard Moore

CenSSIS-ALERT


Narrow "Display Issues"

Technology	Interrogation depth	Interrogation volume	Primary Display	Interpretive Display
Active mm wave	<1mm water	Person-sized	2D picture or rotatogram	Superimposed OOI and RLGL
Passive mm wave	Surface measure	Person-sized	2D picture or rotatogram	Superimposed OOI and RLGL
X-ray backscatter	90% data from <1cm (1.5cm HVL for 125Kev)	Person-sized	2D picture or rotatogram	Superimposed OOI and RLGL
X-ray transmission	Many meters	<1 meter cube	2D display of 3D volume	Superimposed OOI and RLGL
Passive thermography	Surface measure, diffusion limit	Any size	2D picture	Intellect
IR / THz spectroscopy	Surface measure	Any size aggregate	Spectrum(s)	Spectral match Binary
THz spectroscopy	Surface measure	Any size aggregate	Spectrum(s) and built-up images (time-delay, Pico)	Spectral match
MRI (NMR)	meter	Person-sized	2D display of 3D volume	Superimposed OOI and RLGL
NQR (NMR "without static field")	meter	Person-sized	Spectrum	Spectrum RLGL
Metal Detectors			RLGL	RLGL
Puffers (trace portal)	Gas exchange	Person sized	Spectrum	Spectrum RLGL
Acoustic	Meter	Person sized	2D display of 3D volume	Colorized 2D display of 3D volume

= Color video displays

Sufficient for an operator to understand
and respond to the detection of a threat

Broad “Display Issues”

Who's allowed to look at system QC and calibration data

- TSL employees
- Law enforcement
- Manufacturers
- Field engineers

Who's allowed to look at individual screening data once

- TSL screening operators, supervisors and program staff (not all TSL)
- Law enforcement?
- not manufacturers, not developer community
- ? Field engineers

Who's allowed to review individual screening data ad h

- TSL supervisors (not all TSL) and program staff
- ? Field engineers

Legal framework once past :permission to look□

- Privacy policy
 - Privacy Act of 1974 (5 USC section 552a) as amended
 - Section 208 of the E-Government Act of 2002
 - Section 222 of the Homeland Security Act of 2002.
- Need-to-know basis

[Privacy and Civil Liberties Policy Guidance Memorandum 2009-01](#) This document constitutes the Department's Federal ISE Privacy and Civil Liberties Protection Policy, June 5, 2009 (PDF, 12 pages - 261 KB)

[Privacy Policy Guidance Memorandum 2008-02](#), Department Policy Regarding Privacy Impact Assessments, December 30, 2008 (PDF, 6 pages - 101 KB)

[Privacy Policy Guidance Memorandum 2008-01](#), The Fair Information Practice Principles: Framework for Privacy Policy at the Department of Homeland Security, December 29, 2008 (PDF, 4 pages - 101 KB)

[DHS Action Memorandum](#), Review of Safeguarding Policies and Procedures for Personnel-Related Data, June 13, 2007 with attachments. (PDF, 10 pages - 118 KB)

[Attachment 1](#): Review of Personnel-Related Data Policies and Procedures and Self-Assessment (PDF, 13 pages - 113 KB)

[Attachment 2](#): Protecting & Handling Personnel-Related Data □ Quick Reference Guide (PDF, 2 pages □ 14 KB)

[Attachment 3](#): Verification and Confirmation Memorandum Templates (Self-Assessment and Training Certifications), (PDF, 2 pages □ 17 KB)

[Attachment 4](#): DHS Employee Communication from Scott Charbo and Maureen Cooney regarding Data Security and Privacy, June 8, 2006 (PDF, 2 pages □ 294 KB)

[Attachment 5](#): DHS Deputy Secretary Memo, April 26, 2007 regarding Advance Notice to Leadership on Unintentional Release of Privacy Act Protected Information

[Attachment 6](#): OMB Memorandum 07-16, Safeguarding Against and Responding to the Breach of Personally Identifiable Information, May 22, 2007 (PDF, 22 pages □ 228 KB)

[Privacy Policy Guidance Memorandum 2007-02](#), Regarding Use of Social Security Numbers at the Department of Homeland Security, June 4, 2007 (PDF, 4 pages - 118 KB)

[Privacy Policy Guidance Memorandum 2007-01](#), Regarding Collection, Use, Retention, and Dissemination of Information on Non-U.S. Persons, January 7, 2008 (As amended from January 19, 2007) (PDF, 6 pages - 164 KB)

[Privacy Technology Implementation Guide \(PTIG\)](#), August 2007 (PDF, 36 pages - 358 KB) A general guide for technology managers and developers to integrate privacy protections into operational IT systems.

[Privacy Incident Handling Guidance \(PIHG\)](#), September 2007 (PDF, 109 pages - 4.25 MB) Designed to inform all Department personnel of their obligation to protect PII, it also establishes procedures delineating how they must respond to the potential loss or compromise of PII.

[Handbook for Safeguarding Sensitive Personally Identifiable Information at DHS](#), October 2008 (PDF, 21 pages □ 314 KB) This handbook sets minimum standards for how Department personnel should handle Sensitive PII in paper and electronic form during their everyday work activities at the Department.

Display “Issues”

Human Interface □ 2 basic engagement modes

Indicator (RLGL)

Intellect -variable attention, variable TP-rate

Reading environment is important in medical setting

What recommends the particular current aviation screening environs (checkpoint is cluttered, busy, noisy, confusing, distracting □) ?

Known double-reading benefit proven in medical settings from medical checklisting to mammography. Accepted as basic good-practice in many fields:

Aviation -pilot and maintenance checklists

Laboratory -lab safety operations protocols

Carpentry -measure twice, cut once

Why not in this setting?

One recurring thought on privacy from looking at equipment in screening areas:

Tighten up local screen visibility at the checkpoint with screen privacy protectors?

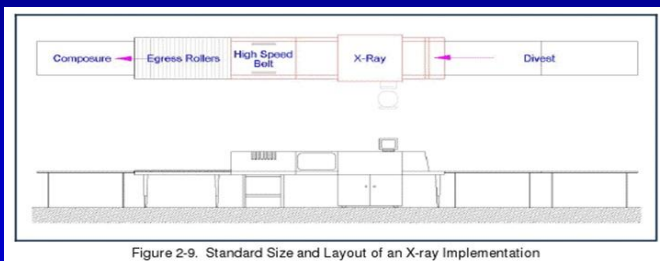


Figure 2-9. Standard Size and Layout of an X-ray Implementation

Minimum separation setup

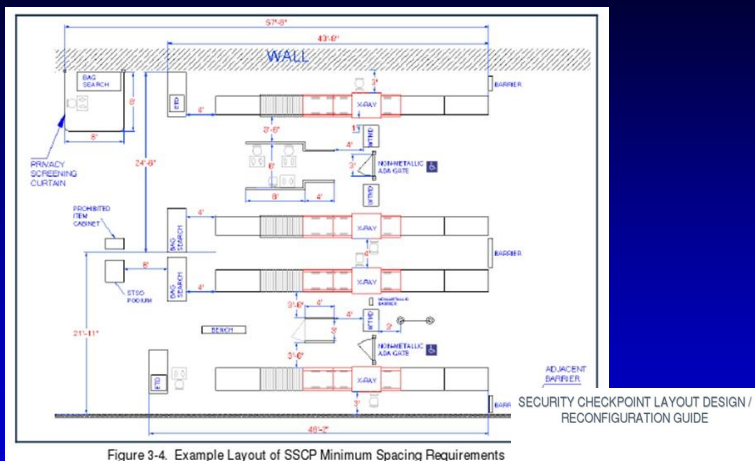


Figure 3-4. Example Layout of SSCP Minimum Spacing Requirements

What is Display Privacy protection?



Privacy you can ignore.
State-of-the-art gloss surface with a vibrant golden screen dazzles onlookers while defending data.

See the light.
Now experience even brighter and sharper text and images without blurring or distortion.

What is Display Privacy protection?



0 degrees

65 degrees

Challenges

Human perception is:

- Dependent on the task at hand and motivation
- An individual talent
- Dependent on the environment -distractable

Successfully "stand" on the shoulders of priors

How to assess improvements? Bias of "selling"

So you did a evoked-potential and functional MRI. how did this change the patient's treatment and outcome?

Recommendations

Understand the human component of monitoring screening systems

- Simulate the reading environment
- Simulate the threat-reaction process
- Open a national simulation-training facility to practice what we do when these rare events occur

Apply lessons already learned via ROC-modeling

- Radar detection (human factors ROC started here)
- Medical screening (e.g. double reading = +7% detection)

Develop an outcome-oriented framework where the where the whole chain (sensor -> processing -> presentation -> response) is represented and apply it systematically:

So you did a evoked-potential and functional MRI. how did this change the patient's treatment and outcome?



Awareness and Localization of Explosives-Related Threats

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