Strategic Study
Workshop Series

Advanced Development for Security Applications

Explosives Detection in Air Cargo - Part II

ADSA11
November 2014 Workshop
Final Report

ALERT
AWARENESS AND LOCALIZATION OF EXPLOSIVES-RELATED THREATS

A Department of Homeland Security Center of Excellence

Northeastern University

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1. Executive Summary

A workshop focusing on explosives detection in air cargo was held at Northeastern University (NEU) in Boston on November 4-5, 2014. This workshop was the eleventh in a series dealing with advanced development for security applications (ADSA11). The workshop was a continuation of the last workshop, ADSA10.

The topic of explosives detection in air cargo was chosen for the workshop in order to support the Department of Homeland Security's (DHS) objective of improving the performance of existing technologies. Improved performance is defined as: increased probability of detection (PD); decreased probability of false alarms (PFA); lowered detected threat mass; increased number of types of explosives detected, including more homemade explosives (HME); and increased throughput and reduced operating costs. Another goal of the workshop was also to support DHS's objective to increase the participation of third parties, such as researchers from academia, national labs, and industry other than the incumbent vendors.

The topics that were addressed at the workshop are as follows:

- Financial considerations, total cost of ownership, impact of an event, buying down risk and concept of operations.
- Viewpoints of airlines, freight forwarders, insurers, and non-US governments.
- Risk-based screening, game theory and deterrence.
- Trace and vapor inspection, including sampling and canine inspection.
- Neutron sources and detectors, high-energy x-ray sources, x-ray backscatter and molecular specific detectors.
- Explosive simulants.

The key findings from the workshop, per the editors of this report, are as follows:

- There are advantages and disadvantages to all detection technologies presently available to scan cargo.
- There is no financial incentive in the United States to deploy detection equipment that overcomes the disadvantages of available scanning technologies.
- The research and development communities must continue to develop new scanning technologies that will be available when the TSA has the need to deploy new technologies.
- More work is required to quantify the impact of risk-based screening,

game theory, and deterrence.

- The workshop continues to foster interaction between third parties, vendors, and the government, and reduces barriers to these parties working together.

2. Disclaimers

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Northeastern University nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation or favoring by the United States government or Northeastern University. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Northeastern University, and shall not be used for advertising or product endorsement purposes.

This document summarizes a workshop at which a number of people participated by discussions and/or presentations. The views in this summary are those of ALERT and do not necessarily reflect the views of all the participants. All errors and omissions are the sole responsibility of ALERT.

This material is based upon work supported by the U.S. Department of Homeland Security under Award Number 2013-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.

3. Introduction

The Explosive Division (EXD) of US Department of Homeland Security (DHS) Science & Technology Directorate (S&T), in coordination with the Transportation Security Administration (TSA), has identified detection requirements for future explosive detection scanners that include a larger number of threat categories, lowered false alarm rates, lowered threat mass, increased throughput, and reduced total operating costs, all at a constant or increased probability of detection. One tactic that DHS is pursuing to achieve these requirements is to create an environment in which the capabilities and capacities of the established vendors can be augmented or complemented by third-party algorithm and hardware development. A third-party developer in this context refers to academia, National Labs, and companies other than the incumbent vendors. DHS is particularly interested in adopting the model that has been used by the medical imaging industry, in which university researchers and small commercial companies develop technologies that are eventually deployed in commercial medical imaging equipment.

A tactic that DHS is using to stimulate third-party algorithm and hardware development is to sponsor a series of workshops addressing the research opportunities that may enable the development of next-generation technologies for homeland security applications. The series of workshops are entitled "Advanced Development for Security Applications (ADSA)." The workshops are convened by Professor Michael B. Silevitch (NEU) as part of the DHS Center of Excellence (COE) for Awareness and Localization of Explosives-Related Threats (ALERT[1]).

The eleventh workshop in the ADSA series (ADSA11) was held on November 4-5, 2014, at NEU. The workshop addressed explosives detection in air cargo. The workshop was a continuation of the last workshop, ADSA10.

This report discusses what transpired at the workshop and details a summary of the findings and recommendations.

1 ALERT in this report refers to the COE at NEU.

4. Discussion

4.1 Objectives

The objective of the workshop was to explore explosives detection in air cargo. The issues that were addressed centered on the following points.

- Financial considerations, total cost of ownership, impact of an event, buying down risk and concept of operations.
- Viewpoints of airlines, freight forwarders, insurers and non-US governments.
- Risk-based screening, game theory and deterrence.
- Trace and vapor inspection, including sampling and canine inspection.
- Neutron sources and detectors, high-energy x-ray sources, x-ray backscatter and molecular specific detectors.
- Explosive simulants.

The purpose of this section is to synthesize the discussion and recommendations in response to these and related questions that surfaced during the discussion.

4.2 What Did We Hear?

1. We heard the following information from the viewpoint of the regulators (e.g., TSA and UK Department for Transport [DfT]):
    a. Air cargo screening is a significant challenge.
        i. No one wants to add cost or delay to shipments.
        ii. Secondary inspection (resolving false alarms) is costly and time consuming.
    b. Regulations drive solutions.
        i. There are strict guidelines about what cannot be used in what situation. There is a process in which a screener's proposed solution is evaluated (so you cannot just buy the cheapest tool and run with it, as a presenter may have implied).
        ii. TSA has an air-cargo-inspection toolbox.
            1. Are the tools being used in the right way?
            2. Can the tools be improved and at what cost?
            3. Are they sufficient for future threats?
        iii. Non-technical approaches (e.g., certified shipper or equivalent) are often chosen.

    iv. Lowest cost (purchase and operating) technologies are most often deployed.
    v. Regulations may drive cost.
        1. The UK has a requirement that trace swabs are performed on the inside of the package (time cost, liability cost).
    vi. Commodity-driven approaches are used.
        1. EMD, RF detection, ETD, AT, and EDS
        2. There may be technologies that are appropriate to specific commodities and may not be appropriate elsewhere (e.g., EMD for fresh berries).

2. We heard the following information from the viewpoint of the freight forwarders and other end users:
    a. "Volunteering" to help
    b. Screening needs to fit a business model.
    c. Life-cycle costs need to be considered, not just initial purchase costs.
        i. DHS / TSA have recognized this as well, even if it has not been communicated clearly.
    d. Does this allow for new opportunities?
        i. Inspection paradigms that offer other business opportunities, i.e.:
            1. RFID tags that allow tracking and chain-of-custody verification; and
            2. An inspection technique that finds items that the shipper cannot ship.
3. We heard the following information from the viewpoint of the geeks (vendors, academics, labs):
    a. Cool technical "solutions"
        i. Parts per quadrillion limits
        ii. Exotic X-ray sources
        iii. MeV CT
        iv. New detectors
        v. Clever algorithms – tomosynthesis and peeling of layers in radiography
        vi. Fake (and real) dog noses
    b. Risk analysis and game theory say we have it all wrong.
        i. We should under-screen, not over-screen.

ii. Game theory may have promise, but more work needs to be done to quantify its impact.

4. We heard the following information from the viewpoint of those in the audience:
   a. Pre-check has been touted as a big success for TSA.
      i. This opinion seems to be driven by less-disgruntled passengers.
      ii. But has it been demonstrated that risk is reduced?
         1. And by corollary, would a similar game in air-cargo reduce risk?
   b. A risk-based screening scenario may allow the infrastructure to remain in place, but it is only "turned on" occasionally (randomly?).
   c. Since air-cargo screening is not done in one place, the discussion needs to consider the entire process, not just a single technology.
      i. This is different than the approach to EDS algorithms.

4.3 What We Did Not Hear?

1. Measures of PD, PFA and throughput
   a. In the old days (ADSA01), this was the problem to solve.
2. Technologies for commodity-specific screening approaches
   a. Metal detectors (EMD), NQR, RF, and technique fusion
3. Fused approaches – equipment and data
4. Optical techniques (e.g., Raman)
5. How do we get the signal in and out of the box?
   a. X-ray energy, penetration and contrast
   b. Is there any vapor/particulate available?
      i. We may have heard about as much of this as possible at the clearance level of the meeting.

4.4 What Can Be Done?

1. Is there a viable "traditional" technical solution?
   a. Can this be solved with AT, EDS, ETD?
   b. Yes:
      i. What should DHS invest in?
      ii. How do we overcome the high cost?

   c. No:
      i. Shall we (ADSA) abandon all hope?
2. Possible path forward: similar to ADSA01, develop a surrogate problem set for this community to work on?
3. Are there alternate solutions?
   a. Vents and heaters in LD-3 (or other) containers to aid in sniffing
   b. Cargo-only flights
   c. Can the business model be flipped over?
      i. Tags and seals (RFID) offer customer feedback (and provide security).
4. Use simulants to develop and test new systems, but be cognizant of the limitations of simulants.
5. There were 170 bright people in the room. What impact can they make on cargo inspection?
6. Is there a benefit to forcing a marriage between the risk, game-theory and instrument geeks?
   a. How does this play into instrument thresholds, PD/PFA?
   b. TSA has risk analysis tools that have been applied to screening regimes that they control. Could they be applied at certified shipping locations?
7. How can the rest of the information (manifest info, history, etc.) be used?
8. Do we really want high PD?
   a. Re-investigate the argument that low PD is acceptable if PFA goes to zero.
   b. Investigate the use of NPV and PPV as metrics.
9. Can we measure the value of deterrence?
   a. If deterrence is the objective, does the preferred technology change?
10. Contact the following people with ideas and funding requests:
   a. Laura Parker, DHS, laura.parker@dhs.gov
   b. Frank Cartwright, TSA, Frank.Cartwright2@tsa.dhs.gov
   c. Danny Fisher, Israel Prime Minister's Office, dannyf@project.gov.il
   d. Paul Redfern, UK DfT Research Analysis and Development Team, Paul.Redfern@dft.gsi.gov.uk
11. <u>Other resources:</u>
   a. TSA's Certified Cargo Screening Program

www.tsa.gov/certified-cargo-screening-program

b. TSA's long range BAA
https://www.fbo.gov/index?s=opportunity&mode=form&id=52af31df223ac9ef141f3130ab09c878&tab=core&_cview=1

c. DHS SBIR portal
https://sbir2.st.dhs.gov/portal/public/Menu.action?page=sbir_current_solicitations

d. Other requests for proposals
www.fbo.gov

5. Acknowledgements

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

- DHS S&T for funding ALERT and sponsoring the workshop.
- Doug Bauer, DHS (retired), Laura Parker, DHS, and George Zarur, DHS & TSA (retired), for their vision to involve third parties in the development of technologies for security applications.
- Laura Parker, DHS, for coordinating DHS/ALERT activities.
- Allan Collier, TSA, for coordinating TSA participation and discussing TSA policies related to cargo inspection.
- Northeastern University for hosting the workshop.
- Harry Martz, LLNL, Laura Parker, DHS, George Zarur, DHS/TSA (retired), Peter Harris, Yankee Foxtrot, and Allan Collier, TSA, for helping with the speaker selection.
- Doug Pearl, Inzight Consulting, for helping to formulate the agenda and for leading a panel discussion.
- Harry Martz and Steve Azevedo, LLNL, for taking notes.

The workshop would not have been a success without the participants and the speakers. We extend our heartfelt thanks to them for their contributions.

6. Workshop Planning and Support

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

Carl Crawford, Csuptwo

Harry Martz, Lawrence Livermore National Laboratory

Michael Silevitch, Northeastern University

The workshop was moderated by:

Carl Crawford, Csuptwo

The body of the final report was written by:

Carl Crawford, Csuptwo

Harry Martz, Lawrence Livermore National Laboratory

Tim White, Pacific Northwest National Laboratory

The final report was assembled by:

Teri Incampo, Northeastern University

Logistics for the workshop were led by:

Melanie Smith, Northeastern University

Other logistics, including minute taking and audiovisual assistance, were handled by:

Sara Baier, Northeastern University

Deanna Beirne, Northeastern University

Kristin Hicks, Northeastern University

Teri Incampo, Northeastern University

Anne Magrath, Northeastern University

The SSI review was performed by:

Horst Wittmann, Northeastern University

7. Appendix: Notes

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

1. The timing in the agenda was only loosely followed because of the amount of discussion that took place during the presentations and to allow for additional times for participants to network.
2. Some of the presenters edited their material (mainly redacted information) after the workshop.
3. The minutes were edited for purposes of clarity. All errors in the minutes are due to the editors of this report and not due to the speakers themselves. Minutes were only recorded during the question and answer period for each presentation.
4. PDF versions of the presentations from this workshop can be found at the following link: https://myfiles.neu.edu/groups/ALERT/strategic_studies/ADSA11_Presentations/.

8. Appendix: Agenda

8.1 November 4, 2014 - Day 1

TIME	TOPIC	SPEAKER	AFFILIATION
	Introduction		
7:30	**Registration/Continental Breakfast**		
8:30	Welcoming remarks - ALERT	Michael Silevitch	ALERT / NEU
8:35	Welcoming remarks - DHS	Laura Parker	DHS
8:40	Welcoming remarks - DHS	Kumar Babu	DHS
8:45	Setting the Stage	Carl Crawford	Csuptwo
	Perspectives		
9:00	The Future of Cargo Detection	Frank Cartwright Eric Houser	TSA
9:25	UK Department for Transport Science and Technology Cargo-Screening Programme	Paul Redfern	UK Government
9:50	TSA Air Cargo Screening	Allan Collier	TSA
10:15	The Background of Screening and Current Perspectives	Richard Fisher	Falcon Global Edge and the Air Forwarders Association
10:45	**Break**		
	Financial and Risk		
11:10	Air Cargo Cost Estimatign Project (ACCEP)	Terri Rose Todd Combs	Oak Ridge National Lab Argonne National Lab
11:35	Present and Desired End States for Air Cargo Security and Risk Discussion	Doug Bauer	DHS (retired)
12:00	Economic Incentives in Air Cargo Screening (Panel Discussion)	Doug Pearl (facilitator) Richard Fisher Doug Bauer	Inzight Consulting Falcon Global Edge DHS (retired)
12:40	**Lunch**		
	Vapor and Trace Detection		
1:30	Vapor Trace Detection with Large Arrays of Silicon Nano-Sensors	Ricardo Osiroff	Tracense Systems

TIME	TOPIC	SPEAKER	AFFILIATION
1:55	Novel Investigations in Trace Explosives Collection	Matthew Staymates	National Institute of Standards and Technology
2:20	**Break**		
2:45	Compound Specific Challenges Associated with Trace Detection	Michelle Clark	MIT Lincoln Lab
3:05	Sampling Limitations for Trace	David Atkinson	Pacific Northwest National Lab
3:30	Trace Explosives Sensor Testbed (TESTbed)	Susan L. Rose-Pehrsson	Navy Technology Center for Safety and Survivability Naval Research Lab
3:55	Air Cargo Screening Requirements and Test Methodology	Danny Fisher	Israeli Prime Ministers' Office
4:20	A New Standard for Testing and Evaluating Cargo X-Ray Technologies	Peter Harris	Synergy 4 Tech
Risk and Deterrence			
4:25	Passenger Prescreening: The Right Kind of Profiling	Sheldon Jacobson	University of Illinois
4:50	Towards a Science of Security Games: Key Algorithmic Principles, Deployed Systems, Research Challenges	Arunesh Sinha Milind Tambe	University of Southern California & CREATE DHS Center of Excellence
5:15	**Reception and Networking Session**		
6:35	Adjourn	Carl Crawford	Csuptwo

8.2 November 5, 2014 - Day 2

TIME	TOPIC	SPEAKER	AFFILIATION
7:30	**Continental Breakfast**		
8:00	Call to Order Day 2 and ADSA12	Carl Crawford	Csuptwo
Vendor Perspectives			
8:05	Dutch Customs High-Speed Cargo Inspection System	Ed Morton	Rapiscan Systems
Assessments			

TIME	TOPIC	SPEAKER	AFFILIATION
8:30	Simulants	Harry Martz Carl Crawford	Lawrence Livermore National Lab Csuptwo
8:55	Analysis of Potential Technologies for Air Cargo Screening: A Progress Report	Michael Finnin	Institute for Defense Analysis
9:20	**Break**		
Methods Not Addressed at ADSA10			
9:45	Canine Detection: If We Could Only See What They Smell	Edward Morrison	Auburn University
10:10	Cargo Inspection Using X-Ray Backscatter	Dan-Cristian Dinca	American Science and Engineering, Inc.
Sources and Detectors			
10:35	Neutron Sources and Detectors (for Air Cargo Screening Applications)	Dan Strellis	Rapiscan Laboratories, Inc.
11:00	Monochromatic Photon Source	Cameron Geddes	Lawrence Berkeley National Lab
11:25	High Energy X-Rays Sources and Detectors	Gongyin Chen	Varian Medical Systems
Algorithms			
11:50	Automated Threat Recognition and Alarm Resolution	Patrick Radisson	Multix Detection
12:15	Few-View, High Resolution Inspection	Jonathan Foley Brian Tracey Eric Miller	Tufts University
12:25	**Lunch**		
1:00	Multilayer Material Discrimination Method with Dual X-Ray Energy	Yuxiang Xing	Tsinghua University
1:25	X-Ray Diffraction and Cargo Inspection	David Castañón	Boston University
1:50	Coded Aperture X-Ray Fluorescence for Cargo Inspection	David Castañón Zach Sun Clem Karl	Boston University
2:05	**Break**		
Next Steps and Discussion			
2:55	Perspectives on Cargo Inspection	Tim White	Pacific Northwest National Lab

TIME	TOPIC	SPEAKER	AFFILIATION
3:20	Next Steps & Discussion	Harry Martz	Lawrence Livermore National Lab
4:15	Closing Remarks - ALERT	Michael Silevitch	ALERT / NEU
4:20	Closing Remarks - DHS	Laura Parker	DHS
4:25	Adjourn	Carl Crawford	Csuptwo

Note: The timing in the agenda was only loosely followed due to the amount of discussion that took place during the presentations and to give additional time for participants to network.

9. Appendix: Previous Workshops

Information about the previous ten workshops, including their final reports, can be found at:

www.northeastern.edu/alert/transitioning-technology/strategic-studies

10. Appendix: List of Participants

NAME		AFFILIATION
Anatoli	Arodzero	RadiaBeam Technologies
David	Atkinson	Pacific Northwest National Laboratory
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Douglas	Bauer	University of Connecticut
John	Beaty	Northeastern University
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Moritz	Beckmann	XinRay Systems, Inc.
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Gongyin	Chen	Varian Medical Systems
Charles	Choi	General Dynamics Advanced Information Systems
Michelle	Clark	MIT Lincoln Laboratory
Allan	Collier	Transportation Security Administration
Todd	Combs	Argonne National Laboratory
James	Connelly	Integrated Defense and Security Solutions
Sean	Corrigan	SureScan Corporation

NAME		AFFILIATION
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Danny	Fisher	Israel Prime Minister's Office
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Eric	Miller	Tufts University
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Edward	Morton	Rapiscan Systems
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David	Perticone	L-3 Communications
Simon	Pongratz	L-3 Communications
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Greg	Struba	Booz Allen Hamilton

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Brian	Tracey	Tufts University
Alex	Van Adzin	Photo Diagnostic Systems, Inc.
Seth	Van Liew	American Science and Engineering, Inc.
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Dana	Wheeler	Radio Physics Solutions, Ltd.
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Yuxiang	Xing	Tsinghua Univiversity
Dong Hye	Ye	Purdue University
Bridget	Yu	Northeastern University
Jun	Zhang	University of Wisconsin-Milwaukee
Vitaliy	Ziskin	Physical Sciences, Inc.

Note: The list of participants reflects those individuals that checked in to the event on either Day 1 or Day 2 of ADSA11. Any errors are due to the editors of this report and not to the participants themselves.

11. Appendix: Presenter Biographies

David Atkinson

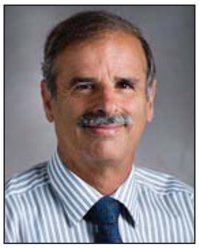
David Atkinson is a senior research scientist and manages the Chem/Bio/Explosive threat detection R&D portfolio at the Pacific Northwest National Laboratory. Dr. Atkinson holds a Ph.D. in analytical chemistry from Washington State University, under the advisement of Herb Hill. He has worked in trace chemical detector development in the DOE National Laboratory complex over the last 22 years, with a specific emphasis on explosives detection. He has participated in all aspects of R&D on explosives detection, from performing fundamental research, to doing testing/evaluation, to deploying equipment in the field and training end users. He has worked for decades with the Federal Aviation Administration (FAA) and then the Department of Homeland Security (DHS) on applying detection instrumentation to aviation security. He was the co-chair of the 2011 Gordon Research Conference on Detecting Illicit Substances and is a co-founder and co-chair of the annual Trace Explosives Detection Workshop.

Doug Bauer

Dr. Douglas Bauer is the Emeritus Program Executive for Basic Research within the Explosives Division of the Science and Technology Directorate at the Department of Homeland Security (DHS). 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.

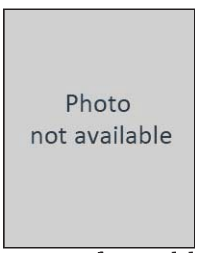
Since 2012, Dr. Bauer has been a research associate at the University of Connecticut (UCONN). He is counseling students and faculty on how to more successfully transition research into commercial usage - either in DHS components or in the economy, generally. He has written about ten case studies on different technology transitions and the lessons to be learned for success. Dr. Bauer has presented seminars on DHS research priorities and acquisition policies and written on the relationship between university research and economic growth and jobs. He is also participate in the UCONN Technology Incubation Program (TIP), an initiative of the Economic Development Office, evaluating start-up company projects and advising on how to improve the prospects for commercialization. Dr. Bauer consults as a subject matter expert (SME) on threat detection technologies and practices in assignments with Quasars for various federal agencies.

David Castañón



Prof. David Castañón is the Chair of the Electrical and Computer Engineering Department at Boston University. He received his Ph.D. in Applied Mathematics at Massachusetts Institute of Technology, and his B.S. in Electrical Engineering at Tulane University. Before joining Boston University, he was Chief Scientist of ALPHATECH, Inc. He has served as a member of the Air Force Scientific Advisory Board and is a former president of the IEEE Control Systems Society. His research interests include optimization, inverse problems, stochastic control and machine learning, with diverse applications such as target recognition, compressive sensing and tomographic image reconstruction.

Michelle L. Clark



Dr. Clark is currently a staff member at MIT Lincoln Laboratory. She received her Ph.D. in chemistry from MIT and Sc.B. from Brown University. Prior to joining MITLL she worked as a senior systems engineer at Raytheon and as a principal scientist at Physical Sciences Inc. She was also a National Research Council postdoctoral research fellow at JILA/NIST/CU. The majority of her research has focused on the development of novel laser based ultrasensitive spectroscopic detection techniques spanning the UV to far-infrared region. Her current work focuses on phenomenology measurements of homemade explosives using a variety of standard analytical methods as well as development of optical measurements for trace detection of explosives, and chemical and biological agents.

Allan Collier

Allan Collier has served as a member of the TSA Headquarters Staff since August 2003 and he is currently the Branch Chief for Air Cargo in TSA's Office of Security Capability's Intermodal Division. Previously he held a number of TSA Air Cargo related positions including: Branch Chief of the Technology, Analysis and Development, Acting Assistant Director for All Cargo Air Carriers and Principle Security Inspector for Air

Cargo Inspections. Allan is responsible for oversight of TSA's cargo screening procedures, providing guidance on air cargo screening policy development, supporting new and emerging technology qualifications, conducting air cargo outreach and supporting strategic planning initiatives while supervising a of team of DHS certified Program Managers. Prior to joining TSA, Allan served 20 years of honorable military service in the United States Marine Corps with a primary focus on helicopter flying assignments, acquisition, and safety. Allan is a graduate of Texas A&M University with an Engineering degree and obtained a Master of Science in Management degree from Troy State University.

Carl R. Crawford

Carl R. Crawford, Ph.D., 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 computerized imaging for more than thirty 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 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 scanning for medical CT scanners, and at Elicit, Haifa, Israel, 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), 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. He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), is a Fellow of the American Association of Physicists in Medicine (AAPM), and is an associate editor of IEEE Transactions on Medical Imaging.

Dan Cristian Dinca

Dan Cristian Dinca is a Principal Scientist working for AS&E since 2005. Prior to that, Cristian completed his Ph.D. in Physics from Michigan State University. He is involved in research and development of new products and improvement of existing products with the main focus on designing X-ray imaging systems and their critical components. Cristian was the lead scientist in developing a miniaturized X-ray backscatter system, a large high energy X-ray transmission gantry, a backscatter X-ray source based on carbon nanotube emitters, and algorithms for material identification using X-rays. He is the author of more than 40 peer-reviewed scientific and technical articles and 30 conference proceedings papers and presentations. Cristian holds three patents and has two more pending.

Michael Finnin

Michael Finnin is a Research Staff Member with the Institute for Defense Analyses (IDA) where he performs technical analyses for the Departments of Homeland Security and Defense. His areas of expertise are in chemical, biological, and explosives detection as well as medical countermeasures to chemical and biological agents. Michael earned his BA in Chemistry from New York University, his Ph.D in Microbiology and Immunology from Duke University, and had post-doctoral training at the Memorial Sloan-Kettering Cancer Center before starting at IDA in 2002. He currently supports the Department of Homeland Security Science and Technology Directorate Explosives Division in the areas of standoff explosive trace detection and standoff person-borne explosive device detection in addition to the air cargo study presented here.

Richard Fisher

Photo
not available

Richard Fisher began his career in the air freight transportation industry in 1978 as an account representative in Boston for WTC Air Freight, followed by a national account sales position at Emery Worldwide. Sensing a need in the marketplace for a smaller, highly personalized transportation service provider, Richard founded Falcon Air Freight in Boston in 1987. As the company grew and market conditions evolved, Richard recently changed the name of the company to Falcon Global Edge to highlight the company's position as a world class source of logistics and transportation expertise.

At about the same time, Richard joined the Airforwarders Association and was elected to the Association's Board of Directors. He is the current Chairman of the Association. As Chairman, Richard is a frequent visitor to the Washington, DC area. He serves as an alternate to the Aviation Security Advisory Committee (ASAC) working group, which acts in an advisory role to the Transportation Security Administration (TSA). In 2009, he was appointed to the Air Cargo Subcommittee of the Commercial Operations Advisory Committee (COAC) which advises the Department of Homeland Security (DHS) on matters relating to air cargo security. Along with the Association's Executive Director, Brandon Fried, Richard is also seen regularly on Capitol Hill advocating for the interests of fellow members of the industry.

Richard attended Trinity College in Hartford, CT and lives in Boston with his wife Marsha.

Cameron Geddes

Dr. Geddes is a staff scientist in the LOASIS program of Lawrence Berkeley National Laboratory, investigating use of laser driven plasma waves to build compact next generation particle accelerators and photon sources. These accelerators sustain much higher accelerating fields than conventional devices, allowing compact machines. Applications include compact sources of near-monochromatic MeV photons for inspection and nuclear interrogation, sources of radiation in the X-ray to THz bands, and extending the future reach of high-energy physics.

Dr. Geddes work was recognized by the APS John Dawson Award for Excellence in Plasma Physics Research in 2010, "For experiments and theory leading to the demonstration of high-quality electron beams from laser-plasma accelerators." He received two Outstanding Performance Awards at LBNL (2005, 2007). He received the Ph.D. in 2005 at the University of California, Berkeley, supported by the Hertz Fellowship, receiving the Hertz and APS Rosenbluth dissertation prizes for the first laser plasma accelerator producing mono-energetic beams. He received the B.A. from Swarthmore College in 1997, and the APS Apker and Swarthmore Elmore prize for thesis work on Spheromak equilibria.

Peter Harris

Peter Harris is President of Yankee Foxtrot, Inc., a consulting firm dedicated to providing specialized guidance on security management issues worldwide. A leader and well-known expert in the aviation security industry, Peter has extensive senior-level management experience with both public and private companies. He started the security business at Analogic in his capacity as President of an Analogic subsidiary, International Security Systems (ISS). He served as the President & CEO of Rapor, Inc., a designer and manufacturer of sophisticated security portals. In addition, he spent five years at American Science & Engineering (AS&E), an international manufacturer of x-ray inspection systems, as VP Sales & Marketing and as a Board member. As a commercial pilot and naval aviator, Peter is no stranger to aviation and security related issues. He amassed over 2000 hours and 400 carrier landings during a 22-year naval aviation career. Peter serves on a number of US company boards and has been a featured speaker at security trade shows around the world. Peter's education includes a B.S. from the US Naval Academy in 1976 and a Master's Degree in National Security from Georgetown University's School of Foreign Service in 1983.

Sheldon H. Jacobson

Sheldon H. Jacobson is a Professor and Director of the Simulation and Optimization Laboratory at the University of Illinois at Urbana-Champaign. He has a B.Sc. and M.Sc. (both in Mathematics) from McGill University, and a M.S. and Ph.D. (both in Operations Research and Information Engineering) from Cornell University. Dr. Jacobson has been working on the design and analysis of aviation security systems using operations research models since 1995. His research has included the design and analysis of performance measures for aviation security systems, as well as the economic analysis of the cost and benefit of 100% checked baggage screening using federally certified screening devices. He has briefed the Office of Science and Technology Policy (in the executive Office of (former) President George W. Bush) on issues related to the cost and benefit of checked baggage screening strategies. His research is featured in the video "Aviation Security: Researching the Risk," which was awarded an *Award of Excellence* ("College or University" and "Video News Release" Categories) in the 13th Annual Communicator's Award Competition, 2006. He has received numerous awards for his research, including a John Simon Guggenheim Memorial Foundation Fellowship and the Award for Technical Innovation in Industrial Engineering from the Institute of Industrial Engineers. His aviation security research has been published in a wide spectrum of journals, including *Naval Research Logistics, Transportation Science, and SIAM Journal on Control and Optimization.*

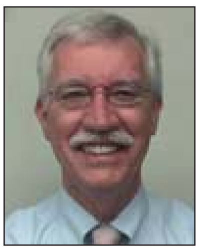
Dr. Jacobson has published over 220 refereed journal articles, book chapters, professional publications, and conference proceedings, and delivered over 360 presentations/seminars/panels/posters at conferences, research labs, workshops, and universities around the world. He has received research funding from several government agencies and industrial partners, including the National Science Foundation, and is a Fellow of the Institute of Industrial Engineers (IIE), and the Institute for Operations Research and the Management Science (INFORMS).

Harry Martz

Harry Martz is the Director for Non-destructive Characterization Institute (NCI) at Lawrence Livermore National Laboratory and PI on DHS S&T Explosive Division Explosive Detection Projects and DNDO Nuclear and Radiological Imaging Platform (NRIP) and Passive And X-ray Imaging Scanning (PAXIS). Harry joined the Laboratory in 1986 as a Physicist to develop the area of x-ray and proton energy loss computed tomography for the non-destructive inspection of materials, components, and assemblies. He received his M.S. and Ph.D. in Nuclear Physics/Inorganic Chemistry from Florida State University, and his B.S. in Chemistry from Siena Collage. Harry's interests include the research, development and application of nonintrusive characterization techniques as a three-dimensional imaging instrumentation to better understand material properties and inspection of components and assemblies, and generation of finite element models from characterization data. He has applied CT to inspect one-millimeter sized laser targets, automobile and aircraft components, reactor-fuel tubes, new production reactor target particles, high explosives, explosive shape charges, dinosaur eggs, concrete and for non-destructive radioactive assay of waste drum contents. Recent R&D efforts include CT imaging for conventional and homemade explosives detection in luggage and radiographic imaging of cargo to detect special nuclear materials and radiological dispersal devices. Dr. Martz has authored or co-authored over 300 papers and is co-author of a chapter on Radiology in Non-destructive Evaluation: Theory, Techniques and Applications, Image Data Analysis in Non-destructive Testing Handbook, third edition: Volume 4, Radiographic Testing, and contributed a chapter entitled

Industrial Computed Tomographic Imaging to the Advanced Signal Processing Handbook: Theory and Implementation for Radar, Sonar and Medical Imaging Real-Time Systems. He has also served on several National Academy of Sciences Committees on Aviation Security and is the Chair of the Committee on Airport Passenger Screening: Backscatter X-Ray Machines. Harry has been co-chair of ALERT ADSA Workshops. Dr. Martz has presented a short course on CT imaging at The Center for Non-destructive Evaluation, Johns Hopkins University and a course on X-ray Imaging for UCLA's Extension Program. Currently Dr. Martz is writing a text book on Industrial X-ray Imaging.

Edward Morrison



Edward E. Morrison, Professor of Veterinary Histology and Neuroscience, joined the College of Veterinary Medicine, Auburn University in 1990 and became Head of the Department of Anatomy, Physiology and Pharmacology in 2003. Along with his teaching Dr. Morrison is extensively involved in research dealing with Neuroscience and Biosensory systems. Dr. Morrison received his BS degree from Massachusetts and his MS and PhD degree from Kansas State University. He was a post-doctoral fellow with Dr. Pasquale Graziadei, Florida State University. The long term goals of research conducted in our laboratory is understand more fully the vertebrate olfactory system.

Dr. Morrison's research spans development, morphology and distribution of the sensory olfactory neuroepithelium, neurophysiology and signal transduction of the olfactory receptor neuron, regeneration and replacement of olfactory receptor neurons, inflammation and pathogen entry into olfactory system and CNS neurophysiological responses to odors as studied using fMRI. Research efforts have been supported by Auburn University, NIH, DHS, ONR, Alhezimers Association.

Ricardo Osiroff

Dr. Ricardo Osiroff has been the CEO of Tracense Systems since 2011, leading the company from laboratory concept to the verge of commercialization. Ricardo is an accomplished leader with vast experience in technology driven environments. Before Tracense, he was the CEO of Cellaris and held VP positions at Printar and the AVX Corporation. Previously Ricardo served as head of the Technical Devices Department with the Israeli Ministry of Defense.

He has received twice the Israel Defense Award, the most prestigious recognition for innovation and contribution to national security. He holds a Ph.D. in Materials Engineering and a M.Sc. in Engineering Mechanics from Virginia Tech (USA), as well as a B.Sc. in Chemical Engineering from the Technion, Israel. Ricardo is married and the father of six children.

Laura Parker

Laura Parker is a Program Manager in the Explosives Division of the Science and Technology Directorate at the Department of Homeland Security (DHS) as well as the Program Manager for the ALERT Center of Excellence, a DHS-sponsored consortium of universities performing research that address explosive threats lead by Northeastern University. She works on multiple projects for trace detection of explosives and algorithm development for improved explosives detection. Previous to her present position at DHS, Laura worked as a contractor providing technical and programmatic support of chemical and biological defense and explosives programs for several Department of Defense (DoD) offices. She also worked in several DoD Navy laboratories in the field of energetic materials. She obtained her Ph.D. in chemistry from the Pennsylvania State University.

Doug Pearl

Doug Pearl has extensive experience evaluating the economic incentives involved in security screening, including those perceived by the private sector, government and the public. He has examined the role of third party involvement and DICOS in the security industry, in part by examining analogous issues in medical imaging.

Doug also has extensive experience in the biomedical industry. He provides strategy and marketing advice to clients in biotech, medical devices and diagnostics, and frequently works with clinicians, scientists and customers to help clients understand key drivers of success in the marketplace. Doug has also written on the problem of False Positives in the screening of low risk (low prevalence) populations.

Doug is president of Inzight Consulting, LLC, which he founded in 1993. Prior to that, he was Vice President, Business Development for Matritech, Inc., a then public biotechnology company in Cambridge, MA. Prior to Matritech, he was a consultant at Bain & Company and a Research Associate at the Harvard School of Public Health. Doug has a Masters in Management from the Yale

School of Management.

Patrick Radisson

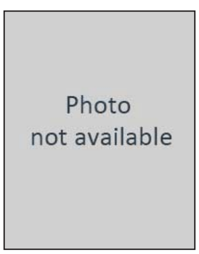
Patrick Radisson is Chief Technical Officer of MultiX. Graduated from Ecole Nationale Supérieure des Telecommunication (ENST) PARIS with an electronics engineering degree he also got a MicroElectronics advanced degree (DEA Micro-électronique) and a degree in Management (MASTER MSGO) from IAE Grenoble.

He has extensive experience in the development of X-ray based detection systems when he was at Thales Electron Devices where he managed a X-ray detector Product line before taking in charge Advanced Technologies activities in X-Ray and THZ giving rise to the development of emerging X-ray spectrometric solutions for security applications through the creation of MultiX.

Patrick is co-founder with Jacques Doremus of MultiX a French spin-off from Thales dedicated to Xray spectrometric detection solution for security application. He is managing a team of highly trained engineers and scientists developing new spectrometric detectors for security applications and define the technical and product Road map.

He also has a strong experience in Detection and Imaging, microelectronics and micro- technologies through different positions in THOMSON CSF, SOFRADIR, PHSMEMS and THALES.

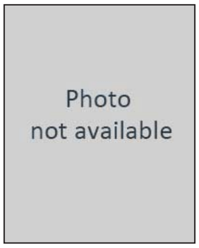
Paul Redfern



Paul Redfern's role in the UK Department for Transport, Research and Development team is to deliver the research programme for aviation security, with particular responsibility for hold baggage and cargo screening. This involves commissioning research, evaluating and technically reviewing the results and providing strategic direction to future research requirements. In this role he also provides technical advice and direction to AvSec policy and the aviation industry and security equipment manufacturers.

He has a background in X-ray physics and previously worked at the UK Defence Science and Technology Laboratory developing portable X-ray screening solutions.

Terri Rose



Terri Rose is a Program Manager at Oak Ridge National Laboratory, where she has been for 35 years. She received her Bachelor of Science in Mechanical Engineering from the University of Tennessee (1978). Before joining ORNL, she worked at General Electric as a design engineer and did graduate work in Engineering Science and Mechanics at the University of Louisville and the University of Tennessee.

Susan L. Rose-Pehrsson

Dr. Susan L. Rose-Pehrsson is the Director of the Navy Technology Center for Safety and Survivability in the Chemistry Division at the Naval Research Laboratory (NRL), Washington, DC. The Navy Technology Center conducts basic and applied research and development programs aimed at the solution of current and future Navy problems in the fields of combustion, fire extinguishment, fire modeling and scaling, damage control, fuels chemistry, lithium battery safety and hazardous chemical and explosives detection. The research scope spans closely coupled theoretical and experimental studies in laboratory-scale to intermediate and real-scale. Dr. Rose-Pehrsson also leads the Sensor Lab in the Laboratory for Autonomous Systems Research. She lead the team to design and construct a Trace Explosives Sensor Testbed (TESTbed) to evaluate sensors and materials using a variety of explosive vapors.

Dr. Rose-Pehrsson received her B.S. in chemistry from the University of Virginia in 1979 and her M.S. in Analytical Chemistry in 1981. She began her career as a research chemist in the Chemistry Division at the Naval Research Laboratory in 1981. In 1984, she was selected by NRL for the Edison Memorial Graduate Training Program at Pennsylvania State University. She received her Ph.D. in Analytical Chemistry from Pennsylvania State University in 1988 (Thesis Title: Pattern Recognition Analysis of Sensor Arrays for Toxic Vapor Detection). She conducts research in toxic vapor detection, explosives detection, trace analysis, sensor development, and data analysis. These activities are directed to method and instrument development for the support and protection of personnel. Dr. Rose-Pehrsson is the author of numerous journal articles, professional society presentations, and technical reports. She also holds nine patents.

Michael B. Silevitch

Michael B. Silevitch is currently the Robert D. Black Professor of Engineering at Northeastern University in Boston, an elected fellow of the IEEE, and the Director of the Homeland Security Center of Excellence for Awareness and Localization of Explosives Related Threats (ALERT).

His training has encompassed both physics and electrical engineering disciplines. An author/co-author of over 65 journal papers, his research interests include laboratory and space plasma dynamics, nonlinear statistical mechanics, and K-12 science and mathematics curriculum implementation. Of particular interest is the study of the Aurora Borealis, one of nature's most artistic phenomena. Avocations include long distance hiking and the study of 17th Century clocks and watches.

Prof. Silevitch is also the Director of the Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems (Gordon-CenSSIS), a graduated National Science Foundation Engineering Research Center (ERC). Established in September of 2000, the mission of Gordon-CenSSIS is to unify the methodology for finding hidden structures in diverse media such as the underground environment or within the human body.

Arunesh Sinha

Arunesh Sinha is a postdoctoral scholar with Prof. Milind Tambe at the Computer Science Department of University of Southern California. He received his Ph.D. from Carnegie Mellon University in Aug 2014, where he was fortunate to be advised by Prof. Anupam Datta. He obtained his undergraduate degree in Electrical Engineering from IIT Kharagpur in India. He has industry research experience in form of internships at Microsoft Research, Redmond and Intel Labs, Hillsboro. He was awarded the Bertucci fellowship at CMU in appreciation of his novel research.

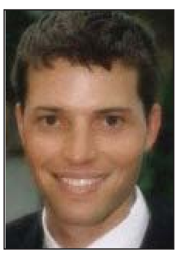
Dr. Sinha has conducted research at the intersection of cyber-security, machine learning and game theory. He introduced a novel game theoretic model of auditing for enforcement of policies in large organizations. He has also worked on the use of machine learning to learn and enforce access policies. His interests lie in the theoretical aspects of multi-agent interaction, along with an emphasis on real-world applicability of the theoretical models.

Matthew Staymates

Research interests focus on improved metrology techniques for the evaluation of trace explosives and narcotics detection technology. Computational fluid dynamics, schlieren imaging, high-speed videography, laser light-sheet flow visualization, and other traditional flow diagnostic methods are used to investigate the performance of current trace detection technology and aid in the development of next-generation technology. Research is also focused on enhancing non-contact aerodynamic sampling for next-generation trace detection.

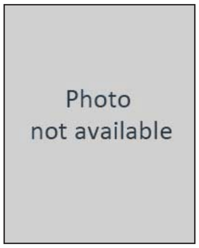
Other interests include standard explosive microparticle fabrication, particle release mechanisms, and precise material deposition for stand-off explosive detection instrumentation. Matthew serves as the Explosives Safety Officer for the division and oversees the safe handling of high explosives and energetic materials.

Dan A. Strellis



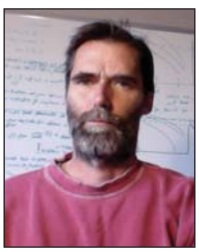
Dr. Strellis manages the US Government R&D program portfolio at Rapiscan Laboratories, the Research and Development center of Rapiscan Systems. In addition to overseeing the government-funded projects, he leads the proposal team to submit responses to government solicitations, and briefs government officials on Rapiscan capabilities. With a technical background in nuclear physics and chemistry, his research work at Rapiscan has focused on the use of pulse neutron interrogation systems for detecting nuclear material, explosives, and contraband using both microsecond and nanosecond pulsed sources. He has been with Rapiscan Laboratories for 14 years. He has authored numerous technical publications in these areas of research and has served in an advisory role to the IAEA on neutron-based interrogation techniques. A graduate of UC Berkeley, his dissertation topic was investigating the fission properties of neutron deficient americium isotopes while performing experimental work at the Lawrence Berkeley National Laboratory 88-in Cyclotron.

Brian Tracey



Brian H. Tracey received his M.S. and Ph.D. degrees from the MIT/Woods Hole Joint Program in 1992 and 1996, where his work focused on computational acoustics modeling and signal processing. He subsequently worked in industry as an acoustical consultant at Cambridge Collaborative, Inc., a technical staff member at MIT Lincoln Laboratory, and most recently at Neurometrix, Inc., where he developed algorithms for medical devices used to diagnose the peripheral nervous system. He joined Tufts University in February 2011 as a Research Assistant Professor in the Department of Electrical and Computer Engineering and was recently appointed a Professor of the Practice. Dr. Tracey's research interests include signal and image denoising, tomography and image formation, and digital signal processing.

Tim White



Tim has a PhD from the Optical Sciences program at the University of Arizona and a history of developing CT solutions for a wide range of problems for longer than he cares to remember. Prior work includes development of a stationary single-photon emission CT system for medical imaging, laboratory micro-CT systems for non-destructive evaluation, field-portable, medium- and high-energy CT systems for environmental-remediation applications, and investigations of spectral CT for security applications. More recent work includes evaluation of the feasibility of emission CT for verification of the integrity of spent nuclear fuel and development of a single-pixel gamma camera.

Yuxiang Xing

Yuxiang Xing is associate professor of department of Engineering Physics in Tsinghua University. She is the executive council member of Chinese Society for Stereology and the editorial board member of CT Theory and Applications in China. Since 2003, she has been working on the development and application of X-ray imaging systems. Her research focus is on imaging physics, computed tomography reconstruction, radiation image processing and performance evaluation. Dr. Xing holds more than 20 patents in X-ray imaging and has authored or co-authored over 50 papers.

12. Appendix: Questionnaire

Attendees were asked to fill out a questionnaire providing feedback on the workshop. The questions are listed below; the answers appear in the next section. Responses are grouped by question and then by person; the first respondent is response A for each question, the second respondent is B, and so on.

1. What is your relationship to ALERT?
2. Which technologies discussed during this workshop show promise?
3. What promising emerging technologies were not discussed at the workshop?
4. What should be done to expedite the deployment of emerging technologies?
5. How should concept of operations be changed for air cargo inspection?
6. What are your thoughts about buying down risk?
7. How should risk-based screening and game-theory be used in cargo inspection?
8. How can third parties be involved in the development of new explosive detection equipment?
9. What did you like and dislike about this workshops?
10. Do you have recommendations for future workshop topics?
11. What would you like to see changed for future workshops?
12. What other comments do you have?

13. Appendix: Questionnaire Responses

Question 1: What is your relationship to ALERT?

A Industry

B Industry

C Industry

D Industry

E Government

F Government

G ALERT team member

H Industry

I ALERT team member

J Industry

K Industry

L Government

M Academia

N Industry

O Industry

P Industry

Q Industry

R Government

S Other: consultant in the space

T ALERT team member

U Industry

V Industry

W Industry

X Other: DOE National Laboratory

Y Government

Z Government

AA ALERT team member/Academia

AB Government

AC Industry

AD Academia

AE Government

Question 2: Which technologies discussed during this workshop show promise?

A No response

B No response

C Vapor detection for trace.

D ATR.

E Vapor trace.

F No response

G Lower cost 3-D and 4-D scanning, AI for ATR, lifecycle costing, realistic multimodal.

H High (dual) energy x-ray CT is the obvious solution for finding explosives in air cargo.

I No response

J Risk-Based Screening. Multi-Energy Detector.

K Many technologies showed ability to screen cargo even in large cargo containers. X-ray back scatter is an example of a solid technology for scanning cargo, with limitation in the depth that can be scanned. The more important issue that was clear from the meeting is the ecenomic pressure on cargo screening that results in limited application of technology.

L No response

M Improved canine detection. More broadly deployed CT.

N Both trace and bulk technologies show promise in a general sense. Improvements in the applications of conventional x-ray both high and low energy looks like it provides a benefit. Trace technologies continue to advance and approaches using MS look like they may be useful in the field.

O All show technical feasibility and promising, but not clear if any will be a commercial product.

P Risk Management.

Q I was not present for this discussion.

R Michelle Clark MIT Lincoln Labs.

S Not qualified to say. Seems like technical challenges are significant.

T Risk based approaches and dynamic algorithms.

U Trace detection.

V Neutron sources and detectors.

W Biomimicry (artificial nose), Game theory / risk-based screening. high speed X-ray inspection.

X Nanotechnology trace sensors. Understanding of canine detection (e.g. modeling of nose structure) and application to improved trace. Ventilation to allow trace on larger objects. MeV photon systems for scanning full cargo containers. Monoenergetic MeV photon systems for combining full container scan with improved resolution and low dose. Combination of photon transmission and backscatter and neutron techniques for improved resolution. Tomography with 'few' views as an approximation to CT.

Y Advanced 3D imaging. Explosives Vapor Detection.

Z Game theory appears to be a useful method to more effectively distribute resources. Trace vapor methods are approaching sensitivities that is useful.

AA Game theory for deploying screening technology and selecting technology types for deployment.

AB I think the work on game theory was the most interesting, especially when thinking about approaching the solution from a systems level perspective.

AC CZT.

AD It is hard to say.

AE No response

Question 3: What promising emerging technologies were not discussed at the workshop?

A XRD for checked baggage and carry-on.

B No response

C No response

D No response

E Maybe something on supply chain integrity, locks bolts seals.

F No response

G NQR, simulation of systems/threats... predictive modeling, real discussion of downsides of risk based screening.

H The 'problem' can be redfined--from finding explosive in air cargo to making air transportation secure. Intelligence, millitary actions and social engagement would help.

I No response

J Data Fusion.

K Technologies not discussed at ADSA 11 were covered in ADSA 10 ... I can't think of any significant gaps.

L No response

M Combination of robotics with sensing. Especially for cargo facilities, it would seem like a natural to have robot 'sniffers' or scanners examining cargo.

N Optical methods perhaps, spatially offset Raman looks interesting possibly as an alarm resolution device in some instances. NQR is also important (although hardly emerging) for select threats and cargo types.

O RF, Low cost, portability & commercialization.

P Mass Spec. Vapor sample collection.

Q Same as above.

R No response

S No response

T na

U No response

V No response

W No response

X No response

Y Detection of initiation mechanism.

Z Multi modal approaches and data fusion methodologies.

AA No response

AB I would love to see a talk on SESI-MS with a field able instrument.

AC No response

AD Tomosynthesis, Mev CT.

AE No response

Question 4: What should be done to expedite the deployment of emerging technologies?

A Better guidance ("buy signals") from primary customer ie. National Governments.

B No response

C TSA BAA may have some ways to address this IF they can actually deliver on the expedited contract award timeframe!

D Test developed ATR algorithms on classified target sets and on large amount of luggage. That luggage does not have to be labeled in any way, just collected.

E Government funding.

F There needs to be a real cargo screening techology specification and a real qualification test program. The current system, at least for imaging devices, is a fallacy. Better-performing technologies will then emerge, but they will not be deployed unless the poorer-performing technologies are removed from the qualified list, and are not grandfathered.

G ADSA meetings with increased skin in the game.

H Focus resource on technology with proven record. Stop wasting money on things that had been 'promising' for many decades--nuclear flourescence, x-ray diffraction for large object, neutron for cargo, etc.

I No response

J Develop incentive programs to reward those who do better than the minimum security requirements. Find a way for end-users to get a return on their investment (ex: reduced manpower, faster throughput, higher margins).

K There needs to be an economically viable model for application of technology to screen cargo, and it doesn't appear to exist. The Rotterdam installation is an example where screening technology is being applied to large containers, but the cost of this approach may not be economical.

L No response

M More projects like the ALERT task orders.

N Federalize the cargo screening activity like checked baggage and checkpoint screening.This introduces a regulatory framework for improved detection and as government acquires the equipment then equipment that is fit for purpose is acquired.

O Low cost solutions.

P Find an operator in the field willing to test in real life applications.

Q Same as above.

R Engage industry partners sooner also expedite the commercialization/licensing process between Universities and industry.

S More expensive will not be deployed unless less expensive are taken off QPL.

T Field test bed with integrated complementary technologies to prove out the capabilities in an operational environment.

U Coordinated investment of the various government agencies in promising technologies. Provide companies with a lot more information to allow them to accelerate and focus their R&D efforts.

V No response

W Motivate and reward vendors to launch new technology.

X I see two categories of emerging technology: a) technologies which reduce cost at fixed capability seem reasonably handled by the current structure and qualified product list, and likely don't need too much additional expediting. b) technologies which improve capability at increased cost have a hard time in a qualified product structure. There seem to me to be two main paths: 1) demonstration of process improvement sufficient that it offsets the purchase cost (total cost benefit). This is a variant of (a) and mostly requires full cost accounting and is shipper driven. 2) revision of the qualification standards upward as capabilities improve. This is the most challenging in the current structure and needs expediting, which will be mostly agency driven. I know that the following may not be possible for classification or other reasons, but as a detection method developer, the most informative thing would be to know what capability improvement would potentially be of interest either to shippers or the agencies (e.g. detection of X grams of substance in a full container —> ability to ship a full container without swiping/scanning every box separately). This would likely be a surrogate problem. From the shippers' point of view a feel for what the dollar value of a given capability might be would be helpful. From the agency point of view a roadmap of desired capability improvements would be helpful. We touched on many of these issues at the workshop, and in particular the TSA 7 year roadmap, but mostly in a qualitative sense. I hope to see more of them in the reports..

Y Ask for special speakers to present.

Z Conduct technology comparisons with target samples in a double blind test.

AA No response

AB Unfortunately, money tends to be a limiting step, and I am not sure anything can be done there. If the turnaround time on BAAs were faster that would certainly help as well as providing access to a facility or simulated facility where vendors equipment could be evaluated and red-teamed.

AC Funding of multiple projects of various configurations and designs using CZT (CZT detectors, electronics, algorithms and system designs) directed at improving and optimizing systems. There needs to be a government purchasing mechanism which does NOT favor status-quo, least-common denominator, and instead rewards innovation and improvements to designs, performance, sensitivity, resolution, etc. Otherwise, the current model of lowest-cost supplier destroys incentives and delays progress.

AD More support and push from government.

AE No response

Question 5: How should concept of operations be changed for air cargo inspection?

A No response

B No response

C No response

D No response

E Risk based screening.

F No response

G Realistic red-teaming the cargo screening systs including pallet insertions.

H Move to centerized screening with technology.

I No response

J Greater collaboration between Security and Customs would highly benefit both sides while allowing shippers to get a return on investment (ex: clearing through customs faster). Need to look at the end-to-end process, not just the scanning part.

K Have no ideas to offer.

L No response

M I don't know enough to have a good opinion (though I know more than I would without ADSA).

N In order to get buy in from the cargo industry CONOPS must not change too much if at all.

O Re-visit ADSA #10.

P Convert from "cost-center" to "revenue center".

Q A thorough, layered, risk based approach should be employed. High intensity screening should be employed for high risk cargo.

R No response

S All should understand 60% getting "non technology" solution per TSA at ADSA11. Whether this is optimal or not TBD, but should be understood. Unless purposely obscured for deterrence...

T Integrated solutions as noted above.

U No response

V No response

W No response

X The move towards more bulk cargo shipment was discussed by several speakers, which motivates scanning of full containers instead of sub-components. Joint programs which encompass explosives and other requirements such as CBP (see 6 for detail). Use of multiple modalities (e.g. X-ray + trace) may be a path to improved capability at low cost.

Y Big problem! Money talks. Only regulations will change it.

Z Known shipper appears to be an effective way to reduce the amount of cargo that has to be extensively scanned. If inexpensive detection systems are available, then they should be incorporated into each cargo container, so that can collect sample over extended period of time.

AA No response

AB It would be great if the onus did not lie solely with the cargo companies. It could be incentivized by the government somehow or maybe the government should just pay for the equipment.

AC No response

AD No response

AE No response

Question 6: What are your thoughts about buying down risk?

A No response

B No response

C No response

D No response

E Very important.

F No response

G Slippery slope.

H There is no total solution--so efforts add up.

I No response

J It makes sense as long as it is part of a comprehensive strategy that covers all security layers. We have a long way to go to reach that level, especially in the sharing of information.

K Risk based screening is a viable and effective approach to mitigate most probably threats with minimal economic impact.

L No response

M I don't know enough to have a good opinion (though I know more than I would without ADSA).

N Deploy equipment fit for purpose, however the only way of doing this is if the government pays for the equipment or if there is an ROI for some element of the security process.

O No response

P No response

Q Risk needs to be categorized. If we agree that an event aboard a passenger aircraft is a risk to society, then society, through its governments, needs to share information more efficiently to make risk based screening more effective.

R No response

S See #5.

T I require more information to answer.

U Positive

V No response

W No response

X A comprehensive view is needed of what needs to be detected and in what contexts. For example, for explosives only trace may be suitable in many circumstances. If the package also needs to be screened for other articles not allowed on aircraft, such as compressed gas cylinders, X-ray may be required. CBP or nuclear materials screening requirements impose additional requirements. There was brief discussion of joint programs with CBP and other agencies but this should be made quantitative to drive development of techniques which can address the full need in the most efficient manner.

Y Already doing it.

Z Techniques that reduce the scanning to use funds more wisely are attractive.

AA No response

AB I think with the sheer volume of cargo, it has to be done. However, I don't have enough information to really examine the trade space and understand the full cost/benefit analysis.

AC Totally agree.

AD No response

AE No response

Question 7: How should risk-based screening and game-theory be used in cargo inspection?

A No response

B Very Carefully! All presenters made use of risk values assigned to different event by an undefined 3rd party. When discussed, it was often brushed off with, “The government is smart, I’m sure they know how to do this...” However, this is a very tricky proposition for even a “smart” person. If the risks aren’t assigned with some realistic basis, then all the gaming theory and risk based screening built on top of those assignments are worthless.

C More discussions on this are needed - speakers were rushed as they were the last of the day. No enough information gained here.

D I doubt that government meetings can produce a reasonable incentives for facilities. Government should enable private risk management. Require airports or screening facilities to carry terrorism insurance that covers external costs. While terrorism events are rare they are not as global in nature as, say, nuclear events, so insurance industry will be able to handle them. See, for example, this discussion http://blog.willis.com/2014/04/are-cargo-insurance-policies-still-fit-for-purpose/.

E Better method to assess risk to ensure success.

F No response

G Judiciously… It is sadly easy to miss the unanticipated threat conops. Risk-based screening is getting a shake in medicine, and will probably fail. It will take time to notice the failures/associated mortality and morbidity. Healthcare continues to be impressed with post-Facteau risk association. For example risk based screening is now becoming vogue in breast cancer... Promise of reduced costs. Factually, only about 30% of breast cancer can be explained by known risk factors, the rest is a crap shoot. I’d argue that terrorist threats are aimilarly were non-deterministic... you cannot think stochastics on really small-number events... Simply analyze the last 10 major terrorist threat events, what predictive capacity rose to the level of actionability?

H Risk profiling, even if it may look like racial profiling, shoiuld be a required part of security.

I No response

J Let's use the Dutch Customs Railroad Screening as an example... We could systematically scan all cargo without necessarily analyze everything in details and make this imagery along with complementary info available to both security and customs organizations. The use of imaging algorithms and data mining tools could then help identify items that require further (remote) screening. Thresholds and screening resources could be deployed based on intelligence, perceived risk, randomization (or gaming theory) and availability of resources.

K Risk-based screening should be applied to air cargo.

L No response

M The Dutch model seemed quite sensible - nominal scanning in general, more intense examination for destinations where intel suggests a higher risk, adjusted over time.

N It is used already, as very little cargo is currently screened.

O Game-theory is not the answer for cargo inspection. Due to the nature and variability of the threats Risk based probably isn't good enough either. Local and Federal DHS requires very close to 100% Pd.

P To identify high risk cargo, leaving maximum resources to the most probable threat targets.

Q We need to employ every tool we can find to assess risk throughout the supply chain.

R No response

S Yes, they should be.

T I feel this has big promise because the probability of a threat is so low. The ability to screen out very low and low risk passengers and parcels will allow us to spend more resources on the higher risk items. Adding the element of game-theory to randomize the selection of screening low risk passengers provides the element of deterrence necessary.

U Very carefully and after extensive validation.

V No response

W No response

X The analysis of the difference between scientific (PD/PFA) versus operator (NPV/PPV) persepctives was important to the applicability of new technologies. The present cargo scanning system appears to be one where 'a scan' using an approved method is enough, which does not lend itself to game theory. Game theory could be used to allocate additional resources to scan in more detail certain cargoes, for example using a secondary screening method such as an MeV xray scanner at the airport to scan a fraction of loaded containers. This would require a change in conops

Y 64K$ question.

Z It seems promising.

AA It seemed that risk-based approaches should be embedded with the technologies that are used for screening, and should be co-developed. In addition, the use of game-theory to level the playing field and take away the cost disincentives that we are under is appropriate. By grinding our processes to an expensive halt by making us screen every bit of cargo and every person with the same level of intensity, the terrorists are fighting a winning battle. The possibility of their threat costs them nothing or next to nothing, while our defense costs us many millions.

AB It can be used to optimize the cargo screened during a high volume period, but if the profile uses obvious features then it will be readily countered. I would love to hear more on the features that are not obvious and what the confidence level is in their ability to distinguish a threat from a non threat.

AC Statistical approach to problemquantification and problem solving.

AD No response

AE No response

Question 8: How can third parties be involved in the development of new explosive detection equipment?

A No response

B No response

C No response

D Government shall put requirements on vendors to provide open systems architecture (OSA) as part of acquisition process. See DoD effort http://www.acq.osd.mil/se/initiatives/init_osa.html. OSA will enable government to implement (or at least test) third party processing and fusion algorithms.

E Government lead industry days.

F The government must acquire the rights and capabilities to manage explosive detection systems as the system integrator, in control of the software. Otherwise, a third party algorithm developer is best integrated by the system developer, or provided rights to access the data, like Optoscreener, which is a third party hardware and software platform.

G (ADSA 12 through 18) build actual work in the security enterprise into the undergraduate and graduate curriculum/ requirements. Not easy, but functional.

H Become the first party.

I No response

J The only way to get third party involved in the development of such equipment is to either have someone pay for it or provide some assurance that they will be able to recover their costs. At the moment, their is no meaningful market for air cargo screening equipment.

K Through partnership with industry.

L No response

M ALERT task order or similar mechanisms are very powerful.

N In the normal way, however as the market for advanced cargo screening equipment is small to non-existent, this limits in general product development and therefore involvement by third parties. Government funding helps the situation but this needs to be more targeted towards what is likely to be acceptable to the cargo industry.

O No response

P Field testing.

Q Only through government funding. The potential cost of new equipment will put it out of reach of most third party operators.

R Licensing and partnerships with universities and national labs.

S No response

T By matching skills with vendor needs through cooperative interaction.

U By joining forces with the core technology providers, such as collaborative agreements, joint ventures and similar.

V No response

W Have open/transparent development programs with clear and straightforward access.

X See 4 on need for definition of what capability improvement would justify what investment. This will drive third party investment and work.

Y Just ask them! They will come. No doubt.

Z Yes. Using people that do not have clearances if difficult as the development becomes more mature. For early testing, the targets should be as realistic as possible.

AA No response

AB I think exploring high risk high return R&D would be great for academia. Companies and gov't labs these days are continually tasked with showing results (technology not science) and don't have the funds follow every avenue.

AC Funding, funding, funding. There needs to be a government purchasing mechanism which does NOT favor status-quo, least-common denominator, and rewards innovation and improvements to designs, performance, sensitivity, resolution, etc. Otherwise, the current model of lowest-cost destroys incentives and delays progress.

AD No response

AE No response

Question 9: What did you like and dislike about this workshop?

A Not enough time to chat with colleagues...perhaps extend the general meeting to 2.5 days or shorten presentations.

B Seemed to jump all over the place. Sort of tried to be a survey of technologies, but not really sure it got there.

C Schedule was poorly kept - both the 4th and 5th were late by at least one hour. Lunch was not a break, but a working lunch which prevented meetings with other attendees.

D No response

E Really loved the great discussions on all topics, didn't like the long day but it went fast.

F I think the agenda strayed too far from technology for screening cargo for explosives.

G No response

H Nice place to social but the proceeding was too intense.

I It's two very long days. I think it should be a shorter 1st day and a half day on the second day. The agenda is too full. There should be less scheduled presentations, more time for discussion, longer breaks, shorter days....

J Great networking and open discussions on the real issues.

K Nothing stands out.

L I did not like how the moderator cut off some speakers early, while letting others go on and on. I particularly liked how actual vendors attended the workshop.

M I'm pretty technically oriented, so while I appreciated the discussions of risk and investment on the first day, it would have been nice to have some more technical talks interspersed to break things up. What I always really like about this workshop is the community - a great chance to understand the problems with much more context than I would *ever* get sitting at a university.

N The workshop is great, it is an ideal networking environment with some good presentations thrown in. The environment is low key and relaxed and really fosters interaction. I describe the meeting as a mini-GRC and recommend it to all my colleagues.

O Primarily same participants covering very little new ground.

P Like new technologies such as Risk Management. Heard enough on imaging.

Q I had never been exposed to this aspect of discussion as all previous discussion was within industry. This conference provided me with a more nuanced perspective of the risk and how to address it.

R The idea of stopping each speaker on the second slide was insulting to those that prepared full presentations and to the audience who spent most of the time listening to the organizer ask questions about information he KNEW was included in later slides. It was also insulting to the speakers at the end of the day who traveled long distances and were short changed because we wasted so much time on the morning talks.

S No response

T Likes: organized staff, interesting topics, lively discussions, networking opportunities. Dislikes: not enough buffer time in the schedule, schedule needs to be rethought so that talks go on as scheduled.

U Like: the workshop format, the presence of all stakeholders, availability of presentations, opportunity to meet with colleagues in an informal atmosphere. Dislike: must move to a different venue where everybody has a table in front to set up a laptop, write notes, etc.

V No response

W Liked fruitful discussions and professionalism present in the workshop.

X I liked the interactive nature of the workshop and appreciate the efforts to foster that. In many cases this led to sessions running over time, so it may be helpful to schedule additional breaks/discussion time and/or shorter scheduled talk times to make explicit the expectation for discussion.

Y Not enough room! We deserve place for notebooks and laptops.

Z Some discussions were allowed to go on too long and other were rushed. I would have liked see more on Game Theory.

AA Carl Crawford is insufferable. I appreciate that he has a deep Rolodex. But my god please, is there no way to take a microphone out of his hands??? Far and away, the worst aspect of this workshop was the endless drivel that he spouted, which seemed primarily focused on either making sure that there was meaningless controversy or giving everyone ample opportunity to check their email. I checked out intellectually after the first half of the first session, due largely to his shenanigans. We spent an endless amount of time listening to him blather on at the start of sessions, and then had to throw competent speakers with interesting, VALUABLE talks off the stage. If I skip future ADSA events, it is because of this.

AB No response

AC Likes: venue, organization/administration, out-of-box brainstorming of possible solutions was part of forum. Controversial subjects were part of the agenda and encouraged open discussions. Dislikes: Too rushed. Not enough time between sessions to talk.

AD No response

AE No response

Question 10: Do you have recommendations for future workshops topics?

A Explosive Detection for carry-on and checked baggage based on next-gen CT and XRD technologies. Innovation in X-ray source ^ Detector technology applied to applications outside cargo

B No response

C No response

D I suggest one restricted workshop where researchers could review performance on SSI data.

E Maybe a discussion on what would happen "in the event there is an incident", since that appears to be the hold up.

F Simulants and simulant validation.

G See above.

H Deterministic modeling method for imaging study. Finite element analysis based method can handle all physics (scatter), imagimg task and counting noise. MCNP includes all physics but rarely gets correct statistic noise in imaging simulation. Ray tracing has limited ability to handle scatterNo response

I No response

J Need to continue to bring real-life examples from non-US initiatives where new security concepts have been implemented.

K More topics on screening at the checkpoint, since this is: the dominant number of nodes; the best opportunity for fusion of screening technology; the toughest challenge to economic viability; and the biggest impact on traveler experience and satisfaction.

L No response

M Not really. I think the topics should be (as I think they always have been) shaped by DHS' needs.

N Personal Electronic Device (PED) screening is currently of interest and this is a hard problem both from a detection and CONOPS perspective.

O No response

P Integration of technologies to solve the problem as opposed to sole focus on single technologies.

Q I'd like to see more input from the air cargo industry. I believe the industry will provide a more thorough view of the operation and the risk involved in air cargo transportation.

R Either give each speaker more time for the questions or DEMAND the organizer keep the meeting relatively on time.

S No response

T See dislikes above.

U No response

V No response

W No response

X No response

Y Field implementation is a must.

Z An entire workshop could be devoted to canines. The advantages and limitations of canines would be useful. Much research is under way in this field.

AA No response

AB No response

AC No response

AD No response

AE No response

Question 11: What would you like to see changed for future workshops?

A See below.

B Discussion is good, but the schedule should be kept to. Its not fair to later speakers if the early speakers throw the schedule off completely.

C No response

D No response

E No response

F No response

G Hold researchers more accountable to the mission, One was “way off”.

H Lighten down the schedule.

I No response

J No response

K Suggest that participants be divided into teams for some structured interaction in smaller groups. Possible ways to do this would be to have 5-10 groups work in a collaborative break-out session to: fill out a questionnaire like this; or review/critique one of the prior presentations or Task Order reports; or take/defend a position on a critical issue like “risk-based screening is good because ...”

L I would recommend that all speakers be kept to their appointed times, but to make the times long enough to allow for an interesting conversation. Also, it would be productive to keep the break times between talks to just 5 minutes, then to allow real dedicated time to networking.

M A few of us were talking - could part of a future ADSA (esp. if on cargo) be held at a facility in the Boston area where screening is done, so we could get a sense of how the process works in real life? Of course there may be issues with revealing exactly how scanning is done, etc that might make this a very bad idea, but if it’s possible, it could be quite interesting.

N The presence of beer at the social events, no seriously nothing, the meeting is great.

O No response

P Parallel workshops; shorter program.

Q No response

R Please utilize a venue that better allows for note taking and is easier to navigate for large audiences. Long rows of tightly packed chairs with few aisle are difficult to manage.

S No response

T No response

U No response

V No response

W Also workshop session could have panel discussion(s).

X As a first time attendee, I had many good discussions and most of those were after my talk, which seemed to act as a prompt for questions. One thought for future workshops would therefore be to schedule first time attendees early in the program to the extent practical (I know this won't always work for other schedule reasons).

Y No response

Z There should be more time for discussion. It should be clear to speakers that their presentations should be short and concise and more of a discussion stimulator.

AA No response

AB No response

AC More and longer breaks, even if that means lengthening the conference by one additional day.

AD No response

AE No response

Question 12: What other comments do you have?

A Based on need for further financial subsidy of the meeting, in addition to participant fees have you also thought about corporate sponsorships? I know we're trying to keep this as a workshop (not a so-called formal conference) but if interested there may be interest by industry to support the meeting in this way. Along these lines, I observe there can be greater opportunity for networking as the time to chat with co-participants is rather limited when you see lunch being condensed based on keeping up with the schedule as well as the small attendance for the social hour after Day 1. Have you thought about holding a workshop dinner one evening at a Boston restaurant with the entire group sponsored by and perhaps organized by "industry"? Again, this would be an area that I would be pleased to support.

B No response

C No response

D No response

E Thank you very much, this is a great workshop and very important.

F STICK TO THE AGENDA. Get a classified project going so (cleared) people can really connect to the problem at hand.

G Great dynamics, as usual. Carl has developed a meaningful and intriguing strategy to engage. It needs to be taken to the next level.

H The proposed registration fee should be applied to (or waivered for) all participants.

I No response

J No response

K Workshop organizers and support staff continue to do a wonderful job.

L No response

M None.

N No response

O Questions 10,11 & 12 - It is a good group of few sharing some technical results and past experience. Define a mission statement for the group that makes a contribution or is a catalysts. "A contribution" means a technology or product that meets a demand and generates revenue and positive ROI's.

P Excellent venue. Feel privileged to participate.

Q No response

R No response

S ADSA continues to be very impressive display of cross-sector co-operation and cross-sector cross-fertilization that is highly worthwhile use of taxpayer funds. ADSA itself is cheap way to "buy down risk" in sense of improving capabilities for break-through improvement in performance, for when/if that should ever be required by policy makers.

T No response

U No response

V It might be informative to have someone present a comparative analysis focusing on (1) the limitations of AT technology as compared to full computed tomography technology, and (2) the economic factors that relate to this choice.

W No response

X No response

Y No response

Z The discussions during the breaks were as useful as the presentations.

AA Facilities and support were excellent, staff was excellent, food was excellent.

AB What happens to the information/report from this workshop...It would be great to have some set of performance metrics, even at a generalized level. For example, a survey issued to past participants exploring if they used the information they learned (new ideas, collaborations, modification of process, etc).

AC No response

AD No response

AE No response

14. Appendix: Acronyms

TERM	DEFINITION
ADSA	Advanced Development for Security Applications (name of workshops at ALERT
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
ADSA03	Third ADSA workshop held in April 2010 on AIT
ADSA04	Fourth ADSA workshop held in October 2010 on advanced reconstruction algorithms for CT-based scanners.
ADSA05	Fifth ADSA workshop held in May 2011 on fusing orthogonal technologies
ADSA06	Sixth ADSA workshop held in November 2011 on the development of fused explosive detection equipment with specific application to advanced imaging technology
ADSA07	Seventh ADSA workshop held in May 2012 on reconstruction algorithms for CT-based explosive detection equipment
ADSA08	Eighth ADSA workshop held in October 2012 on automated target recognition (ATR) algorithms
ADSA09	Ninth ADSA workshop held in October 2013 on new methods for explosive detection
ADSA10	Tenth ADSA workshop to be held in May 2014 on air cargo inspection
ADSA11	Eleventh ADSA workshop held in November 2014 on air cargo inspection
ADSA12	Twelfth ADSA workshop to be held in May 2015 on explosive detection at the checkpoint
AIT	Advanced imaging technology. Technology for find objects of interest on passengers.
ALERT	Awareness and Localization of Explosives-Related Threats, A Department of Homeland Security Center of Excellence, at NEU
ANSI	American National Standards Institute
AT	Advanced Technology; a TSA term for equipment deployed at the checkpoint
ATR	Automated threat resolution
BAA	Broad Agency Announcement; a DHS and TSA term for a request for proposals

TERM	DEFINITION
CAPPS	Computer-Assisted Passenger Prescreening System
COE	Center of Excellence, a DHS designation
CONOP	Concept of operations
CREATE	A DHS Center of Excellence
CT	Computed tomography
DfT	Department for Transport, UK
DHS	Department of Homeland Security
DHS S&T	DHS Science & Technology division
DNO	Defense Non-Nuclear Proliferation
ECAC	European Civil Aviation Conference
EDS	Explosive detection system; a TSA term for systems to detect explosives in checked baggage.
EMD	Enhanced metal detector
ETD	Explosive trace detection
EXD	Explosive detection directorate of DHS
FA	False alarm
GT	Game theory
HME	Homemade explosive
IED	Improvised explosive device
IMS	Ion mobility spectrometry
NEU	Northeastern University
NPV	Negative predictive value
NQR	Nuclear quadrupole resonance
NRF	Nuclear resonance fluorescence
OSARP	On screen alarm resolution protocol/process
OSR	On screen resolution
PD	Probability of detection
PFA	Probability of false alarm
PPV	Positive predictive value
QPL	Qualified product list
RBS	Risk-based screening
RF	Radio frequency
RFID	Radio frequency identification

TERM	DEFINITION
SNM	Special nuclear materials
SOP	Standard operating procedure
SSI	Sensitive security information
TBD	To be determined
TCO	Total cost of ownership
Trace	Synonym of ETD
TSA	Transportation Security Administration
TSL	Transportation Security Lab, Atlantic City, NJ
TSO	Transportation security officer; scanner operator
ULD	Unit load device (a container used for aviation cargo). LD3 is a type of a ULD.
XBS	X-ray back scatter
XRD	X-ray diffraction

15. Appendix: Minutes[2, 3, 4, 5]

The ADSA11 minutes were edited for purposes of clarity. All errors in the minutes are due to the editors of this report and not due to the speakers themselves.

15.1 Day 1 Minutes: November 4, 2014

Michael B. Silevitch: Welcome to ADSA11.

Laura Parker: Welcome to ADSA11.

Kumar Babu: Welcome to ADSA11. Aviation has four main points – air cargo, check baggage, check point and trace. With air cargo, not all of the checking is done by TSA, as some is done by private companies.

Speaker: Carl Crawford

Q: There used to be concerns about what was meant by screening and scanning. A lot of cargo is screened but not scanned.

CC: Screening includes scanning, trace detection and known-shipper programs..

Q: I don't think Congress ever said they were satisfied with the current issue. Self-screening by private agencies with an approved instrument is the current status. I don't think congress has approved of that situation. There is a mode of operation that may or may not agree with the law.

C: I am going to talk about that in my presentation. We accomplished this mission, and briefed it to congress and they approved. We can always get better, but we have an approved method.

Q: During the last conference we talked about the TSA, but I was wondering if we can talk about the global response.

CC: There are many devices on the approved list. Many of the air cargo hand-

2 "Q" indicates a question made by an ADSA11 attendee.
3 Inaudible or missing portions of the minutes will be indicated in parentheses as (???).
4 "C" indicates an answer or comment made by an audience member.
5 "A" indicates an answer made by a panelist during the panel discussions.

ing people are using x-ray. There is also risk-based screening as well.

CC: We talked about material discrimination. It would be interesting to hear from end users. In this room there are many great solutions.

CC: There is a body of CT data that is publicly available through ALERT. There is a body behind that dataset of all of the objects scanned. The data are available for research on the ALERT website.

Q: What is the point of having it in the public domain? Crowd-sourcing?

CC: The point is to get as many people working on our problems as possible.

CC: There is money coming in from government, etc. You can track someone through an airport, and you can track them through other means.

Speaker: Frank Cartwright

Q: How does academia and small industry get access to the money?

FC: BAA process (slide 6).

Q: In addition to that, with the new DHS joint requirement council, will these be available with other entities?

FC: We decided that we wanted to clean up house, but now that we have done that, we want to coordinate efforts.

Q: Is the new BAA process going to target newer equipment?

FC: I am not sure. I think it will probably be a bit of both? It exists; but we are developing the capability to support that device.

C: I like the idea of this revolving list of system providers. If this list could be public, that would be great.

FC: The target is not out yet, but the write up that will explain the new process will be out shortly.

Q: Who can some of these people call for questions on government funding? The process will go over their heads. There are experts in medical imaging, but they don't know these terms.

FC: Broad Area Announcement (BAA), rather than calling me with questions, go online. This is a vehicle. How do you guys get that to us? If you post that, someone will review it. From there, if it meets their needs, it will be awarded.

Q: You mentioned that 7% of your funds were going to be spent on (???) cases, but you didn't give us the breakdown. Can you tell us those things and then go back to the CT algorithm capabilities?

FC: I left out the breakdown. I would have to look that up – it's one of those things that winds up sounding low, but it's a sizable amount.

Q: Is this S&T?

FC: Just TSA. In terms of CT, it would be adjacent. In this, it is case palletized screening.

C: I think you are missing one thing: a point of contact. It's impossible to get someone on the phone for this. **C**: On the bottom of the BAAs there is contact information.

FC: We are the funnel for all of this. My group is the one that takes all of that. It goes to acquisitions first.

Q: What is the review process? How do you ensure that it is fair? Is it anonymous?

FC: In terms of anonymity, we have to get better at asking the right questions. We may not accept a proposal if it doesn't meet our need. We have to identify what we are trying to do and address those. We can look to technology results. How are vendors notified? There are 3 or 4 touch-points that we are communicating with them. There is constant communication.

Q: I was trying to think of ways to get people information without putting it on you. Some program officers have a program outline and pointers for small businesses, vs. a university, because I don't know if those industries have different protocols. Should we think of this here?

FC: We have invested a lot of time into this process; the idea of that single point of contact and in the past there has been someone who is based in that process. I can name people in acquisition. I would rather check back in to let them know there has to be a better way to communicate.

Q: Can we send a BAA out to the ADSA list?

FC: For the target BAA, we are going to hold an industry day. The plan is that when we issue this, we would be hosting the industry day.

Q: Are these BAAs open to national labs?

FC: I don't know.

C: I know TSA has contracted the national labs for different programs.

C: The point of contact is listed on www.fbo.gov. They are the ones who can respond, and they go to the technical staff, and they know who to ask to get you the right answer. The only time I have seen restrictions, is for small businesses.

C: I know the contracting officers, but have you picked up the phone to a contractor or email? Did you ever get a response? I would say the communication through that vehicle is broken.

Q: Do you take into account the work being done in other countries?

FC: Not a lot at this point. I would rely on him. I know what we are dealing with now; we don't have a strong line of communication.

C: I think that would help. There is a lot of duplication of the work going on.

FC: There are results from our chief scientists, but they will be quick to let us know.

Q: I am interested in your first bullet point about system costs. The TSA would be able to make total life cycle costs part of the criteria. Are you committed to push down that process?

FC: We are looking at the life cycle costs, but I wouldn't say committed. We are having those conversations.

Q: It seems like you have different people in different branches. Are you communicating? When you talk about costs here, that may be different for the acquisitions. Are we on the same page?

FC: Yes. To answer your question, we have a model for trace. We may be able to make something cheaper, but it might not meet the need. I am looking forward to that process.

Q: Is that transparent to the vendor?

FC: I am not sure. How we make those calls justifies how it is handled. It is internal. We are trying to be more open but on those key leadership decisions, I am not 100%

Q: Could you talk about CGUI (common graphical interface)?

FC: For each manufacturer, it is different. That requires training for different environments. One of the benefits we are pursuing is to make that transparent. What is displayed on the front end is the same. So far it has been successful in the check baggage department, and we hope to make it that way for air cargo as well.

Speaker: Paul Redfern

Q: Can you repeat the second category?

PR: Known consigners and regulated agents.

Q: No, the second.

PR: That is transport exemption; known companies can apply for a transport exemption.

Q: What about sea transport?

PR: We deal with air, land, and maritime. We don't regulate the same in sea transport. We don't 100% screen, as we do in aviation.

Q: So a shipper can pick any of those screening options and use them?

PR: Exactly.

Q: Trace detection? Vapor or swabbing?

PR: The EU regulation itself allows both swabbing and vapor. It says swab the outside and open it up and swab the inside. By opening them up, it does cause insurance liabilities.

Q: Is this list decided by a committee or testing?

PR: All EU systems are run through a committee.

Q: Tests?

PR: It has to be allowed by regulation to be on the list. If you are screening cargo, you can use any of these techniques. You go to ECAC and get tested and then it goes on the approved list. If there is not an ECAC methodology for testing it, then you have to go to a member state and ask for a national qualification procedure to move it to the list.

Q: Each method has its specialties. Is there an ECAC cargo test?

PR: No. If you take EDS, there is only one test for EDS machines. So if it works on luggage, it could be applied to cargo and carry-ons.

Q: What are you using EDS for?

PR: The only place in the UK and the EU using EDS is small baggage. The integrator will put a process together of back up testing methodologies and bring it to ask if it works or not.

Q: What is considered?

PR: They determine what is most appropriate.

Q: Who are *they*?

PR: The screeners, themselves. They look at the cargo coming in and ask "how do we screen that?" They use their past knowledge and experience with similar cargo.

Q: Are there specific training requirements for cargo?

PR: The EU regulation and UK regulation have quite a lot of training requirements. X-Ray training is off line. You have to do the classroom-based training, even if it is not just to meet the requirement. We think about what is a useful benefit to TIP that you can tailor people's training to depending on their strengths with certain items.

Q: There is probability that I guess right. Is there a process where you run a certain number with confidence, statistically, that they haven't guessed?

PR: Yes. You take 3-4 operators and average from there and get something everyone can live with. Most operators are pretty similar, we've found.

Q: The filters that you use to collect vapors, do you know the mass on those filters?

PR: I don't. It's very low. The dogs can work at those levels. I just can't calibrate how much is on there.

Q: Do you guys have money?

PR: Nothing like in terms of the numbers you see over here. The user is who flows the cash at the end of the day. If a vendor comes to us and we see evidence that it would be a game changer, we can direct the funds. We can get access to small amounts of cash.

C: The UK programs are very helpful. There are a number of programs that you have in the UK with different funding levels.

Q: Are you the point of contact?

PR: I can be. The investment in cargo has been dramatically smaller. We are breaking down a lot of things and hand searching a lot of things. We are losing business with the rest of Europe. We need other options to do those hard and difficult things faster. We are looking to invest in long term projects but none will come online anytime soon. The other way would be to take something to a member state and have them get onboard.

Q: There has been a shift towards the sea?

PR: Yes, definitely. It is moving away from the UK and towards the sea. The risk is that for something time dependent, we worry that people will screen using something that might not be effective. That's what we don't want.

Q: (???)

PR: Screening by sea is significantly less.

Speaker: Allan Collier

Q: How do you measure "prevent and deter"?

AC: Anything.

Q: Can you say how that was met?

AC: I will get to that and all the approved screening methods. Screening is defined on the next slide.

Q: Congress …They didn't pay for it.

AC: No. Industry.

Q: So if you had a palette with five pieces, you can split that up?

AC: Yes.

Q: (???)

AC: In some configurations and some policy rules.

Q: (???)

AC: TSA works on layers of security. The known shipper is one layer of security.

Q: It says voluntary. What does that mean?

Q: What percent of those technologies do you use?

AC: I will show you that one. You do your manifest verification and you see what's in it, say basketballs, (???) and you see a blob (???). It's the pump. (???)

Q: (???) UPO guaranteed procurement?

AC: (???) Better to be on the certified list.

Q: Do you tell industry?

AC: No. We would tell facilities about the technologies and all the stuff associated with the technologies. They showed us their shipments, floor model and plans. We would brief them with the certified shipper program and leave them to devise their plan for screening cargo. They decide what technologies they use and TSA decides if it's (???).

Q: What is the difference between qualified and certified?

AC: Qualified is that they have gone through the first stage and been approved. The second stage is running cargo through and testing their systems. Once they have been approved, they go into the qualified section.

Q: What is the difference between the SSI and non-SSI version.

AC: The non-SSI will include (???).

Q: Do qualified shippers need to use those technologies?

AC: Yes.

Q: There are no instances where a qualified shipper (???) opposes a threat or not.

AC: No. (???)

Q: Screening vs. scanning?

AC: EDS is a scanning machine. That is scanning. Screening is the overall process, with all these technologies. I am looking at the screening process as a whole.

Q: There is no path to say that X is a known piece of cargo from a certified shipper?

Q: (???)

AC: Electronic metal detector.

Q: Is a facility that is using EMD only able to certify a shipment?

AC: Yes. They are briefed on the capability of the technology.

Q: Could one (???) with only 155-265 X-rays to screen cargo (???) 100% screened. We know how many EDS systems are deployed (???) and here we say on 265 X-ray systems screening for cargo, about 10% would be critically scanned.

AC: (???)

Q: (???)

AC: Frank might know that.

Q: X-ray screening seems to be completely dominant for luggage. Can you give us a feel as to why that is not for cargo? Is it a penetration issue?

AC: The businesses made the decision of what technology to use based on their business models.

Q: Do you seek meaningful stats from sites using technology versus sites not using technology?

AC: I don't think we have that; compliance inspections maybe. If someone looks at an X-ray image, (???). Should they have passed it?

Q: Is there a stress testing for the system?

AC: Yes.

Q: Including threats?

AC: Yes. (???) is part of the process for approving the method. Simulated threats assessments happen throughout the lifetime.

Q: In the US, with trace, do you only scan the outside of the package?

AC: For the most part, no.

Q: Can you give an example of challenges?

AC: Screening of human remains. That, for example, requires alternative measures.

Q: What energies to do you use?

AC: What would you say, Frank, maybe on average, 250-450 kV. We might have one or two on the list but they aren't looking to buy them. The power source may wash out the components and what we are looking for.

Q: Can you talk about the problem on ATR cargo systems?

AC: The only problem is (???). You have to look at the holding.

Q: (???)

AC: Large X-ray is (???).

Q: Difference between ETD and Trace?

AC: They are the same.

Q: (???)

AC: 5 seconds for small, 20 seconds for large, 25 seconds for trace.

Q: What do you mean when you are saying hardening?

AC: Aircraft hardening.

Speaker: Richard Fisher

Q: (???)

RF: Not really. This was in the legislation. They made sure the legislation was interpreted the way they wanted it to be.

Q: In relationship to the comment you made earlier, there was another trade association housing you? Neither of you want (???) going in.

RF: They didn't want us being involved in the screening at all. They really just wanted to move it away from anything we did.

Q: I'm interested in the value proposition. For example: you're a freight forwarder; you could explain to your companies that testing allows you to expedite the freight process to your handlers if you want to purchase a new market for all your manufacturers testing systems. What I hear is a new marketplace—you as a freight forwarder or the airliners for screening in general.

RF: By testing, you mean screening?

Q: I'm not trying to say. Is there a value proposition for you as the freight forwarder?

RF: I would have to say no. The problem is that the equipment is expensive. My customers expect me to get their freight through at the lowest price possible. If we add additional costs into the supply chain, I don't know if it's a new market or not.

Q: (???)

RF: Yes, it's all through the data.

Q: In terms of the data, how much work is going on (???)

RF: (???) the answer is you can put it in the cloud, encrypt it and distribute as you choose.

Q: Since you have been doing this, how many threats have you detected that would have been (???)

RF: Zero.

Speaker: Doug Bauer

(Context: Bauer explains different types of risk and compares perceived risk of living next to a nuclear power plant to the radiation one is exposed to on a flight. Even though the risk is less than that of the flight, the public perceives that the risk is greater. See his whitepaper at the end of the final report for additional information.)

C: Another good example of perceived risk versus explicit risk is the backscatter X-ray. There's a lot of controversy over the safety of that versus the perceived risk.

DB: The effect of radiation at whatever minimal level is often a matter of concern to the public, and causes them to seek out a Plan B if available.

Q: There will be a talk by the (???) group later on today.

DB: Good. I'm looking forward to that. I would like to break the silence on that topic.

Q: About buying down risk, there are people that do risk technology for a living. The part that I struggle to quantify is the value of deterrence? The other speaker (Richard Fisher) said that they had zero incidents. Some of that zero could be that people know a system is in place. I think if the TSA announced that they would stop screening, you would see something happen in a short amount of time.

DB: I don't think there's any question in the value of deterrence on human conduct. How you quantify that is a deep method for human resources and risk management. The second part it is the adequacy of approaches to risk methodology. We're dealing with highly improbable events that have huge consequences. It seems to me that this is not unlike the question asked of Eisenhower during the Nuclear Age when he opened the shipping ports in Pittsburgh. There was the Price Anderson Act (???). It strikes me when you think about incidents such as 9/11 or lesser incidents perceived by the public or authorities, but also the derivative costs, which could be reasonably accommodated by (???).

Q: Do you believe that perceived risk is still dominating quantitative risk? It's been many years since 9/11, but (???).

DB: It's subjective. Yes, perceived risk dominates. There are two reasons I'm concerned about this. It could well lead to investments that do not create for government purposes the highest return on investment. Maybe the risk of not educating poor children in our cities, or the risk of our rickety infrastructure—maybe not in the United States – but in other parts of the world it is far greater. These are huge issues. But if our leadership cites that these risks (???), I would ask if the emperor wears clothes.

Panel Discussion

Q: This is a good academic discussion of risks, but (???). Terrorists are still targeting large aircrafts according to intelligence. We can't put an emotional quantitative measure on a post 9/11 world. When you go to put your grandchildren on a plane, it's something you think about.

A: It's not only not measureable, but we make progress in our conversations in our abilities to perceive risks. We have to decide what to do with public investment. We should disenthrall ourselves and try to seek some common methodological approach to assess risks, and not just our emotional responses to assess them.

(Doug Pearl presentation slides w/hypotheses.)

A: These are two colleagues discussing

C: I don't think so. It all comes down to (???). It depends on the configuration, the size of the (???), and (???).

A: Are you saying that (???). Total life cycle costs are dominated by labor.

C: This is a market. This is not the TSA going out to buy a piece of hardware to satisfy the baggage handling need, meaning the vendors will be able to create what is best to satisfy the market and the customer being able to look at the offers in general and decide what is the most cost effective choice they have in the market place. I think all bets are off here.

A: Is cost effective different than cheapest in an industry where (???) does TSA compare the system (???) one system works on apples, another works on watermelons, and the third on basketballs?

C: I don't think so. Cost effectiveness includes how long it takes you to do it, or cost of training labor (???).

C: But it's still independent of performance.

A: I suggest some paraphrasing of the issue. One of these people should say I have a technology that will maximize my profit, and the other person could say I have a technology that would not maximize profits but would greatly reduce risk to the public. This reminds me of the late Milton Friedman who said that a corporation's only responsibility is to maximize profits. (???) I think the best way to go through this is to say if the government establishes a (???) the only responsibility of a vendor is maximize profit while meeting QPL.

C: At the moment, there is no emphasis to make the equipment better. You could actually have a less expensive solution if you took into consideration the costs of operating the equipment and training to use the equipment.

A: I also hope in the future that the TSA requires total life cycle cost minimization. We're going to be having a presentation discussion with Terri Rose on the (???). As (???) as we have initial acquisition cost in one bucket and (???) in another bucket, we're not going to have overall cost effectiveness in the decisions we are making.

A: I really did mean and still do mean, methods. The methods in mind mean not just the box, but all the decisions made during the life cycle. I really do need total system costs.

Q: The cost of future tech insertion. If someone is coming three years later with a better machine, (???).

A: So upgrade path?

Q: In relationship to some of the info from this morning, the number of X-ray machines in the US is about 260. It's not really a business, (???) screening and checkpoint screening. I spent a lot of time in the EU looking for manufacturers to get (???). The only way you're going to do it is to mandate it. To say that you will use this equipment by a certain date.

A: I'm going to take that opportunity to look to my next slide. I'm going to let people read the balloons here.

Q: One of the things in here that we don't want to miss out on a ton is that a diversity of methods is important because it encourages competition. If there's four different methods using four different (???). I think a diversity of methods allows for a more security.

A: Once that's done, it's the job of the company to maximize profits in accordance to the law.

C: Maybe instead of saying this is the equipment you should buy, maybe say these are the requirements. The definition should be on requirements, not equipment. At the end of the day, you need to find an IED.

C: I think if you put a list out there setting up the requirements, (???).

A: I'm wondering if there's anyone from the government here to address anything that is on the QPL as good, better, or best.

C: From that question you would have to quantify the value of (???). **C**: That puts you in a very sticky situation when you begin to label it as good, better, or best. It's up to the individual to make that judgment based on the characteristics. Maybe you have a system that costs more that can do 20 pallets an hour in contrast to another system.

A: As a legal matter, I can remember doing experiments with pagers and radiation. We were thinking of good, better, and best. It violates the law. The government cannot favor one product over another. We showed quantitative results and let the public decide what they were going to do. It could be perceived as favoring one vendor over another.

A: (???) My question is, would it ever be legal or plausible if the (???).

A: What I was going to say was its very difficult for us as forwarders to tell the better and best to our shippers. How much am I going to gain by paying a little bit more. In Doug Bauer's presentation, when he was talking about the vertical integration of the (???) and the TSA. (???) There is no transparency. They meet the requirements set by the government.

Q: Did anyone try to have market accessories (???)? Let insurance charge the rate based on the materials. Was that tried?

A: That implies that insurers would have to have insight into the system as a whole integrated into the other.

A: What are you insuring against? If there are cataclysmic events, that would make it difficult. (???) There are rare instances with high (???).

Q: We are talking about run of the mill IED. Is that is insurable?

A: The QPL is the QPL (???). My question becomes, is there logic for collective action by the air cargo carriers/vendors to indicate to government, lobbying and such, that they are open to raising the bar for the QPL.

Q: Doug, are you considering in that model that it would be a combo of the risk based approach and chemical screening, and that they would be interlaced?

A: I would start with an agnostic approach to both possibilities. Look at the resistance that first existed in the power industry to renewable energy and efficiency. Over years of research with government and industry, we have shown that you can make money investing money in renewable technologies, taking in the environmental externalities. Why can't we have that same conversation between public and private sector to decide what research should be and the topics should be? The interests that would be reflected in that is the private interest of industry to find new markets and capture new capabilities. Let's face it, for a combo of technologies, we are free riders. It is free riders on medicine in CT technologies and checked baggage.

Q: For a marketplace to accept a new way, it has to be transparent, which it isn't. ' The integration of screening technologies with risk based assessment (???). There are some of my customers that won't care. There will be a delta between customers who care and customers who don't.

Q: Raise the bar, as in stronger?

A: Making the QPL stronger would bring safety to the system and lower the risk of an incident happening.

Q: (???) Those are the kinds of things that need to be more apparent. Will the perceived threat be high enough to warrant that raising of the bar? We had to push technology and ask for more from manufactures.

A: I am giving you how it is working on the other side of the fence.

Q: I wanted to state that in the EU we successfully have performance standards in relation to the QPL.

Q: EU doesn't have pre-checks. If you can deploy a standard piece of equipment then they are allowed to keep laptop in the bag. (???) For the cargo to acquire better technology, they have to give something back. (???) You will ultimately end up with slightly better security.

Q: (???) Providers are allowed to use (???) Argue against ourselves. (???) It will still be the equipment to you for more money and you will have to hire and pay people to run it. That motivation is true.

Q: Based on whose risk it is, who pays?

A: Exactly.

Q: So you think we should have an intelligent conversation in Washington (???).

A: Yes.

Q: Every day we have to make decisions on where we invest our money. You are making business decisions based on the market assessment. We are looking at technologies that are 5 years out. Will the regulator make it with us? We are balancing risk. We are trying to make decisions on where the customer community will get to in several years' time.

A: The vendors wouldn't mind if the QPL goes out because (???) so you have to guess what the regulators will do.

Q: The way to create order is to make sure you use the same term on the ordinate as you do on the (???). You should have incremental investment by the people.

A: Just because we use a different curve doesn't mean the risk to society goes away.

Q: Why isn't the public on there? Shouldn't the people who fly have a say?

A: I am using government as a short hand for what the public wants.

Q: If there is a desire out there to know more, there should be a concerted effort to do so. The performance is not (???). There is less sensitive information that you can put out in a QPL, it is performance information. Everything from footprint to processing time are key pieces of information. This is one component that is missing and of interest.

A: (???)

A: Thank you for bringing that up. It is the government's responsibility to change the QPL.

Q: And those that only pass the QPL will be pushed to do better (???).

Q: TSA would never say good, better, best. We have robust qualification and intelligence processes. We are upgrading systems based on that. It is not just screening that is a layer. There are multiple layers. (???) Known manufacturer through random screening and inspectors, all the things that happen along the way, deal with this. If a vendor comes with a better system, what makes it better? Explain that to the government by bringing them in to explain but also bounce it off of our intelligence. (???) If it is a vendor with a better idea, we will make changes to the software and qualified product list.

Q: I think that the risk idea applied to a regulated market where vendors are paying for it is perceived by the customer as a non-issue because the government has regulations regarding the QPL addressing risks. Dealing with an additional perceived risk will not make vendors buy it. If they see an efficiency gain from the technology, would that be an impetus to buy it?

Q: I am with Dave on raising the bar. They have to contract with government and maintain service for a year. (???)

A: So getting on the QPL is not enough?

Speakers: Terri Rose and Todd Combs

Q: How can we get access to this model? This is important in assessing risk, and costs, etc.

TR: I don't know if TSA can.

TC: I would recommend sending me an email and asking for it (TSA rep).

TR: When the project was done, 3/4 of the team splits, and the PI is not there anymore. The modeler is still there, and she holds the code, etc.

TC: I understand what you are asking. We could find out from the right people, if we can get a version in the public domain.

TC: The reports are S&T.

TR: The roll up is unclassified.

Speaker: Ricardo Osiroff

Q: What is the time on the chart (slide 8)?

RO: 100 seconds (but it changes in proportion).

Q: Do you have a prototype unit now?

RO: We have two.

Q: Do you know what that agent is?

RO: We looked at the explosives.

Q: How do you experiment with particles?

RO: We place them in a filter, and the filter goes inside of the machine.

Q: So you are dissolving particles?

RO: Yes.

Q: Does the collection time affect the signatures?

RO: No.

Q: But not at the same time?

Q: What kind of signal would a regular gas generate?

RO: It would not be recognized as an explosive signal.

Q: What is the downtime?

RO: 15 seconds

Q: Is that the same from one material to the next?

RO: As long as all of the parts used are not changed.

Q: Are all the axes the same?

RO: Yes.

Q: Does your algorithm include a probability? There are interferences with light characteristics.

RO: Yes, this could happen. The way we deal with it is that we have 8 different reactions, and it is extremely unlikely that they will do something different than expected.

Q: Can you increase the number of reactors?

RO: Yes.

Q: What is the scope?

RO: Sensitivity is actually the ratio.

Speaker: Matthew Staymates

Q: What about the flow perpendicularly?

MS: It is completely different, and it’s hard to visualize on the screen.

Q: In this diagram, where is the origination?

MS: Center block.

Q: What is your generator?

MS: I don't know, but I would guess it's reduced.

Q: You are using a heater, I assume?

MS: Doing this heater cartridge, it creates both particles and vapor. I can see it after firing the heater cartridge. If I can see, it it's not a vapor.

Q: The particles that you collected would be dependent on the size.

MS: Anything smaller than 2.5 I can't do.

C: The problem with this way of doing business is that we need really to understand the (???). If you read Paul Barron's book on aerosol, that process is critically important. Are you getting any dry vapor on those particles?

Speaker: Michelle Clark

Q: Did you make an attempt to be careful in not getting exposed?

MC: Yes.

Speaker: David Atkinson

Q: What's the false alarm rate?

DA: Whatever the IMS rate is.

Q: You have to pull that cargo container then?

DA: Yeah, that's the problem.

Q: If you had a better collector (???).

DA: Yes. If I went to Canada and got one of those, it would be much better.

Q: Do you (???)

DA: Yes. Perfect timing.

Q: How do you get it on the TSA protocol that you have to sample every parcel that goes through?

DA: Right now TSA only accepts single piece by single piece detection. Every box is getting sampled because you're getting vapor from all of them. You could try configurations and see if you find the explosive.

Q: Assuming you will get contamination from the boxes in the middle (???).

DA: Yes. You have to do the worst case scenario for TSA to accept it.

Q: It seems as though your specificity is really (???).

DA: Our specificity is very high. There are things we can't see and I don't know if we will ever see it because the (???). We have yet to see a false alarm; without our new system. IMS has false alarms. The guys from Spain are using DNA with the mass spec to get the false alarms down.

Q: (???)

DA: You have to play that game. You get rid of false alarms by making your PD work.

Speaker: Susan Rose-Pehrsson

Q: So this is how you avoid using diffusion (???)

SRP: Yes. We dissolve ??? with water.

Q: Can you take it with you?

SRP: We don't have a portable testbed right now.

Speaker: Danny Fisher

Q: When you say in no way harm the cargo?

DF: If a manufacturer completely sealed the package, say it is military, the option of punching a hole in the cardboard is not an option. If vapor doesn't work, I guess use a giant CT scanner.

Q: What about activation? Do you consider that harmful?

DF: I do not know about it. I am not up-to-date on the technology.

Q: But would you say that radiation damage is not of your principle concerns?

DF: Unless we are told it should not be in contact with radiation, then it is fine. That being said, I don't know. I am not a physicist.

Q: Your bubble means better as in (???).

DF: Better maintenance (???).

Q: You had canines at KRL5. They've had time to develop. Will they ever?

DF: This was presented a few years ago. (???)

Q: Your applications and container type paletts, are you seeing reasonable detection results within these containerized situations?

DF: (???) don't know the concentration.

Q: If you put a sizable amount in the container, do you detect it?

DF: I will be able to test it with a known amount at some point.

Q: Are you planning on put it inside the container?

DF: Yes. I will put it inside the palette. We will conceal 100 and measure it. I do not know the numbers of the concentration. If it works, it works.

Q: Why are you here? I ask because why did you choose this conference?

DF: I am in the trace community. I present some of the slides. This new project of air cargo screening, this is my main project, so I wanted to see who is dealing with that. Is there a database for air cargo screening? We found almost nothing. I am here because people will understand the needs and I might leave with new ideas and new vendors that will want to incorporate. All the vendors I have presented to have a limited turnkey solution. It is unlike the technologies that are well cooked. This is in a preliminary stage. I am telling you what is needed.

Q: Can people contact you?

DF: Yes. My information is on the first slide. The slides will be on the web.

Speaker: Sheldon Jacobson

Q: The counterargument is taking that tactic into more than one event.

SJ: There is always the counterargument.

Q: Shouldn't the deterrents be primary?

SJ: Yes. I think that is a good point.

Q: Deterrence to you means what?

SJ: Stopping an event before it happens; eliminate the possibility to zero.

Q: Is the passenger aware that they have been selected?

SJ: Today you know you've been selected because it is on your boarding pass. That is foolish because if you are a selectee and have a threat, you (???).

Q: I was selected even though I was pre-check. I set the metal detector off.

SJ: That means you were a second level selectee. Did they swab you?

C: No. I went through the AIT.

Q: (???) says that behavioral doesn't make a difference?

SJ: I kind of agree with that but haven't given up on it.

Q: Is voluntary an assumption?

SJ: We make it voluntary. If they don't offer it, we assume (???).

Q: Why didn't you put things like address and religion?

SJ: The question marks meant here are others. We can ask any and all of those things. This is not an exhaustive list.

Q: If you would boil this down into the characteristics of a sensor, what would it be?

SJ: CAPS comes up with thumbs up or thumbs down. The more information a person is willing to provide then the more likely they are not to be a risk. There is small group of people who are high risk. Everyone has a score, a risk score. Most people have so much information it is easy to find out who is low-risk.

Q: We have been talking about gaming and things like that. It doesn't seem particularly strange that someone would invest in someone to employ a person to fly a lot and have frequent flier miles. To what extent does that affect this?

SJ: If they are a person that we cannot assess that they are low-risk, then their luggage will be subject as they are to screening.

Q: This seems to be a potentially game-able system.

SJ: I believe that the TSA is smart enough that they will have more information than just these characteristics. We will talk more about that.

Q: We do have a branch about risk. I wish (???) was here to speak about this.

SJ: And what I am listing is consistent with what you have?

C: Yes.

Q: That's why you test the system?

SJ: I test the system so that I know how it operates.

Q: Behavioral and racial is information.

SJ: Information is easier to collect. Behavioral (???). Racial is not as valuable.

Q: I flew for a day through Logan and everyone went through the AIT. What is the number of people you are trying to pre-screen?

SJ: TSA pre-check moves this closer to the appropriate level. The input is the TSA's and we don't have access to that.

Q: Given that there is a category of attributes that the TSA is looking at, as a citizen, I would be concerned of where the TSA is getting those, as far as legal rights. I understand for security purposes it's important, but after you catch someone, and show the attributes that are available, the rights violated will make the prosecution fail. How do you get around the legality?

C: I can only speak to some degree, I don't think the line is being crossed. I think those who are of interest are being monitored to that respect. We are looking to separate those who are of low risk. When it comes to the constitution, and the info we are using to characterize for low and high risk, what can you prove. As we get closer to that, we have to determine how to tell low and high risk. Characteristics could be someone acting nervous.

Speaker: Arunesh Sinha

Q: Can you explain targets 1 and 2? (Slide 3)?

AS: The defender vs. the adversary, depending on target 1 or 2 will get the 'payoff' that is listed in the corresponding box.

Q: It's hard to measure security applications. What about poaching?

AS: Even in security, we have evaluation; its working better now than it has been.

C: I think the take-away message is that the game theory approach has an advantage to other theories. It has been demonstrated that it has a value add.

Q: How do you handle that the probability could be 0 and cost could be 5?

AS: We are thinking in terms of the cost and the advisory.

15.2 Day 2 Minutes: November 5, 2014

Speaker: Carl Crawford

Q: It seems that the paradigm is shifting, and I think it's having a great (???).

C: I just went through Heathrow, and we were amazed at how well it worked.

C: There are a lot of designers and engineers looking at getting this or better – improving the passenger experience, with shorter lines, less strenuous, etc.

Q: If you want to look at the checkpoint of the future, shouldn't we look at the layers of security? There are things that are valuable to look at, such as video tracking outside of the terminal.

C: This whole initiative is about AIT of smart security. It looks at the security point, but also the operations in general, outside of the checkpoint.

C: One of the important things to realize is that as you work on some areas, others become more vulnerable. It is good to start thinking about these as the risk is lowered in certain points.

C: As part of the smart security program, there is risk based screening supported by different versions of ATRs.

C: But the prevalence is zero.

C: There are other ways of measuring it, and other ways of measuring success.

C: Check point of the future with all of this as an umbrella.

C: Check point of the future is the old name. Smart security is the new name.

C: Dynamic screening is when someone comes in the airport, and you get an algorithm. ,

C: There is advanced baggage screening.

C: There are experts who deal with very real events, and we can find out how to talk with them.

C: CREATE is changing the way we talk about the TSA. This is changing the scene, but we need to hear more so we know what our new position is.

Q: Allan, would it be okay if we circled back?

CC: I was thinking that maybe the government would buy this. We do have a significant risk based team, and maybe I can come up with someone to come and talk.

Q: The other concern I have is, how do we rationalize some of the metrics going on? Are we going to look at it from an industry standpoint. How do we bring the two together? General assumption of ADSA is that the government is smart but they have to be augmented with other smart people.

C: The argument is that we have to have SSI to really discuss this.

C: With all due respect to the government employees, we have a world out there of smart people to contribute, and they want us to think about this.

C: We want academic outreach, but we can't have SSI to have them here.

C: If you want to add it up, you can do that. We discuss this every time.

CC: We have tried this, and it's complicated.

C: It's not that hard, first you start with SSI.

C: I don't want to have this discussion. It can be easy, but it's not something I want to discuss.

Q: Are people hiding behind the discussion?

CC: I think it was SSI.

C: I am not sure. There are countries that use this stuff. We need to have this conversation.

C: What you are talking about is risk. If the risk formula leads to profiling, then you have to discuss it with that. It's driven by risk. Not by race or ethnicity, by risk.

C: There is a compliment to this whole conference.

C: It is a sort of risk based screening. A point I would like to make is that it's not just profiling. There are other criteria. There is a whole discourse and a whole feel, as something we should bring up at the conference. In order to make it work properly, you need to adjust the parameters. If you don't do it right, you can essentially reduce the goals. The whole way of testing in a risk based environment would need to change. Industry can't do it itself; we need the government. We need to introduce those concepts. We need to understand the impact on the dynamic adjustment on the algorithms.

C: To steal the thunder from Tim White talking later today, at ADSA1 we found that 90-30 is better than 90-5.

C: It depends on the context.

Q: Should I lower PD or PFA to make this better? This is something we ask of the government. You should lower PD, and we should have some scientific evidence.

Q: What kind of risk factors are important, but you can't remove the speculation? If the answer that it best is on the government side, that's fine, but if you can use publicly available information, that may be the best way. But what is the true accepted level of risk?

CC: I wasn't at ADSA01, but Michael's comment of what's better, the concept of what happens with a 90/35 or a 90/5, is the point that those didn't exist at the first ADSA. The whole train is optimized.

Q: What do you mean by the automatic bin return?

CC: They are very sophisticated.

C: Where the operator doesn't react at all.

C: You move out of the way, so that 80% that are clear move faster.

C: But it goes beyond automatic tracing; not having TSO at the entrance, having automated systems that exist in those systems.

C: But you distribute the work a bit better.

Q: Any more comments on ADSA12?

C: I just want to say that this kind of discussion is the hallmark of what we want from the ADSA. The interplay between different opinions is what makes this a community, not just talking heads.

C: Tim, if you hear the word appropriate, put it on your slide for the end of the day.

Speaker: Ed Morton

Q: Are you saying $10 USD per container?

C: That sounds cheap.

EM: That's what it is.

Q: Is that an advantage?

EM: If people want to use the port, that's an advantage to the country of Holland.

Q: How far away?

EM: 5 meters.

Q: Did they tell you what they were?

EM: I wouldn't know.

Q: When you have the anomaly, and you highlighted it, when did they find it?

EM: When it is detected, they go in and remove it. I am not privy to if they found anything on these machines.

Q: What percent of the cargo going out of the port goes through that?

EM: There's a new port they are putting in, and this scans about half of the cargo for the new port.

Q: What percentage of containers get seen?

EM: There are no people in the port. It is automatic. Nobody works on the port. If there is something to detect, it removes the cargo, and then everything keeps going.

Q: Is it mechanically mastered?

EM: It's a simple x-ray system.

Q: Did you guys develop the ATR?

EM: Yes. If you want to go see it, check out Miniworld in Rotterdam!

C: This is an example of risk based screening that can be applied to cargo

Q: Does this system work?

C: Not a question of the PD, but the Dutch customs does screening on a random basis anyway, and they are trying to collect contraband. Now it's a question of what are the figures now, but they are able to measure it.

Speaker: Harry Martz

Q: Where were they developed?

HM: Some were developed at TSL. They are not particularly sophisticated.

HM: Do you think people will start using that?

C: It seems inevitable.

C: It seems relatively easy, but based on the performance. There are a couple of Israeli companies making these, and there are others developing those too. Those are available commercially. Specific contexts, and specific density, they developed those more like powder based, and gel based screening.

HM: Most of this is X-ray based.

C: Millimeter wave is more of an anomaly detector. It has to simulate the proper case that you are trying to detect.

HM: You know the system is better if the only thing it can detect is the real thing.

C: X-ray diffraction goes beyond the physical properties.

C: I assume that some CT is probably different.

HM: There are different methods of how you would do that. One issue to consider is, are simulants needed? I think they are.

C: They use them all of the time for AITs.

Q: What is the rationale for that?

HM: I do not know the rationale.

Q: Can you just say that it's sensitive?

HM: You could have code names for sensitive things.

Q: But characteristics?

C: We didn't have access to the threats themselves. Fortunately, we could get that info from the Europeans. The threats were similar, and close enough that we could see what was matching.

HM: That impedes progress.

Q: What was the context? When would you have access?

HM: What access?

C: The simulant vendor is not a scanner vendor.

C: We were not simulant vendors. But we were not X-ray manufacturers.

C: I can't speak for the TSA.

C: The list of explosives, we can't get other countries to have the same list, and we have to share that list.

HM: It can be done, but you're right, it's hard. The US is working with the EU so that we could have a threat list. We don't have a priority of the threat list.

C: Because the company asks the company for the threat list, they have to have a contract to do so.

C: There is a process for this.

HM: I think they are useful.

Q: If the simulant is so close to the explosives, do they become classified?

HM: I don't know.

Q: If someone tried to develop an algorithm in a different country, and wanted access to the list that was classified, could they get the simulant?

HM: We could show 'sensitive' but not classified, and just not say what the explosive is that it's tied to.

Q: Are there any outcomes for preferred vendors?

HM: Things change and evolve.

C: There are two companies in Israel, and they are preferred vendors.

Q: Preferred by who and validated by who?

HM: In some cases, TSA. As far as I can tell, in the industry, they sell the most.

C: The fact that TSA uses them, does it look close enough for the human? Does it alarm? When you are using the developed system, if they have never been validated?

C: We have an in-house range of simulants, and they are all matched, and therefore we have to work out how close those have to be to cover the whole space. Two or three hundred simulants if you come up with all of that data, you are using real explosives are mapped. After the case, if you want to change what you are interested in, you can go back to the vendor, and you already know you can have that conversation. We have materials, and we know we can do it cheaply.

Q: Can you share that with vendors?

HM: We do. We are characterizing individual materials, and that simulant, and we can bring that back, but we can do it when needed.

C: This was a complicated problem a couple of years ago. But we could probably have a whole workshop in the future.

C: Millimeter is much better. And we are trying to characterize much more as well.

Speaker: Michael Finnin

Q: Has it been easy to get these documents?

MF: It has not. We didn't know the extent of it.

Q: Can you say more about the effects side?

MF: It's PD. What do you want to get out of it? Meta-studies are usually done in the medical field. It's just the variable that you want to optimize.

Q: What extent are you considering economics and cost?

MF: I am not sure

Q: I understand the math on power you are shopping up to 60 or 70%, I am not sure in the real world when you show zero, how that helps?

MF: You are right, it's not obtainable.

C: Even the analysis approach is challenging. You could have a probability of 10%.

Speaker: Peter Harris

Q: What about Australian customs?

PH: They are going through 9 tests that are much more complex.

C: They do it on a routine basis. The standard calls for test plates. You normally have to have swap test plates so this doesn't show that.

Q: To your point, what is the difference or advantage compared to the Australian system?

PH: The current (???), and they are very small compared to these, and they don't give you a great image. It just doesn't give a proper image. The material discrimination is much different.

C: For material discrimination, and there is a standard, I don't see how this can be compared to that.

C: Customers have their own requirements for that. For almost every system.

C: The concept of daily check is a must for the system that we used. Especially the system that we see, every system that we used in Israel.

Q: There is a difference between needs. There is one where you need to test the machine in comparison to another, in which case, you need to have a lot of different tests. This is, where this site becomes very useful. Then there is the system run for a quality run. It's a simpler test, but it's normally automatic, then it goes through all of the different phases that are required. In which case you need to provide something the algorithm can detect. It has to be a target of some sort, if it's a material, or something else. Normally it requires a different type of (???).

Speaker: Edward Morrison

Q: What about breeds?

EM: We typically use the trainable breeds, such as Labradors and Retrievers.

Q: What about Beagles and Shelties, for example? They're highly intelligent.

EM: They have to have that trait of wanting to please you, of being trainable. Beagles are very intelligent. They are often used in customs.

Q: How long does it take [for neurons in the olfactory system to grow back]?

EM: 28 days. If I kill all the neurons in your nose, you won't be able to smell anything. (???)

Q: Has anybody done any experiments with (???) on humans to enhance the effectiveness of the nasal senses?

EM: We have done the pathology studies. There is no effect on the cells of the olfactory system.

Q: After you train the dog, how do you know they're not actually sniffing out something else you don't know about?

EM: Typically the dog is trained, and through a serials of trials and false negatives, (???). The trainability is there.

C: Another project being held in Israel is how to track what the dogs see or think when you send them into this activity. This is standoff ECG reading of the dog's bring from a distance.

EM: We are also doing that. We have not gone far enough that I can present that information to you. The remote sensing with the microphone proved to be very effective in Iraq.

Q: Someone made a joke the other day that dogs have been around for a couple million years. When you're dealing with technology, you can ask vendors for technology to be bigger, better, and faster? How can you apply this to canines? What is the next monumental change we can expect from canines? When you think of canines, beyond understanding how they think, what are some potential improvements on canines that we could use them better?

EM: One of the largest deterrents to the canine is the handler. We at Auburn are trying to engage in the best and highest quality training and research. We have increased our breeding program, which is ramping up. By selective breeding, we hope to improve the selection of the dog we are trying to breed. (???) Can we increase the olfactory receptors present on a neuron? That would be a goal, and that's doable.

EM: There are pathogens always present in the environment. The size of that surface area is significant so that it maintains its purity. This is a brand new field of research. (???)

Speaker: Dan Cristian-Dinca

Q: If the left hand side feature were taken from the bottom, would you be able to see the simulants?

DCD: You would see basically something, because this is not very dense. Based on experience something like (???).

Q: You would need something like 360 degrees for full coverage?

DCD: (???) Unless you want to clear a lot of containers, you would do those first.

C: That makes the ANSI standard for general purposes.

Speaker: Dan Strellis

Q: Those are whopping ginormous huge hurdles. Is there an organization that is ever going to say yes to neutron stuff, especially with the safety concerns? What will you all do to mitigate these concerns?

DS: There's a lot of regulations and discussions going on about limitations and standards we have to use. But if you go back 30 years to how (???) was scanning cargo, they were using a drill and then gamma ray scanning. Maybe the field needs to progress as technology develops, so some of these hurdles can be overcome.

C: I think it's up to us in the industry to look to the future and new technologies and take a risk.

Q: I spent many years studying neutrons myself. My understanding is that it is widely used. The acceptance is a mild issue. Neutron is not a new (???). It's as old as X-rays. Over decades, the problem is (???) they work very well in (???), but this perceived risk exist in the field.

Q: Is the perception in China that you can use neutrons?

DS: I only know a little about this. We combine them to form a better solution for the explosives detection.

Q: You mentioned earlier in one of your slides that sources were one of the biggest hurdles. In the early 90s, the TSA was heavily funding neutrons. We just need sources that are efficient and reliable. It doesn't sound like that has changed.

DS: No it hasn't changed. Teletrons are used all over the world. (???) It's not even a neutron source. You have to combine it with other sources. Maybe the (???) project is ambitious, but we'll see.

Speaker: Cameron Geddes

Q: You still have all these different densities.

CG: You're taking a line (???) through the target. If your source is illuminating the whole target at once and do a CT and move your source around it. (???) I could get some of that tomographic information. (???) Does that make sense?

Q: You only need tomography for that path. You might want to (???).

CG: That's correct. That is in fact the approach. You raster the beam, and by looking at angle of the source and angle of the detection to get tomographic information.

Q: (???)

CG: That's right. Those are not on this slide. They would not separate out as much as aluminum, so they're not listed here. They don't separate much. (???)

Q: How did you measure the energy available?

CG: A dipole magnetic spectrometer.

Q: Flux (???).

CG: 10 to the 8th per shot, the goal is 10 to the 7th per shot.

Q: Range?

CG: 10Hz. That is not enough for a source. That laser development part I talked about is critical to work alongside this. It is a 10 Kilohertz laser with 10% efficiency. We are proposing at Berkeley Lab in the next few years. Everything I will talk about it on a per shot basis.

Q: What is the energy range from lowest to highest?

CG: It is dependent on the beam energy squared. (???) Span of 10^{th} MEV to half a GEV. The advantage is greatest for the high energy photons.

Q: (???) Figure for a system like this?

CG: About a million dollars. The time scale to implement is about 10 years, with the cost of about 100K. It will scan full pallets and cargo with full resolution.

Q: Why mono-energetic photons when you are shooting into a target?

CG: We are not shooting into a target, we are shooting into a laser beam. (???) The photon beam coming out is dominated by the electron bunch.

Q: What is the (???)

CG: 100 MEV to half a GEV.

Q: Where does it go?

CG: I will defer that for the middle of my presentation. That is the right question, though. You can tune the energy of the accelerator. If you want two or three frequencies of photons, I can do that with a single electron accelerator and multiple frequencies that can be set.

Q: Do you do this in a vacuum?

CG: Yes.

Q: What is DNO?

CG: Defense Non-Nuclear Proliferation. They used to be called NA22. They are trying to transition. I've made the switch.

Q: How do you determine the (???)?

CG: It's the beam energy spread. We want to get down to 10%. (???) It allows you to drive the scattering harder and (???).

Q: How long is the photon pulse?

CG: Dependent on the photon beam. It will be very short. It is challenge for (???) based techniques. You cannot count. You have to use integrated systems or do one photon.

Q: Tenth of second?

CG: Yes.

Q: Where does it go?

CG: It goes into the plasma wave. It is heat. It is not a large amount of energy to thermalize.

Q: Angular coverage of the source?

CG: The source will have native divergence of a few mili(???). To use such a source to do a large object you raster it. You raster in one dimension, maybe vertical, then pull the target past in the second direction. It can be a fan beam and it's like the translation.

Q: Scatter efficiency is low? Is that why you need a high energy laser to start with? What is limiting the efficiency?

CG: Yes it is low and yes it is why it is high energy. I need a long laser pulse to generate a significant number of photons. If I do this interaction in vacuum, it has to stay focused over interaction life and have a large spot size. That is wasteful. That is what drives this energy beam to be so high, 40 joule laser. I can get around half of that problem by guiding the laser pulse around that structure. That is a small waste for a small laser pulse. (???)

Q: The interaction one (???) of photon?

CG: Yes. You can get non-linearly but the spectrum broadens radically. (???)

Speaker: Gongyin Chen

Q: Is that for industrial or cargo?

GC: It is mostly cargo. We have 15-20K units in medical.

Q: What about radiation damage?

GC: Typically it is (???). You try to hide this (???) beam.

Q: What about the time of damage?

GC: It lasts many days. It can deteriorate a little bit or recover.

Q: Are there limits to (???)?

GC: Yes. Those two parts together (???).

Q: Heterogeneous space is a little more complicated.

GC: Yes.

Q: What information do you guess?

GC: The fender (???) region. You add special information from energy sensitive detectors?

Q: What do you mean by energy sensitive detectors?

GC: Slow spectral detectors. It detects along the depths.

Q: Is it dual energy?

GC: You can do single or dual.

Q: Is (???) linearly?

GC: Linearly. (???)

Q: We know CT systems are reaching the end of their shelf lives, around 7-10 years. Is Varian working on things to extend that shelf life? Anything you can do to increase the shelf life is beneficial.

GC: I am just a stupid scientist and don't know much about the business side. In our situation the customer is government and I don't know about the other side.

Q: You showed CT images and systems like this. Is Varian going into that area?

GC: Some might say we are out, others say we are in. It's not very decisive.

Q: The 20 million frames/second the (???)

GC: Yes. You need it to be very fast.

Speaker: Patrick Radisson

Q: What is cross talk?

PR: On a radio, you have two channels which have natural cross talk. Here it can be seen as a lot of photo pixels.

Q: How long before you think you can display this to a testable platform?

PR: We are developing a corresponding algorithm with (???). So it is at their discretion.

Q: So it is ready now for OEMS to use.

PR: We are not developing hardware so (???).

Speaker: Jonathan Foley

Q: If I take the fourth view (???)

JF: It is cleaning up.

Q: The 90 degree projection looks great. But you are saying your system doesn't give you the 90 degree projection?

JF: You can do the 90 degree projection (???)

Q: So you are seeing the same thing in two angles?

JF: Yes.

Q: What's your ultimate career goal? PhD? Industry?

JF: I would like to go into industry.

Q: So (???)

JF: This is just a masked version of this version.

Q: So you take a projection and remove things that are in the path so you can view it better?

JF: Yes.

Q: So you are doing peeling?

C: It is 2D with many angles.

Q: Can you apply conventional peeling?

Q: What is conventional peeling?

C: What (???) did.

Speaker: Yuxiang Xing

Q: What (???) do you use?

YX: 3 and 6 megavolt.

Q: Aren't all of these methods only a function of an assumption you make?

YX: Yes but this one is simple, and you can do a more complicated one. If you have the container, you are likely to have the box. Is this homogeneous cargo vs heterogeneous cargo?

Q: I am not familiar with this, are you assuming that the material is homogenous material?

YX: Not the thickness.

Q: If you only have two materials, you have to be exact, but I just want to understand.

YX: We are making assumptions that as you peel off (???), but after the peeling you can still get compartment.

Q: So it's like peeling an onion?

YX: It's dependent on the size of the part. If it's small, you can use that information.

Q: You said that the beam hardening is corrective?

YX: It's just overlapping. We used (???).

Q: Can this be combined with multi-view?

YX: The multi-view and multilayer is different than this problem. It's not enough for reconstruction.

Speaker: David Castañón

Q: Did the noise level go up?

DC: We had to replace the diffraction modules, then what about the secondary scatter modules? I am not going to tell you that the noise level didn't go up by a certain level.

Q: Once it's in the row, that's the beam hardening?

DC: The bottom row is where we apply some approximations.

Q: What kind of pattern did you use for coded apertures?

DC: "X"s and "Y"s, checkered.

Q: Can you come up with an estimate of the scan time? And how much time do you need to acquire the data?

DC: I didn't use a specific source. But I thought we could cut the time by a factor of 15. We could collect a signal of the same quality. The point is that our analysis was based on how much we can increase the signal strength. It went up by 100.

Q: If you were going to build and instrument, do you use the source and place the detector so that once you have a reconstructed image where you have an idea of where the beam hardening is, and then set your detector for the appropriate scatter?

DC: Their system has a front end system that is used in many areas. We were trying to figure out if this could be the primary system.

C: Morpho has a next generation design.

DC: That's the one I put in my slide.

C: It's looking good.

DC: I was just looking at the principle.

Q: In your opinion, with the coded aperture, is it necessary to have a dual energy CT scan?

DC: (???)

Q: You weren't able to do that through direct reconstruction?

DC: No.

Speaker: David Castañón

Q: What's the relationship between video and passport?

DC: We are friends.

Q: How did you become friends? What does that mean?

DC: We met through ADSA. We followed up the idea with ALERT, and we talked about joint projects we could do.

Q: You're showing the easy 3D. Is an RF the same?

DC: Nominally yes.

Q: What kind of noise did you put in the background?

DC: To get the right type of noise, you have to get the right kind of background level.

Q: Are you accounting for attenuation and what is the power of the source?

DC: Both questions are very tight. We did not model the source outside of the container. So both questions are relevant, but neither can be addressed.

Q: Do you need a dual energy CT scan?

DC: No. I would prefer to take that off line.

C: The attenuation, it's largely linear. It's not a function of material type. The way it operates, it comes with an attenuation map.

Q: So you are able to estimate it?

DC: That's why you don't need the energy map.

Speaker: Tim White

C: I think it might be worth pointing out the non-homogeneity, that certain points have different cargo and commodities moving out.

C: I have one comment on cost. One of the things people kept repeating that it's the total cost of ownership, and it's not the cheapest box that gets you there. And if TSA is driven to buy the cheapest box, it may point to different opportunities.

C: We are told to look at the cost of technologies.

C: I thought I heard that there was a lack of commitment from TSA.

TW: I don't think we can propose the cost of the system, life cycle costs. I think everyone is shifting that way.

C: You can't ignore labor when you are talking about a system.

C: My view of the world is different than what's being discussed. I understood that TSA is not funding this area. That's a marketplace. That sits outside of our previous mode of thinking. If I have to qualify what I ship, my calculus is part of the cost of labor and shipping. That's how I run my business. This doesn't make any sense unless TSA is the purchaser. The other thing that has to be thought of is that risk has to be factored in. There has to be a value proposition. If I can see a way of getting my stuff through the system faster, then it doesn't help my overall value. If I can't find value then I am going to find the cheapest way out possible.

Q: Does any of that point of view come with other components?

TW: Some of it.

Q: I agree, but one thing we are missing, even if there is something that is more expensive, but the government would benefit with a reduction of labor. They can use the labor for other things. It doesn't take into account the full operation.

TW: When you are doing screening for air cargo, that's not the government.

C: I agree with this, but part of the slides I showed the other day with pillars, in the security program. If you buy that because you think that's the cheapest, then you are going to get false alarms. As a business process, it's not necessary to take the cheapest thing out there. They are going to go a cheap route, but it has to fit other frames.

Q: We need to give the stakeholders something in return. We need them to move the technology in a different way. If they would like a dispensation from something, like aerosols, they use a burn look for aerosol. A screening systems something that we can look at and take back.

TW: Does it need to be between all regulators to be decided?

C: It's best not to have the regulators involved. Provided the business stakeholders are happy, then the regulators fall into line.

Q: Who were the risk analysis people?

TW: Sheldon, Davidson, and CREATE.

Q: This risk analysis thing is worth bringing up because it is now very loud. It is probably one of the best successes. I wouldn't be surprised if the success of pre-check goes to air cargo. I think it's going towards facilitation

C: I think it's less costly. If we can recognize reduced risk, we can taking better measurements; time, lower risk, and money for measurement. I think it can be negotiated in this space. Just like we go through the airport more quickly, we can make the cargo go more quickly. I think having freight forwarders is all about speed. It tells us what we need to do.

C: I don't agree with the last bullet. I think that the scenarios that were looked at had the human behavior, rather than automate object screening. How do you minimize the impact of an attack? I think it was interesting intellectually. But I am not sure it was relevant.

Q: What did they say that was wrong?

TW: 100% check bags is a waste of time.

C: You can't screen people the same. The number of people who fly doubles.

C: Risk based screening says that you have to live in a place that there isn't a lot of risk, and make judgments on the basis of that.

C: He said clearly that we live in a low risk place. The actual chance is small, not that it wouldn't be bad.

C: I am reminded by the decision to go by AT vs CT. They said AT was good enough. There is better technology for that. It killed CT. And I look at these here. What's good enough?

C: The problem is a different problem because it's cost.

C: I think there was more discussion at ADSA10, not directly, but more of that this is a hard problem, and here are technologies that might solve it.

C: This may still be relevant. What you might want to do is keep all your machines in case you need to turn them up someday. (???)

C: I think if we're going to start tracking risk analysis, you're going to have to start including false alarms as well.

Q: Anything else? Nothing. You're just going to let Carl's comment lie?

C: The way I understood the discussion is that what's going to drive discussion. (???) It's either going to be costs or a regulatory drive that increases performance.

C: Right.

C: PFA is a subset of costs. If you can increase speed without reducing detection, that's a gain. There are different types of tradeoffs you can make.

C: (???) Dropping PD is (???)

Q: (???) Those methods are new. They're things that TSA is still learning how to do. The information based (???) the cargo they do some of that as well. How good are those methods that help you draw down PFA?

C: TSA has a PFA in the (???) process. (???)

C: I thought for C-ray imaging, it was based on that test piece. There's a requirement on the test plan. It's not the detection of threats; it's detection based on the phantom. Is that what you're referring to for the X-ray system?

Q: Are there any other pet technologies that didn't make it into the discussion?

TW: I was thinking (???)

Q: The other thing we didn't talk about is how we get the signal in and out. We touched on that a little bit today. (???)

TW: Another big issue for trace is whether or not you open the pallet cargo when you do your screening. In Europe they do that, but in the U.S. we usually don't do that.

C: I meant to mention that on the regulation page. They are very similar.

TW: The area we haven't talked about is (???). We are focusing on individual pieces of the technology without looking at the whole process. (???)

C: Right. I suppose that's another difference between this and the EDS (???) case.

Q: Have you ever had participation from someone on the known shipper list?

TW: A known shipper is anyone with a relationship with the air carrier.

TW: Oh, I know that, but (???)

TW: You mean a certified shipper.

TW: I think that Richard F (???) was the first and he gave us insight that we previously did not have.

Q: Is this a problem that can be solved with these technologies [referring to slides] and if not, do we kick air cargo off the bus and go onto something else?

Q: I'm asking the question, is my hammer the right one? If the answer is no, I'm comfortable with that. There has to be a way to solve the problem. I agree with that completely. But is my hammer the right one to use?

TW: (???) It's not the enemy. So it does actually a great job. (???) If you have a small percentage on cargo and then you go on to a high level of screening you have (???).

TW: The TSA does not only need the hammer, they have the whole toolbox. Are we using the tools we have in the most efficient way right now? The second one is how do I improve my hammer? There's two things we can do. One is to concentrate on what is the future? And the other is am I using the technology I have in the most effective way? The hammer may be as good as it needs to be and I may not need to do anything more.

TW: We need to have more dialogue with the end users, the people that are using the equipment. The program that we are using right now is (???).

TW: I agree with that. We need tools in the tool box. We have a qualified technology list with a number of approved technologies. Increase the number of BPPs, lower the cost of EDSs, we do need to have tools in the tool box in case something does happen and continue with the what-if scenarios. (???) I would hate to say that everyone is sailing at 100% with the tools they have. We need to continue to improve upon them.

Q: We're describing the problem in broad terms, but another approach is to establish (???). What's the scenario we can create?

C: The scale of cargo screening is much broader than baggage screening. (???) It's very intriguing.

C: So TSA now has some analytic tools to look at the tradeoffs in detection and (???) and so forth; to precisely lay out some requirements for these technologies. Maybe what the sub group ought to do is take a sample of ten operations and see how fast they need to be to make some profits and see (???).

C: That falls within the ops modeling (???).

C: It's being applied to passenger screening and (???).

C: It just need to be focused more on (???).

C: You've got to start somewhere.

Q: Do you have any other ideas? Can we flip the business model over? You need 40 data points to trace these bags. Could they use these ideas as a security measure? Can you flip some of these requirements that we're forced to have around and use them for security purposes?

Q: So one more comment then a slide. There were 170 people here. What do you got?

C: The (???) show last week. There were a lot of people from air cargo talking about this. Data is a big issue for this and understanding the data is a big issue. (???) They are trying to inform this. It would be a good idea to link the security needs with the air cargo (???) business needs.

Closing Remarks

MBS: I want to thank Carl. Can we give a hand to Carl? I want to thank the dedicated staff that put in long hours and make this seem seamless. I am blown away by the power of what we have created. We have 170 brilliant people in the room and we have begun to brainstorm a problem that is very difficult to solve and I don't want to lose that momentum. I got a lot out of this meeting and thought it was very thought provoking. Thanks to all of you for committing, coming, and staying. Can I have a hand for all of us?

LP: Thank you from the perspective of the DHS funder for the Center. Thank you for attending. Tomorrow we will be here for Task Order 4. As usual, we have more questions than we have answers. Hopefully, we can use some of the momentum for that.

16. Appendix: Questions for Speakers

The speakers were asked to address the questions noted in this appendix in their presentations.

16.1 Advanced Algorithms

1. What is the potential impact on probability of detection (PD) and probability of false alarm (PFA)?
2. What will it take to transition your algorithm to a fielded product?
3. What additional research is required to mature your algorithm?
4. How does the algorithm's performance change with the following scenarios:
    a. Type of threats?
    b. Location of screening (shipper, freight forwarder, airport, tarmac)?
    c. Type of cargo (produce, automobile parts, mail, etc.)?
    d. Containers (break bulk, palletized, containerized)?
5. Are there any disadvantages with your algorithm?

16.2 Buying Down Risk

1. With respect to risk:
    a. Whose risk should be considered?
    b. Which stakeholders are at risk?
    c. How to address perceived risk?
2. With respect to "buying down":
    a. Who will pay for this buy down?
    b. Do the stakeholders need to be forced to buy down risk?
    c. How does *a priori* risk (perception and real) affect willingness to "buy down" risk and how much is willing to be spent for how much reduction?
3. Other questions
    a. Is improved security a competitive advantage?
    b. What is the impact of the TSA (government) not doing the screening of air cargo itself?

c. Is there a benefit to having technology more expensive than trace on the QPL (or, will stakeholders always choose the least expensive technology)?
d. What will happen if there is an event due to explosives in air cargo?
e. Is it difficult to understand risk from the framework of Bayesian probability because the probability of any single piece of air cargo containing a threat is very low but the cost of an event is very large? I've seen literature suggesting that these two numbers are on the order of 10^{-9} threats/piece and 10^{12} USD/event, respectively.
f. Vendors don't live in a Monte Carlo simulation. If they increase costs and go out of business, the theoretical calculations of risk reduction are academic and moot (from their perspective). Is there an impetus for "collective action" on the part of industry to "force themselves" to all buy down risk, ensuring the playing field is level? (Of course, this is over-simplified as in a complex economy, there are other ways to do same thing. The economy could shift to other shipping methods or less shipping etc., but those are presumably second order compared to competition within the air cargo industry.)

16.3 Freight Forwarders

1. With respect to risk:
    a. Whose risk should be considered?
    b. Which stakeholders are at risk?
    c. How to address perceived risk?
2. Is improved security a competitive advantage?
3. What is the impact of the TSA (government) not doing the screening of air cargo itself?
4. Is there a benefit to having technology more expensive than trace on the QPL (or, will stakeholders always choose the least expensive technology)?
5. What will happen if there is an event due to explosives in air cargo?

16.4 Risk-Based Screening

1. How did you get involved with risk-based screening (RBS) and deterrence?
2. What are the financial benefits of RBS?
3. What is your definition of RBS?

4. How is risk measured?
5. How can RBS be applied to increase the perception that detection equipment and procedures have better performance than they really have?
6. How does randomization of performance and procedures affect perception of performance?
7. Will increased perception of performance just displace threats to different venues?
8. How can perception of performance be measured and quantified?
9. Is there literature on RBS that can be applied to aviation security?
10. Are there situations where security has to be increased instead of decreased? For example, is it useful to go overboard with low-risk groups periodically?
11. How do the TSA's trusted traveler and trusted shipper programs factor into RBS?
12. What, if any, is the connection between RBS and deterrence?
13. With respect to deterrence:
    a. How can deterrence be applied to increase the perception that detection equipment and procedures have better performance than they really have?
    b. How does randomization of performance and procedures affect perception of performance?
    c. Will increased perception of performance just displace threats to different venues?
    d. How can perception of performance be measured and quantified?
    e. Is there literature on deterrence that can be applied to aviation security?
14. How should layered approaches be designed and what is their effectiveness?

16.5 Canine

1. Why are dogs good for explosive detection?
2. What are their strengths and weaknesses?
3. What does it cost to train and operate a dog?
4. How are dogs trained?
5. What is their useful professional life?

6. How many people does it take to operate a dog?
7. What are the procedures (concepts of operation) when applying dogs?
8. Can dogs be emulated with technology?
9. Are there limitations based on the following:
    a. Type of threats?
    b. Location of screening (shipper, freight forwarder, airport, tarmac)?
    c. Type of cargo (produce, automobile parts, mail, etc.)?
    d. Containers (break bulk, palletized, containerized)?
10. How is quality assurance performed in the field?
11. With respect to secondary inspection:
    a. What methods are used?
    b. How long does it take?
12. What improvements are coming in the future with dogs?

16.6 Financial Models

1. What are the estimated costs for the following:
    a. Installing a cargo handling system?
    b. Inspecting (primary and secondary) a piece of cargo?
    c. Breaking down cargo for secondary inspection?
2. How does the cost model change based on the following topics:
    a. Type of threats?
    b. Location of screening (shipper, freight forwarder, airport, tarmac)?
    c. Type of cargo (produce, automobile parts, mail, etc.)?
    d. Containers (break bulk, palletized, containerized)?
3. Who pays for the risk of damaging freight while it is being inspected?
4. Do any of the stakeholders have indemnity or insurance?

16.7 Game Theory

1. What is game theory (GT)?
2. What is CREATE's mission?
3. With respect to the application of GT to aviation security:
    a. How can GT be applied to increase the perception that detection

equipment and procedures have better performance than they really have?

   b. How does randomization of performance and procedures affect perception of performance?
   c. Will increased perception of performance just displace threats to different venues?
   d. How can perception of performance be measured and quantified?
   e. Is there literature on GT that can be applied to aviation security?

16.8 Trace and Vapor

1. How much does it cost to purchase and operate the equipment?
2. What are the procedures (concept of operations) used with the equipment?
3. How long does it take to screen?
4. What are the limitations on obtaining good samples?
5. What is the effect of dirty environments?
6. Are there limitations based on the following:
   a. Type of threats?
   b. Location of screening (shipper, freight forwarder, airport, tarmac)?
   c. Type of cargo (produce, automobile parts, mail, etc.)?
   d. Containers (break bulk, palletized, containerized)?
7. How is quality assurance performed in the field?
8. With respect to secondary inspection:
   a. What methods are used?
   b. How long does it take?
9. Why is trace/vapor the most commonly used method to screen aviation cargo?
10. What improvements are required?
11. How can non-classified problems be created for the academic community?

16.9 Missing Technologies

1. What promising technologies were missed (not discussed) at the combination of ADSA10 and ADSA11?

2. Why bother developing new technology when trace (ETD) is already on the QPL?
3. How can fusion be applied?
4. What should be done differently for each of the following scenarios:
    a. Type of threats?
    b. Location of screening (shipper, freight forwarder, airport, tarmac)?
    c. Type of cargo (produce, automobile parts, mail, etc.)?
    d. Containers (break bulk, palletized, containerized)?
5. What role should deterrence and risk play in the design and operation of equipment and protocols (e.g., trusted shipper)?

17. Appendix: Presentations

This section contains the slides presented by speakers at the workshop. The slides appear in the order that talks were given as shown on the agenda. Some of the presentation slides have been redacted to ensure their suitability for public distribution.

PDF versions of selected presentations can be found at the following link: https://myfiles.neu.edu/groups/ALERT/strategic_studies/ADSA11_Presentations/.

17.1 Carl Crawford: Workshop Objectives

Eleventh *Advanced* Development for Security Applications Workshop (ADSA11):

Explosives Detection in Air Cargo – Part II

Workshop Objectives

Carl R. Crawford
Csuptwo, LLC

1

So What? Who Cares?

- Known:
  - Airlines favorite target of terrorists and they have put IEDs in cargo
  - Known shipper and equipment [mainly trace] on qualified product list (QPL) satisfies US congressional legislation to mandate the screening of all commercial air cargo
- Problem: Detecting explosives in cargo very difficult problem in part because of:
  - Size/penetration
    - Neutrons moderated by hydrogen
    - X-rays moderated by large path lengths, high Z material or do not create contrast
    - Sampling for particle and vapor
  - Concept of operations
  - Resolution of false alarms
  - Screening/scanning not done by TSA
  - Costs
- Solution: Assemble very bright people and allow scientific method to develop improved methods for detecting explosives and concepts of operations in air cargo
- Successful workshop: People here working on the problem with DHS, TSA, vendors

2

Rule #1 – Open Discussions

- This is a workshop, not conference
- Conversation and questions expected at all times, especially during presentations
- Moderator responsible for keeping discussions focused and initiating discussion
  - Will *try* to allow speakers to complete their introduction

3

Rule #2 – Speaker Instructions

- 2^{nd} slide has to be "so what who cares"
  - State how technology will improve explosive detection
  - Optimum presentation: stop at 2^{nd} slide
- Don't get trapped into developing the whole story before giving the bottom line.

4

Rule #3 – Public Domain

- Do not present classified, SSI, FOUO or proprietary material
- Presentations, minutes and proceedings will be placed in the public domain
  - After review for SSI and classified material

5

So What? Who Cares?

- Known:
  - Airlines favorite target of terrorists and they have put IEDs in cargo
  - Known shipper and equipment [mainly trace] on qualified product list (QPL) satisfies US congressional legislation to mandate the screening of all commercial air cargo
- Problem: Detecting explosives in cargo very difficult problem in part because of:
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  - Concept of operations
  - Resolution of false alarms
  - Screening/scanning not done by TSA
  - Costs
- Solution: Assemble very bright people and allow scientific method to develop improved methods for detecting explosives and concepts of operations in air cargo
- Successful workshop: People here working on the problem with DHS, TSA, vendors

6

ADSA10 Findings (I)

- There are advantages and disadvantages with all the deployed and the potential future technologies, especially in light of the following considerations.
  - Type of containment: break-bulk, palletized, containerized
  - Type of cargo: hydrogenous, highly attenuating, heterogeneous
  - Location of screening: off-site or at airport
  - Total cost of ownership: equipment, labor
  - Concept of operation: throughput, alarm resolution
  - Type of explosive: mass, thickness, density, elemental composition

7

ADSA10 Findings (II)

- QPL includes trace, CT EDS, 2D projection
  - Trace mainly used because of cost
- Many promising technologies were discussed including high-energy x-rays, neutrons, nuclear resonance fluorescence, risk-based screening, sparse view sampling and interior tomography.
- However, many may not be suitable for deployment as stand-alone devices.
- Instead, these technologies may be more suitable for fusing with other technologies.

8

ADSA10 Findings (III)

- The next ADSA should continue to address air cargo inspection. The topics that should be discussed include the following topics as applied to cargo inspection:
  - Concept of operation
  - Cost of ownership
  - Financial considerations – externality
    - "an externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit"
  - Canine inspection
  - Particle and vapor inspection including sampling
  - More viewpoints of the following stakeholders: airlines, freight forwarders, insurers and US governments and ROW
  - Differences between screening and scanning
  - Risk-based screening and scanning

9

Points to Consider

- Screening includes known shipper
- "There are advantages and disadvantages with all the deployed and the potential future technologies"
  - Cannot discuss here
- Externality
  - Shippers may not know detection specs
  - Purchase cheapest equipment – trace
- How to get "better" equipment developed and deployed?
- Assume for this workshop that TSA's needs may change in the future, especially if there is an event.

10

DHS Tactics

- Augment abilities of vendors with 3rd parties
  - Academia
  - National labs
  - Industry other than the vendors
- Create centers of excellence (COE) at universities
- Hold workshops to educate 3rd parties and discuss issues with involvement of 3rd parties
  - Algorithm Development for Security Applications (ADSA)
- Forage for technology in other fields

11

Equipment Requirements

- Probability of detection (PD)
- Probability of false alarm (PFA)
- FA resolution
- # types of threats
- Minimum mass
- Minimum sheet thickness
- Total cost of ownership
  - Purchase price
  - Siting
  - Labor
  - Maintenance
- Extensibility
- Ability to fuse
- Compatible with risk-based screening
- False alarm resolution methodologies
- Siting
- HVAC, space, weight shielding
- Throughput
- Safety

12

Questionnaire

- Request for everyone to answer questions preferably during the workshop
- ~10 questions – 10 minutes
- Available via Survey Monkey

https://www.surveymonkey.com/s/ADSA11

SurveyMonkey.com
because knowledge is everything

13

Minutes

- Minutes will be taken of discussion
  - Sensitive information to be redacted
- Please identify yourself and institution first time you speak

14

Acknowledgements

- Northeastern University (NEU)
- Awareness and Localization of Explosives-Related Threats (ALERT) DHS Center of Excellence
- Department of Homeland Security (DHS)
- Presenters
- Participants

15

Acknowledgements

- Speaker selection
  - Harry Martz, LLNL
  - Laura Parker, DHS
  - George Zarur, DHS/TSA (retired)
  - Peter Harris, Yankee Foxtrot
  - Allan Collier, TSA
- Agenda suggestions
  - Doug Pearl, Inzight Consulting

16

Logistics

- Melanie Smith, lead
- Deanna Beirne
- Kristin Hicks
- Teri Incampo
- Anne Magrath

Let them know if you need support during or after workshop.

17

ADSA12 Provisional Topics

- Risk-based screening & gaming theory
  - Hardening, deterrence
- Computer simulations
  - X-ray transmission, back-scatter, diffraction, MMW, neutrons
  - Standardized phantoms
- Improving statistical significance of testing

18

ATR Program Review

- Thursday, November 6th, here
- 5 groups developed automated threat recognition (ATR) algorithms for CT-based EDS
- Detect objects of interest from scans on medical CT scanner
- All data, results and tools in public domain
- Details in your folders
- All are welcome to attend

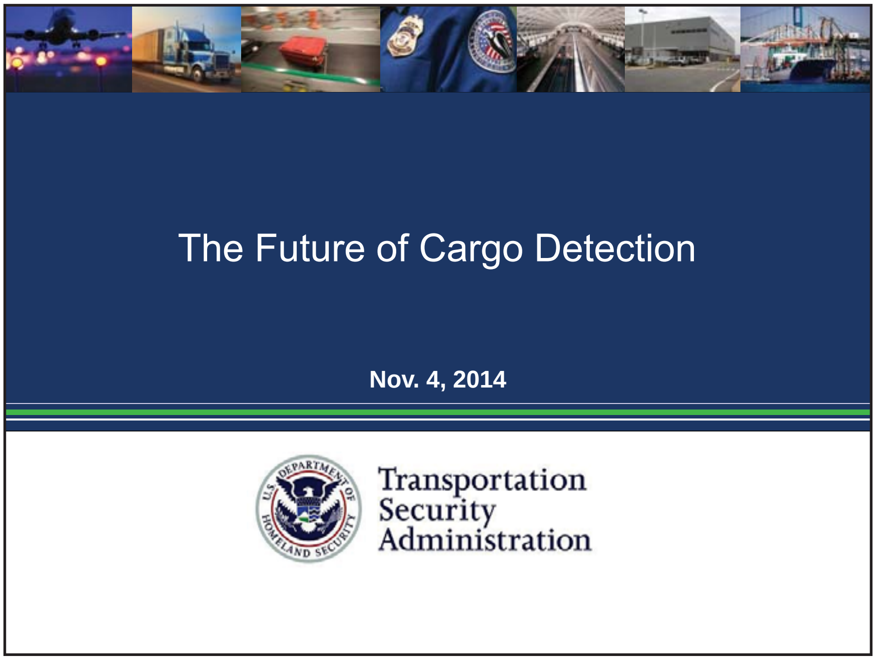
19

Final Remarks

- "Terrorism causes a loss of life and a loss of quality of life," Lisa Dolev, Qylur
- Need improved technology
- Thank you for participating

20

17.2 Frank Cartwright: The Future of Cargo Detection



Improvised Threats

We face an intelligent and adaptive adversary

- Improvised explosives/HMEs
  - Liquids, powders
  - Broader signature space (broader properties)
- Changing nature of concealments
  - Non/low-metallic IEDs

Transportation Security Administration

Slide 3

Mission Analysis Division

- The forward reaching arm of OSC...
- Bridging developmental concepts to deployable capability
- Coordinating technical maturity with acquisition cycles
- Aligning technologies with operational needs
- Aligning emerging threats with emerging capabilities

Transportation Security Administration

Slide 4

Capability Investment

Mitigation Approach:

- ***Core Capabilities*** - incremental improvements to existing capabilities.
- ***Adjacent Capabilities*** - innovation that draws upon existing capabilities.
- ***Transformational Capabilities*** - capabilities that will see innovation.

Slide 5

Transportation Security Administration

BAA Process Update

New BAA Process:

- Includes both "Open & Targeted" BAAs
- 5 pg Concept Papers
- Oral Presentation
- 6 mth Cycle time (up to award)

Slide 6

Transportation Security Administration

Emerging Technologies

Next Generation Technologies:

- Reduce system costs to make high quality imaging systems more affordable
- Develop capability to more effectively screen complex objects (e.g. heterogenous pallets)
- Other possible area:
  - *ATR, CGUI, System Integration*

Slide 7

Transportation
Security
Administration

17.3 Paul Redfern: UK Department of Transport Science and Technology Cargo Screening Programme

Department for Transport

UK Department for Transport Science and Technology

Cargo Screening Programme

Paul Redfern
UK DfT Research Analysis and Development Team

Department for Transport

Known Consignors

- Come in all shapes and sizes

Can be:

- Manufacturer
- Distributor
- Must originate the cargo
- Must control access to it once it is identifiable as air cargo
- Must Train and background check staff who have access to the cargo once it is identifiable as air cargo

Department for Transport

Regulated agent

- Screens cargo
- The only entity to declare cargo as secure
- Maintains security of cargo
- Completes a cargo security Declaration (CSD)

Department for Transport

Approved Methods of screening

Method of screening must be appropriate

- The "*means or method most likely to detect prohibited articles*" must be used when screening the cargo.
- The "*means or method employed shall be of a standard sufficient to reasonably ensure that no prohibited articles are concealed in the consignment*".

EU Cargo Screening options

- Dual View X-ray
- Explosive Detection Systems (EDS)
- Hand Search and Visual Inspection
- Metal Detection Equipment (MDE)
- Explosive Trace Detection (ETD)
- Remote Explosive Scent Tracing (REST)
- Free Running Explosive Detection Dogs (FREDD)

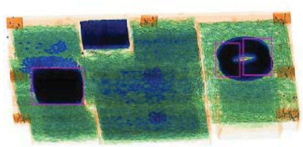
Dual view X ray

- No automated detection in use
- EU image quality test piece daily check is the only acceptance method
- No type testing of Standard X-ray equipment
- UK has required all new installations of cargo X-ray to be dual view since Sept 2011
- All cargo X-ray in the UK will be dual view by 1st Jan 2015
- Non-compliance screening mostly due to dense items

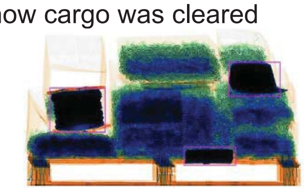
Department for Transport

DARC Alarm

- Dense Area Recognition Capability
- Indicates large areas of cargo that do not contain enough information to make a screening decision
- Software is present on most vendors machines but thresholds have not been mandated by regulators
- Process to calibrate thresholds across machine types
- To include an Audit Trail to record how cargo was cleared



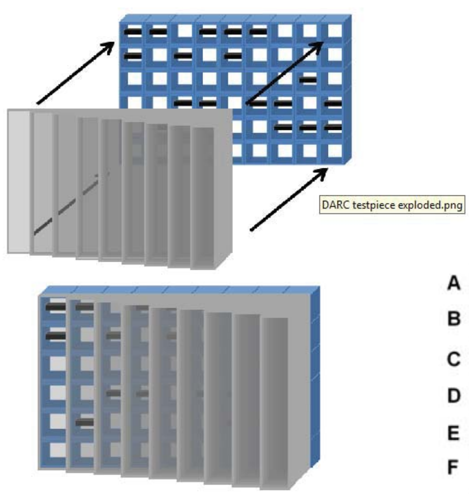
TOP VIEW

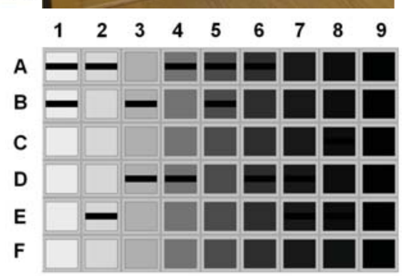


SIDE VIEW

Department for Transport

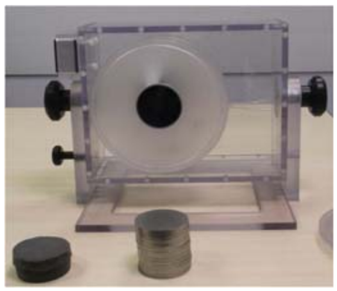
DARC Alarm grey scale test piece





Department for Transport

DARC Alarm area test piece



To determine if the area setting of the non penetration alarm is set correctly

Department for Transport

Explosive Detection Systems EDS

ECAC • CEAC

- More than 70 EDS configurations tested from 6 manufacturers under the ECAC common evaluation process
- 44 EDS configurations are listed on the ECAC website
  - 36 – Standard 3
  - 8 – Standard 2
- Standard 1 for EDS expired on 1 Sept 2012
- Standard 2 for EDS expires on 1 Sept 2018 in the UK

Department for Transport

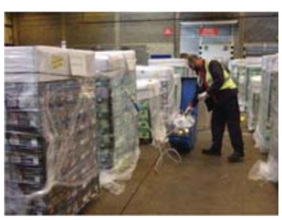
ETD approvals

- EU Regulation requires swabbing of the outside, inside and contents of the consignment.
- Too slow for the majority of consignments so used for resolution of difficult to screen cargo

- From June 2014 to date (October 2014):
  - Endorsement of the Common Testing Methodology (CTM) for ETD on 18 April 2014
  - 4 ETD systems tested and 14 tests are currently ongoing
  - 2 ETD configurations listed on the ECAC website
  - Only 1 approved configuration for cargo

Department for Transport

Remote Explosive Scent Tracing REST



- Cargo Consignment wrapped in plastic
- Vapour left to soak for a minimum of 2 hours
- Vapour is pumped through a filter
- Filter is presented to a dog for screening

Cargo Screening Using Canines - REST

Department for Transport

- Following operational compliance trials jointly conducted with DHS in 2014, all the accreditations for operational REST dogs were revoked
- UK currently has no private REST dogs that meet our requirements, but we are open to work with any companies who apply
- Operational REST operations are still ongoing in other European member states following successful trials
- Dog providers *methods* in UK are not regulated
  - Dogs are required to meet the accreditation test and ongoing QA requirement
  - Can only provide guidance on the methods for training

Free-Running Explosive Detection Dogs (FREDD)

Department for Transport

- Provide a mobile targeted area search capability
- Directly search cargo consignments
- Dogs indicate exact position of threat item
- Developing certification and deployment protocols for a UK capability based on robust scientific trial data
- Steering European common standards
  - European Civil Aviation Conference (ECAC)

Department for Transport

Cargo Screening Using Canines - FREDD

- Currently finalising accreditation and quality assurance procedures
  - Operational deployment expected early 2015
- Benefits
  - Real time screening
  - Portable system
  - Less infrastructure and staff than REST
  - Quick to imprint dogs on new odours
  - Less intrusive than hand search
  - Properly trained and maintained dogs have demonstrated a high detection and low false alarm rate during UK trials in 2012 - 2014
- Challenges
  - Screening odour which has permeated out of cargo
  - Screening items bigger than 1 x 1 x 1.3m is time consuming
  - Dogs working in the “cargo” environment
  - Quality assurance testing is difficult and can’t be blind due to numbers

UK method will require air holes to be apparent or drilled to allow permeation of vapour

Department for Transport

Cargo Metal Detection Equipment

- EU Standard for Cargo Metal Detection CMD
- Testing currently conducted to a national methodology
- ECAC test method in draft
- There are currently no operational deployments in the UK
- Aspiration to make more use of CMD for niche applications or first level filtering of all cargo

Department for Transport

Electronics detection

- Most currently approved techniques concentrate on detection of the main explosive charge material
- Ongoing UK project to determine if additional capability can be added by focusing on the means of initiation
- Currently not accepted as an EU screening technique
- Investigating the use of:
  - Radar techniques
  - Passive RF techniques
  - Non Linear Junction detection
  - Passive RF detection

As an addition to current screening or to aid facilitation of clearing suspect consignments

17.4 Allan Collier: TSA Air Cargo Screening

TSA Air Cargo Screening

ALERT ADSA11
Cargo Inspection Workshop
4 November 2014

1

TSA Air Cargo Screening

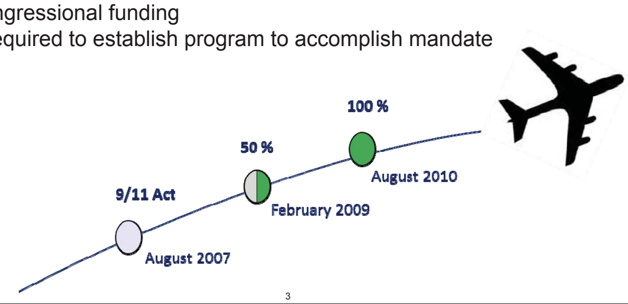
What benefit could TSA obtain from this workshop?

- Prevent or deter a terrorist attack
- Do not impede commerce
- Provide industry with variety of technologies
- Address challenges
- Facilitate Regulatory/Compliance
- Collaboration/Open dialog
- Expand the Marketplace
- Good Ideas

2

Law – 100% Screening Legislation

- The Implementing Recommendations of the 9/11 Commission Act of 2007 were signed into law on August 3, 2007
- The law required 100% screened for domestic flights by August 3, 2010 at the piece level
- Further guidance required 100% screened for international inbound flights to the United States by December 3, 2012
- Prevent or deter the carriage of any unauthorized persons, and any unauthorized explosives, incendiaries, and other destructive substances or items in cargo onboard an aircraft.
- Commensurate with baggage (piece level)
- No Congressional funding
- TSA required to establish program to accomplish mandate



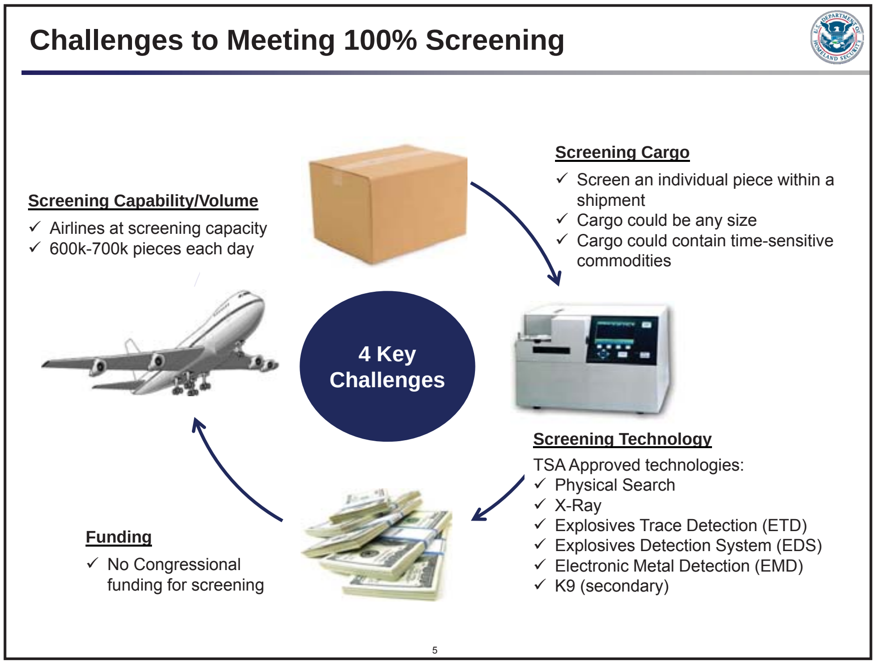
3

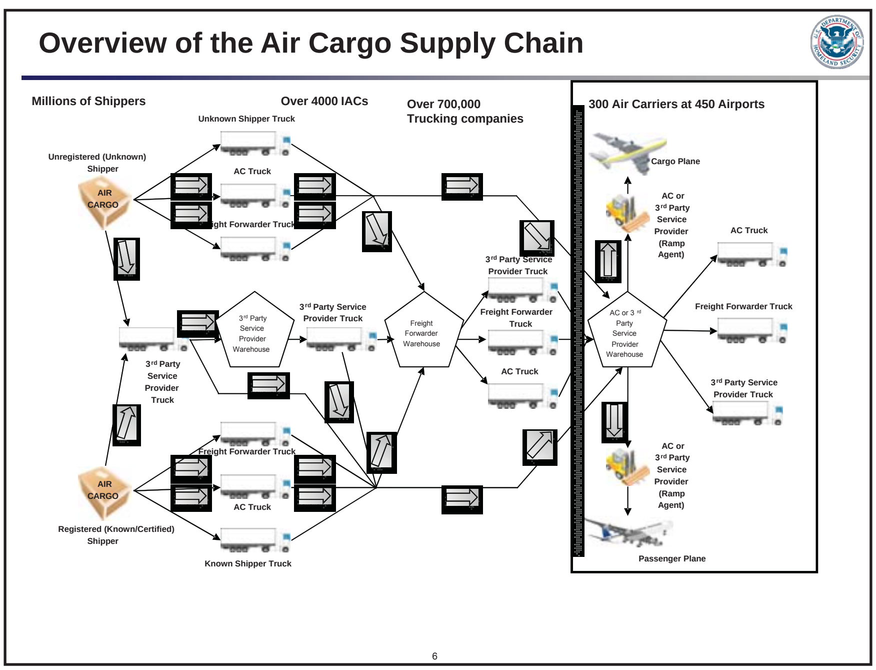
Definitions and Sources

- “Piece” The number of pieces generally is determined by the number of pieces identified by the documentation such as the airway bill
- “Screening” as defined in the 9/11 Act, Section 1602:

  A physical examination or non-intrusive methods of assessing whether cargo poses a threat to transportation security.
- “Commensurate” The level of security to be provided for the system for screening cargo must correspond to the level of security for screened checked baggage.

4


Challenges to Meeting 100% Screening
Screening Capability/Volume
✓ Airlines at screening capacity
✓ 600k-700k pieces each day
Screening Cargo
✓ Screen an individual piece within a shipment
✓ Cargo could be any size
✓ Cargo could contain time-sensitive commodities
4 Key Challenges
Screening Technology
TSA Approved technologies:
✓ Physical Search
✓ X-Ray
✓ Explosives Trace Detection (ETD)
✓ Explosives Detection System (EDS)
✓ Electronic Metal Detection (EMD)
✓ K9 (secondary)
Funding
✓ No Congressional funding for screening
5


Overview of the Air Cargo Supply Chain
Millions of Shippers
Over 4000 IACs
Over 700,000 Trucking companies
300 Air Carriers at 450 Airports
Unknown Shipper Truck
Unregistered (Unknown) Shipper
AIR CARGO
AC Truck
Freight Forwarder Truck
3rd Party Service Provider Truck
3rd Party Service Provider Warehouse
Freight Forwarder Warehouse
Freight Forwarder Truck
AC Truck
Registered (Known/Certified) Shipper
Known Shipper Truck
Cargo Plane
AC or 3rd Party Service Provider (Ramp Agent)
AC or 3rd Party Service Provider Warehouse
Passenger Plane
6

TSA Domestic Approach for 100% Screening

- TSA established the Certified Cargo Screening Program (CCSP)

CCSP

- Enables all entities in the supply chain who meet stringent security standards to screen cargo
- Businesses may choose the best and most effective screening model for their needs
- Supported and implemented by industry
- Leverages best practices from global supply chain security programs

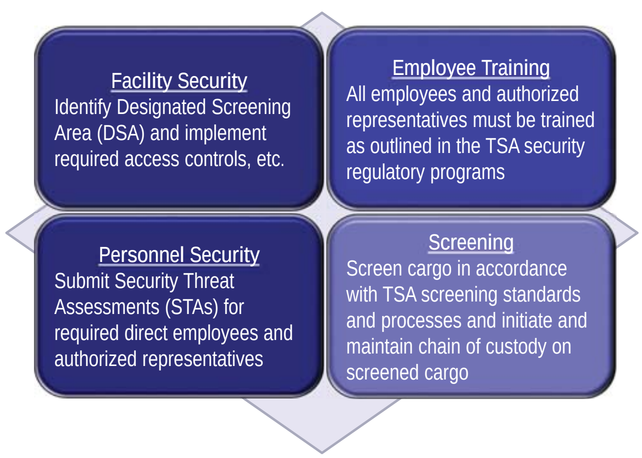
Approach Includes:

- Standard Security Program updates
- Compliance Inspections/Audits
- TSA Proprietary Canine Teams
- Risk-Based Strategies

7

Facility Requirements: 4 Cornerstones of Participation

- Participation is *voluntary*, but requires facilities to adhere to the following requirements:



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Facility Types

Over 2300 CCSP Facilities Across Supply Chain Enrolled

Air Carriers

~1200 sites

IACs

~520 sites

Shippers

~500 sites

Independents (ICSFs)

~80 sites

9

Current Approved Methods of Screening

- The following screening methods are approved for passenger air cargo:
  - Physical Search
  - X-Ray
  - Explosives Trace Detection (ETD)
  - Electronic Metal Detection (EMD)
  - Explosives Detection System (EDS)
  - TSA-Certified Canines
  - CO2 Monitors
- Additionally, Sec. 1602 of the 9/11 Act states, “The Administrator may approve additional methods to ensure that the cargo does not pose a threat to transportation security and to assist in meeting the [screening] requirements…”

- Manifest Verification
- Alarm Resolution
- Shield/Opaque

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Air Cargo Technology Qualification

Strategic Objectives

Near Term	Qualify viable air cargo screening technology that is currently in the marketplace and/or can be quickly modified to support the requirements of the 100% cargo screening mandate.
Medium Term	Evaluate emerging air cargo screening technologies and provide feedback to vendors to enhance products for qualification and the development of refined technology standards.
Long Term	Collaborate through the DHS Capstone IPT with S&T to identify current technology gaps/opportunities and support R&D efforts for future sophisticated air cargo screening technology requirements.

11

Air Cargo Screening Qualification Process

Overview

The Transportation Security Administration (TSA) has initiated Air Cargo Screening Qualification Test (ACSQT) activities to qualify air cargo screening devices. TSA will publicize the devices that successfully pass the qualification process within the TSA Air Cargo Screening Technology List. Regulated parties will reference this document when procuring air cargo screening equipment to meet the 100% screening mandate in Public Law 110-53.

Qualification Groups (QGs)

TSA has identified three categories of unique and mature screening technology for near term qualification.

QG	Description
QG-1	Non-Computed Tomography (Non-CT) Transmission X-ray Devices
QG-2	Explosive Trace Detection (ETD) Devices
QG-3	Electronic Metal Detection (EMD) Devices

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Air Cargo Screening Qualification Process

- Air cargo screening devices will pass through a qualification process
- Devices that successfully pass the qualification process will be publicized within the TSA Air Cargo Qualified Technology List
- Regulated parties will reference this document when procuring air cargo screening equipment (published SSI and non-SSI)

Each screening technology model undergoes an 8-step qualification process

Screening Technology Qualification Process		
1	Submit White Papers	Manufacturers
2	Assess White Papers	TSA
3	Conduct/Participate in Industry Day	TSA / Manufacturers
4	Submit Qualification Data Packets	Manufacturers
5	Assess Qualification Data Packets	TSA
6	Coordinate Logistics / Bailment Agreements	TSA / Manufacturers
7	Conduct Qualification Test	TSA
8	Assess Final Reports	TSA

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ACSQT Redesign Overview

Rolling Submission Process

- Manufacturers may submit white papers for all technology categories throughout the calendar year
- Manufacturers may resubmit devices 90 days from the date of non-approval notification from TSA (formerly, manufacturers would have to wait till a new submission window opened)

TSA issued this Request for Information (RFI) to announce a redesigned Air Cargo Screening Qualification Test (ACSQT) on FedBizOpps.Gov

https://www.fbo.gov/index?s=opportunity&mode=form&id=d94e62f9e1d0d864d3f15d4456026516&tab=core&_cview=0

14

TSA Air Cargo Screening Technology List (ACSTL)

Currently, there are 113 pieces of technology on the list, version 9.1 dated 06/25/2014.

- 83 qualified x-ray
- 3 qualified ETD
- 15 qualified EDS
- 3 approved x-ray
- 7 approved EMD
- 2 CO2 monitors

- Non-SSI version posted on TSA.Gov site

  http://www.tsa.gov/certified-cargo-screening-program

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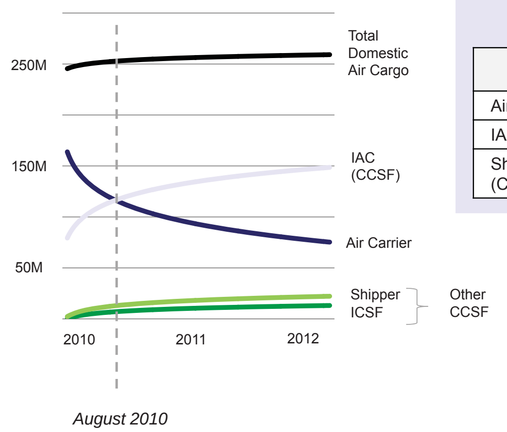
Tonnage Screened



Proportion Screened

	March 2010	July 2012
Air Carrier	66%	34%
IAC (CCSF)	35%	52%
Shipper + ICSF (CCSF)	1%	14%

Key Point:
Today, CCSFs perform 2/3 of domestic screening

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Estimated Tech Count

Equipment Quantities, as of July 2012

Domestic Air Cargo Population			
	CCSF	Air Carrier (a)	Total
ETD	493	482	**975**
X-Ray	155	110	**265**
EMD	10	1	**11**
EDS	2	2	**4**
Total	**660**	**595**	**1,255**

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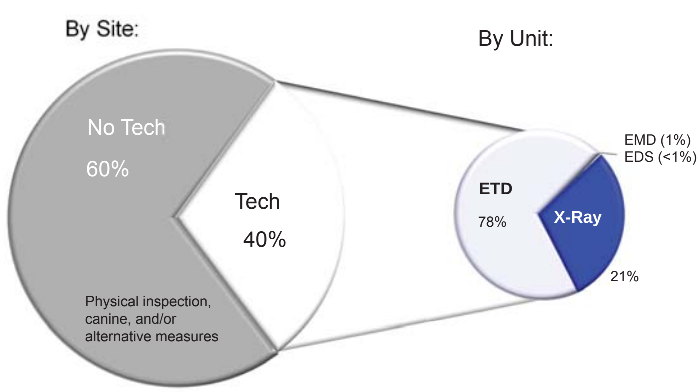
Technology Usage



Total No. of active domestic screening sites: ~2,300
Total No. of Sites using Technology: ~700

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Commodities pose significant screening challenges

Supply Chain Challenges	Screening Challenges
• Requires cold chain handling • FDA sealed	• X-Ray may affect shipments • Compromised package integrity
• Requires cold chain handling • Perishable/limited shelf life • USDA/APHIS requirements	• Too dense for X-Ray • Risk of physical search bruising • Difficult for ETD (wet)
• Sealed drums • Possibly toxic if opened • Liquids/powders	• Too dense for X-Ray • No alarm resolution for ETD • Inability to physically screen
• Compromised package integrity • High value security	• Static discharge • Risk of physical search damage
• Sanctity of the remains	• Inability to physically screen
• Varying sizes • Sophisticated packaging • High value	• X-Ray sensitivity • Inability to physically screen

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International Inbound

- TSA has adopted a two-fold approach to implementing 100% screening for international inbound cargo:
  - Increase screening requirements in the airline Standard Security Programs (SSPs)
  - Recognize commensurate foreign air cargo security programs thru the National Cargo Security Program (NCSP) to enable air carriers flying directly into the U.S. to follow only the national cargo security program
- TSA is developing a risk-based strategy based on identifying high-risk cargo for enhanced screening measures
  - Air Cargo Advance Screening (ACAS) pilot is a joint effort between TSA and CBP to test and implement baseline threshold targeting in the pre-departure air cargo environment
  - Applying knowledge gained from on-going risk assessment and mitigation efforts in domestic air cargo

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Additional Information

- Funding vehicles
  - BAA - Broad Agency Announcement
  - RFI - Request for Information
  - ITRP - Innovative Technology Review Process
    - https://www.fbo.gov/
  - SBIR - The Small Business Innovation Research
    - http://www.sbir.gov/about/about-sbir
  - CRADA - Cooperative Research and Development Agreement
    - http://www.dhs.gov/technology-transfer-mechanisms

- ATR
- Screening Times
- Hardening
- Simulants

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TSA Air Cargo Screening

Questions?

Allan Collier

Allan.Collier@dhs.gov
571-227-1344

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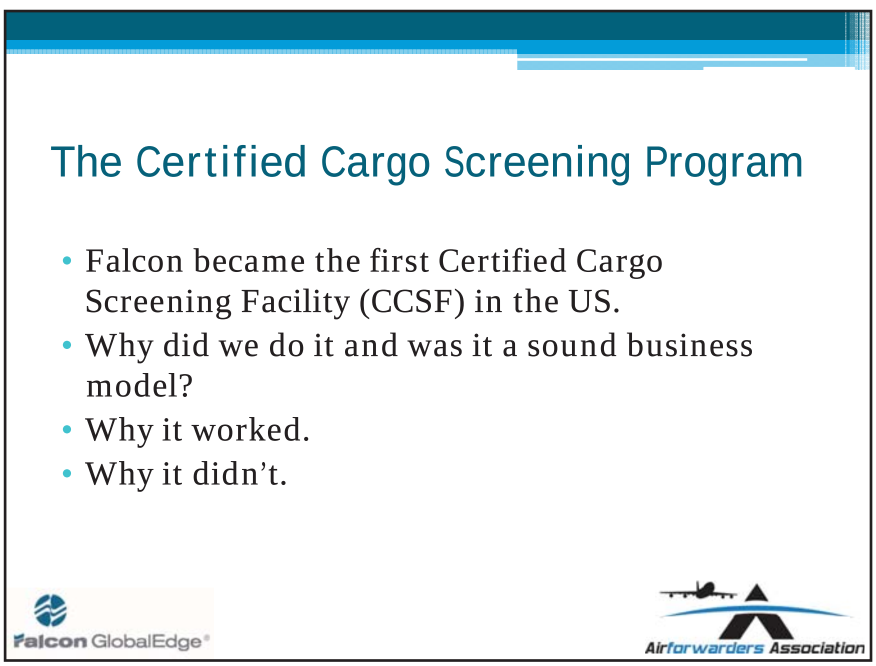
17.5 Richard Fisher: The Background of Screening and Current Perspectives



TSA

- What If TSA performed air cargo screening?
- Pros and cons.

Falcon GlobalEdge
Airforwarders Association

Operational screening realities

- Sunsetting on approved equipment.
- Cost of newer/better equipment.
- How clean is your warehouse?
- Logistics & location.

Falcon GlobalEdge
Airforwarders Association

Smart security as competitive advantage

- Customer supply chains becoming more complex.
- The velocity factor in air cargo.
- 100% screening vs. risk based, layered approach.
- ACAS pilot program.
- How good real time data benefits shippers and regulators.

What will happen?

- If there is an event due to explosives in air cargo?
- The Pan Am 103 factor.
- Risk, risk, risk.

17.6 Terri Rose & Todd Combs: Air Cargo Cost Estimating Project (ACCEP)

Air Cargo Cost Estimating Project (ACCEP)

ADSA11 – Explosive Detection in Air Cargo Part 2

4 November 2014
Boston, MA

Terri Rose,
Oak Ridge National Laboratory

Todd Combs,
Argonne National Laboratory

Argonne National Laboratory
Oak Ridge National Laboratory

Acknowledgements

This work was funded and supported by the Department of Homeland Security Transportation Security Administration Office of Security Technology.

Argonne National Laboratory
Oak Ridge National Laboratory

So What, Who Cares?

- Expanded cargo screening data base
  - Building on ACEDPP study, cargo screening cost estimates were determined for an additional top ten passenger cargo operations airports: ATL, DEN, DFW, HNL, IAH, JFK, LAS, LAX, MIA, ORD and top five cargo-only operations: LAX, SJU, BQN, PDX, MIA
- Independently verified and validated EMA
- Cost estimates for implementing screening systems as mandated in 49 U.S.C.§ 44901(g) using 12 ACEDPP cost categories
  - Screening resources for smaller, underutilized operations result in minimal cost increase; 7 of 16 passenger cargo operations would incur increases exceeding 100%
  - Labor costs varied from 65% to 85% of total screening costs
  - Screening resources for all cargo freighter operations are minimal with low unit costs $0.04 to $0.41

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Project Background: Original Tasking from House Report on Appropriations Bill (2006)

- **… conduct three cargo screening pilot programs - one at an all cargo airport and two at top ten passenger cargo airports. These pilots shall test different concepts of operation that TSA designs in coordination with the S&T. Testing shall consist of the following: (1) physically screening a significant percentage (e.g. six times more than today) of cargo at a passenger airport using TSA screeners during slack passenger and checked baggage screening periods; (2) physically screening a significant percentage (e.g. six times more than today) of cargo at a passenger airport using TSA or private screeners solely dedicated to cargo screening; and (3) using canine teams, supplemented as needed by technology, screening a similar percentage of cargo at an all cargo airport, specifically to detect explosives and hidden passengers. Based on results of each pilot, TSA will provide cost estimates (both non-recurring and recurring) of these different operational concepts if deployed to the top five air cargo only airports and top 10 passenger airports.**

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Project Objectives

- Identify major cost drivers for air cargo screening for passenger and freighter cargo traffic
- Provide rough order of magnitude (ROM) cost estimates for alternative screening technologies at the legislatively mandated 100% screening level for cargo on passenger aircraft
- Give insight into most cost efficient screening configurations for actual, large volume airports
- Utilize life cycle cost analysis methodology to optimize screening techniques

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Project Scope

- Expand data gathering beyond the 3 original DHS S&T ACEDPP Pilots to 15 sites chosen for this TSA cost study
- Utilize proven ORNL cost model and IV&V to ensure realistic cost projections
- Analyze costs only; benefits associated with screening efficiency and effectiveness were not considered
- Make no policy recommendations; study results are intended to be utilized in conjunction with other studies of secure supply chain programs as input to agency decision-making
- Provide findings, conclusions, and recommendations for future research based on ROM cost estimates comparing current screening requirements against future 100% screening requirements

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Key Study Assumptions

- Utilize EDS (primary) and ETD (secondary) for Screening Cargo on Passenger Aircraft
- Utilize CO2 Monitoring (primary) and Heart Beat Monitoring (secondary) for Screening Cargo on Freighter Aircraft

Note: Both assumptions reflect regulatory interpretations for explosives screening current in the 2007/2008 timeframe)

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Project Findings

The results generally show economies of scale for passenger cargo operations under the August 2010 Congressional mandate.

- Unit costs at the smallest three passenger operations in the study are projected to range from $19.93 to $28.76 per parcel, while the unit costs at the largest three passenger operations in the study are projected to range from $0.88 to $1.07 per parcel.
- 7 of 16 passenger cargo operations incur screening cost increases exceeding 100% (when compared to baseline operations).
- Because of economies of scale for passenger cargo operations, future research in large scale, centralized operations offering cargo screening as a central service to all shippers at or near an airport may be needed.

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Project Findings

Study results indicate the cost for cargo screening at freighter operations is significantly less than for passenger operations under the August 2010 Congressional mandate.

- Unit costs on a per 100 pound basis for passenger operation screening range from $1.20 to $56.70, while the unit costs for freighter operation screening range from $0.04 to $0.20 per hundred pounds.
- Future research to examine the feasibility of shifting air cargo that is more difficult to screen for explosives from passenger to freighter aircraft is warranted.

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Enterprise Modeling and Analysis (EMA)

EMA is the integrated study of organization, people, processes, systems, technology, and the environment in which they operate and their impacts

EMA integrates multiple modeling, analysis, and visualization tools

- Statistical analysis (data integration, filling gaps, relationships, assess effectiveness – ROC, etc.)
- Simulation (operations analysis and evaluations, efficiencies,)
- Optimization (alternatives analysis – cost, risk, affinity, design optimal system, etc.)
- Life cycle cost and economics (impact assessment - gainers and losers)
- Sustainment (long-term risk and vulnerability)
- Readiness and resiliency (transition)

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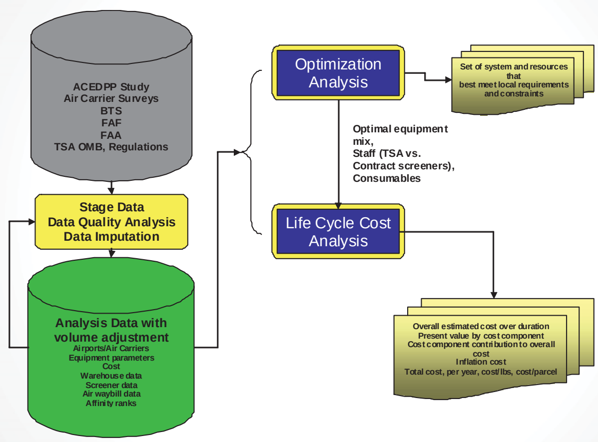
EMA as Applied to ACCEP



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EMA Data Input

- Data Standards
  - o Airway bill, pallet, piece, parcel, etc.
- Data Category
  - o Interviews with facility manager; Samples (5-10 days, 8 hours/day etc.) and 100% airway bill data for the sampling period
- Data Elements
  - o Airport, air carrier, air waybill number, pieces, commodity, weight, estimated parcels, consolidation, packaging material, destination, service level etc.
- Other Data Sources to Augment/Fill in Gaps/Data Quality Checks
  - o BTS – airport, air carrier, weight, freight assessment framework
- Data Structure/Organization – Databases
  - o Infrastructure data, operational data, volume-adjusted data, model parameters and scenario
- Data Access – user via secure web
- Data Implementation – MS-SQL

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Actual Data

- 18 Airports Surveyed in 2007 and 2008 (Baseline)
- Number of Warehouses: 41
- Number of Air Carriers: 72
- Number of Air Waybills: 124,820
- Duration
  - ✓ 5-10 day for the 15 Airports
  - ✓ 6-9 months of data for 3 Airport (ACEDPP)
- BTS and FAF Data: National Level (all airport, all modes)

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Independent Verification and Validation of EMA

- IV&V Goals
  - o Conceptual Model Validation
  - o Computerized Model Verification
  - o Sensitivity Analysis
  - o Model Stability and Consistency
  - o Stress Testing
- IV&V Conclusion
  - o Model confirms observed processes at ORD
  - o Validated responses to singular and multiple input parameters changes
  - o Model stress and volume limits are far beyond the current operational requirements

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Recommendations for Future Research

- Because of economies of scale found at larger carriers, future research in large scale, centralized operations may be warranted
- The study shows that costs for screening freighter operations is significantly less than screening passenger operations. Therefore, future research may examine feasibility of shifting air cargo that is difficult to screen for explosive from passenger to freighter aircraft
- Due to increased costs in passenger cargo operations, future research may examine the extent to which air cargo commerce is shifted to other modes of transportation and how that will impact small businesses
- Various options for cost sharing between the public and private sector should be examined

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Questions?

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BACK-UP SLIDES

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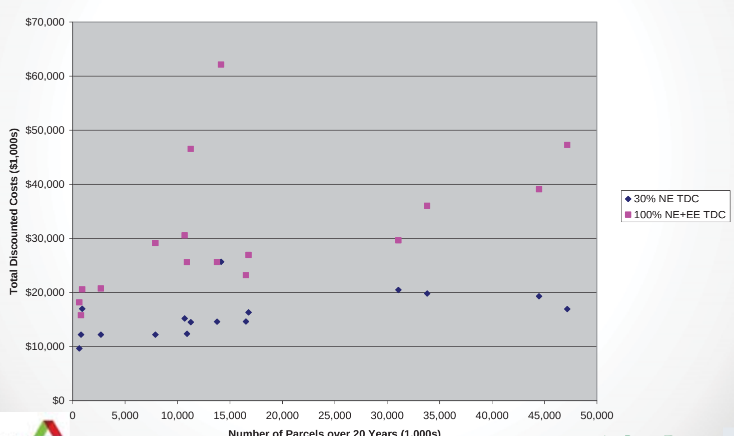
20 Year Total Discounted Costs – Passenger Carriers

Figure 1. Total Discounted Cost over 20 Years for Passenger Cargo Operations



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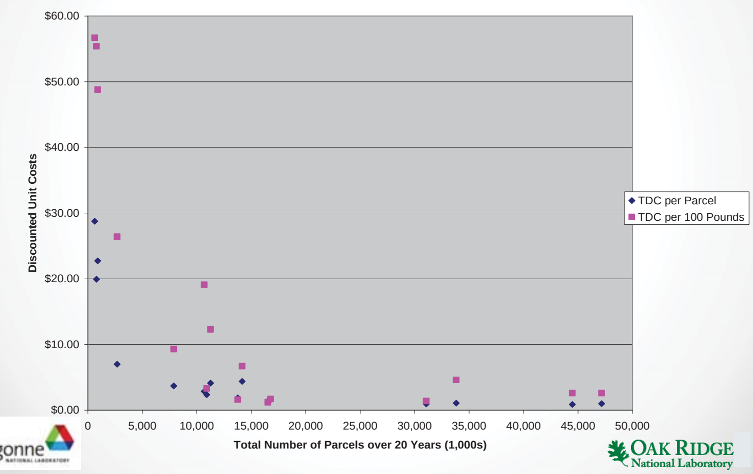
20 Year Total Discounted Unit Costs – Passenger Carriers

Figure 2. Discounted Unit Costs over 20 Years for Passenger Cargo Operations



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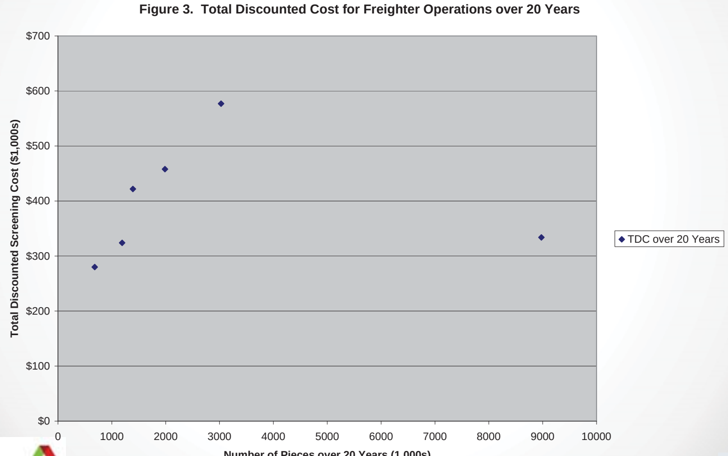
20 Year Total Discounted Unit Costs – All Cargo Carriers

Figure 3. Total Discounted Cost for Freighter Operations over 20 Years



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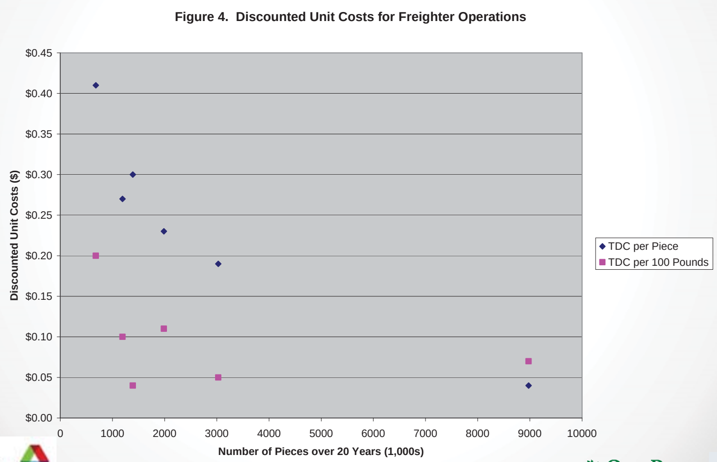
20 Year Total Discounted Unit Costs – All Cargo Carriers



Benefits of EMA

- Baseline analysis – characterizing infrastructure, flow, operations, efficiencies, business constraints, regulations, and effectiveness
- Trade analysis of alternatives systems
- Optimal design of screening system that maximize affinity and probability of detection and minimize cost while meeting stakeholder operations, business, and budget constraints
- Assess operational impacts and support the optimization of service time, business rules, throughput, delay, traffic pattern, resources, etc. for different ConOps
- Equipment Testing and data needs assessment to include both screening, operational, industry, and infrastructure data
- Human factors assessment (man-machine interface) and training requirements development
- Life cycle cost assessment
- Economic impacts assessments (industry/commerce tradeoffs)
- Sustainment (reliability, maintainability, supportability, logistics, periodic testing, etc.) requirements assessment
- Extrapolation assessment based technology attributes, performance, test and pilot analysis.
- Deployment and transition strategy assessment (what combination of technology mix, number, resources, infrastructure changes based on security, operational, financial, and other constraints.)

17.7 Doug Bauer: Present and Desired End States for Air Cargo Security and Risk Discussion

Present and Desired End
States for

Air Cargo Security

and

Risk Discussion

Doug Bauer, University of Connecticut

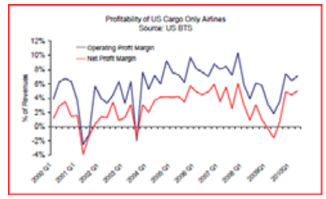
Presentation Outline

- Setting the Stage I: the Air Cargo Global Environment
- Setting the Stage II: the United States Air Cargo Security Environment
- Current State of U.S. Air Cargo Supply Chain Security
- Vision for U.S. Air Cargo Supply Chain Security
- A 3-pronged approach: Screening, Supply Chain Integrity Technology, and Data/Information Management
- Overview of Current Technology, Qualification Status, Limitations, and Gaps
- Summary of gaps
- Transitioning approach (business, technology)
- Risk Questions for Consideration
- Recommendations

2

Overview of the Air Cargo Business

- $50 Billion business
- 35% value of goods traded internationally
- 4% margin
- Growth 5.8% annually since 2001
  - Asia is ½ the business and it is booming
  - China has a 300% increase in volume
- Expected growth over the next two decades (2005 – 2025)
  - 5.3% through 6.9%
- Sea growing market share links to air cargo
  - Faster ships, lower prices, innovative solutions
  - ~11%
- 200-300 new wide-bodies come into the market each year
  - More bulk cargo
- Import operations in Canada, Singapore, and Australia
- Export operations in India, China, Taipei, Columbia, and Israel
- Flight departs every 3.5 seconds
- Freight volume is highly variable due to seasonal variations in commodity mix and national/local economy



Low profit margins; Linked to other modes; Smaller weight high value goods; Moving towards specialized operations; Fast, Varied commodities

3

Challenges of Global Supply Chain Security

- Security must be cost sensitive
- Security impacts commerce/business
- Security program must be stable and predictable
- Security must integrate Technology, Procedures and Processes

Understanding the challenges of the air cargo environment and constraints facing industry is key to improving air cargo security

4

Air Cargo Supply Chain Security: Status

- Fragmented
  - Supply chain operators
  - Individual operators are taking on the responsibility based on resource availability
- Limited/No technology standards
  - Still based on baggage, screening and supply chain integrity technologies are slowly being qualified
- No security data standards
- No security process standards
- No accreditation standards
- No integration standards
- Less than ½ industry have electronic messaging system (e-Freight)
- Global cargo security regulatory framework
  - ICAO (190 states participate)
  - However, it is not clear who has implemented cargo security?
  - How many are integrated with customs?
  - How many have Harmonized programs?
- One Nation's accreditation standards not accepted by another

5

Current Screening Technology:

- Explosive Detection System
  - Computed Tomography
- X-Ray Technology
  - Non-CT transmission X-Rays
  - Back scattered X-Rays
  - Extremely low-dose X-Ray devices
  - Coherent X-Ray scattering
  - Duel Energy X-Ray
  - Gamma Ray systems
- Explosive Trace Detectors
- Electromagnetic Metal Detectors
- Nonlinear Junction Device Detectors
- Stowaway Detection Technology
  - Heartbeat monitors
  - CO2 detectors
- Non-SSI website for qualified technologies: **https://www.tsa.gov/certified-cargo-srenning-program**

6

Current Screening Technology (cont'd)

- Improvised Explosive Device (IED) Detection & Defeat Technology
  - Detectors
  - Disruptors
- Acoustic Technology
- Colormetrics Technology
- Vapor-based Explosives Detection Trace Portal (Puffers)
- Millimeter-Wave and Terahertz Technology
- Containerized Cargo Screening Technologies:
  - Pulsed Fast Neutron Analysis (PFNA)
  - Pressure Activated Screening System (PASS-C)
  - Quadrupole Resonance/Trace (QRT)
  - Megavolt Computed Tomography (MCT)
- Canine & Propriety Canine

7

Transitioning Approaches:

What is our starting point?

- The air cargo supply chain network has piecemeal screening solutions
- No solutions currently exist to continuously maintain chain of custody of previously screened cargo
- There is no transparency in the supply chain for outbound and inbound cargo
- No international data standards or harmonization requirements are implemented globally

8

Transitioning Approaches:
Where do we want to be?

Desired End State: a fully integrated, secure global supply chain network that allows seamless movement between transportation modes:

- The supply chain network has transparent screening for outbound and inbound cargo. At all times, systems knows
- International data standards and harmonization requirements are implemented globally
- The supply chain network has comprehensive, effective, affordable screening solutions
- The supply chain network maintains chain of custody of previously screened cargo at all times

9

Risk Questions for Consideration

- 3 Kinds
  - Explicit
  - Implicit
  - Perceived

- 2 Categories of Risks
  - Internalized
  - Externalized

* For Government Relevant Stakeholder: Traveler

10

Buying Down Risk

- Public should pay for internalized risk reduction
- Stakeholder vendors set prices
- Public costs brought down by incremental risk reduction investment
- A-priori risk: perceived risk affects political receptivity
- Precedents
  - FAA Safety Program
  - Integrated Resources Planning (IRP) for electric utilities

11

Other Questions for Consideration

- Commence initiatives of Security improvements
- Collective Action in Security:
  - EPRI
  - GRI
  - NRRI

12

Proposed Research Areas

- Neutron Technology with smaller footprint
  - Application to pallets characterization

- Risk Quantification for Air Cargo
  - Create and Alert
  - DHS - BMD & EXD
  - DHS/S&T & TSA

- Supply Chain Integrity
  - Short Fall of Present System
  - Technical
  - Cost ?

13

Recommendations

- The U.S. should lead an effort to create international air cargo data standards and harmonization

- DHS should develop an Air Cargo Security Knowledge Center.

- DHS should develop a formal road map for implementing these recommendations. Road map development would include convening a panel of subject matter experts in each area to aid in drafting and annually reviewing the path forward.

14

17.8 Doug Pearl: Economic Incentives in Air Cargo Screening

Last updated: Nov 2, 2014

Economic Incentives in Air Cargo Screening
Some Topics for Discussion

Prepared by
Doug Pearl
Inzight Consulting, LLC
for ADSA11 November 4, 2014

Inzight Consulting, LLC ADSA11 November 4, 2014

~~Conclusions~~ Hypotheses

- **Air Cargo Vendors will use the least expensive screening methods available, subject to meeting requirements (and good citizenship)**
- **If new, *better*, and *more expensive* technologies become available, they probably will not be adopted if older, less expensive options are still allowed.**
- **In some circumstances, Air Cargo Vendors *collectively* may have an incentive to welcome government requirements for *better* and *more expensive* technology.**
- **Even if Air Cargo Vendors are not supportive, requiring new, *better* and *more expensive* technology is a policy trade-off that may be desired by society and government.**

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Two Colleagues at an Air Cargo Vendor Discuss Screening Methods: Their Initial Conversation (Short Version)

QPL: Qualified Product List.
SOP: Standard Operating Procedure.

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Their Conversation After a New Product Launch (Short Version)

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~~Conclusions~~ Hypotheses

- Air Cargo Vendors will use the least expensive screening methods available, subject to meeting requirements (and good citizenship)
- If new, *better*, and *more expensive* technologies become available, they probably will not be adopted if older, less expensive options are still allowed.
- **In some circumstances, Air Cargo Vendors *collectively* may have an incentive to welcome government requirements for *better* and *more expensive* technology.**
- Even if Air Cargo Vendors are not supportive, requiring new, *better* and *more expensive* technology is a policy trade-off that may be desired by society and government.

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Value of Reducing Risk by One Order of Magnitude Air Cargo Vendor Perspective (Simplistic Model)

Vendor view: black font	Initial Risk	Lower Risk
Risk	0.1	0.01
Cost of Event if it occurs	$100	$100
"Expected" Cost (product of rows above)	$10	$1
Savings vs. One Column to Left	-	$9
Breakeven Cost of Risk Reduction	-	$9

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Their Conversation, Continued... (Short Version)

OK; I'm convinced. I'd pay $9 extra for the new technology to reduce risk. It makes economic sense, like buying insurance.

But if we do it and competitors don't they may drive us out of business....We don't live in a Monte Carlo simulation.

What if the QPL changed and we all had to do it?

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~~Conclusions~~ Hypotheses

- Air Cargo Vendors will use the least expensive screening methods available, subject to meeting requirements (and good citizenship)
- If new, *better*, and *more expensive* technologies become available, they probably will not be adopted if older, less expensive options are still allowed.
- In some circumstances, Air Cargo Vendors *collectively* may have an incentive to welcome government requirements for *better* and *more expensive* technology.
- **Even if Air Cargo Vendors are not supportive, requiring new, *better* and *more expensive* technology is a policy trade-off that may be desired by society and government.**

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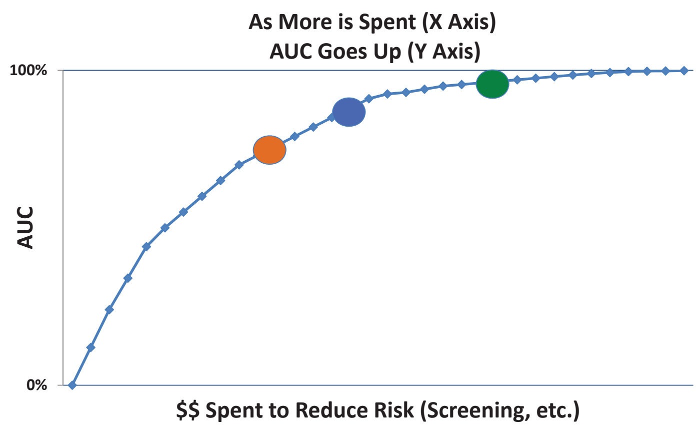
**Who Decides How Much "Risk Reduction" to Buy
Or Where We Should be On this Curve?**

Government? Industry?



*AUC (Area Under the Curve) is one statistical method of summarizing screening efficacy. Higher is better.

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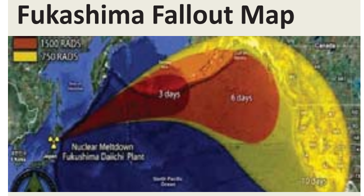
Whose "Risk" Are We Talking About? (Whose Cost if an Event Occurs?)

Externalities: Costs Borne by Society but Not by the Decision Makers in Private Sector

Fossil Fuel Power Plant

Utility's? Or Society's?

Fukashima Fallout Map



TEPCO's? Or Society's?

Pan Am 103

Pan Am's? Or Society's?

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Value of Reducing Risk by One Order of Magnitude

Air Cargo Vendor View: $9 (Black font). Society's View: $900 (Red)

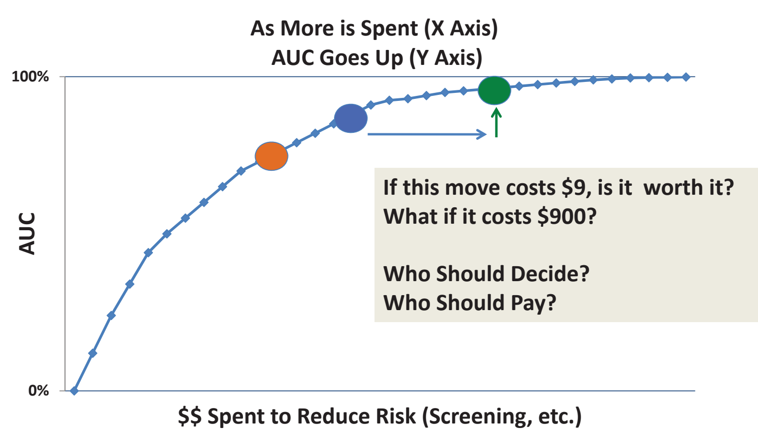
So How Much Should We Spend? Who is *We*? Who Should Bear the Cost?

Vendor view: black font Society view: red font	Initial Risk	Lower Risk
Risk	0.1	0.01
Cost of Event if it occurs	$100 $10,000	$100 $10,000
"Expected" Cost (product of rows above)	$10 $1000	$1 $100
Savings vs. One Column to Left	-	$9 $900
Breakeven Cost of Risk Reduction	-	$9 $900

Who Decides How Much "Risk Reduction" to Buy

Or Where We Should be On this Curve?

Government? Industry?



*AUC (Area Under the Curve) is one statistical method of summarizing screening efficacy. Higher is better.

Decision Makers Can Only Decide Based on What They Can Know

Who Knows What?

Who Has Insight? / Potential Decision Criteria	Gov't Agencies	Air Cargo Vendors
COST of RISK REDUCTION		
Cost to Acquire/Implement a Technology	Yes	Yes
Labor Cost to Operate	No?	Yes
Cost to Resolve (False) Alarms (and PFA in the Field)	No?	Yes
Total Cost of Ownership (TCO)	No?	Yes
THE NEED		
Cost of an Event (To Carrier?/ To Society?)	Yes?	Yes?/?
Actual Risk Level; Change in Risk Level (Intelligence, etc.)	Yes?	No
Change in Threat Type (Intelligence, etc.)	Yes?	No
EFFICACY OF PRODUCTS ON QPL		
Nominal PD of Products on QPL	Yes	No
Nominal PFA (lab tests)	Yes	No
PFA in the Field	No?	Yes

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~~Conclusions~~ Hypotheses

- Air Cargo Vendors will use the least expensive screening methods available, subject to meeting requirements (and good citizenship)
- If new, *better*, and *more expensive* technologies become available, they probably will not be adopted if older, less expensive options are still allowed.
- In some circumstances, Air Cargo Vendors *collectively* may have an incentive to welcome government requirements for *better* and *more expensive* technology.
- Even if Air Cargo Vendors are not supportive, requiring new, *better* and *more expensive* technology is a policy trade-off that may be desired by society and government.

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Backup

Value of Reducing Risk by One Order of Magnitude (OM)
Depends on Initial Risk and Cost of *Event* (as perceived by the decision maker)

Vendor view: black font Society view: red font	Initial Risk	Lower Risk	Lower Still	Even Lower
Risk	0.1	0.01	0.001	0.0001
Cost of Event if it occurs	$100	$100	$100	$100
"Expected" Cost (product of rows above)	$10	$1	$0.10	$0.01
Savings vs. One Column to Left	-	$9	$0.90	$0.09
Breakeven Cost of Risk Reduction	-	$9	$0.90	$0.09

Lower Risk; Lower Value of One OM Risk Reduction

Value of Reducing Risk by One Order of Magnitude (OM) Depends on Initial Risk and Cost of *Event* (as perceived by the decision maker)

From either perspective, value of OM risk reduction goes down as risk goes down

Vendor view: black font Society view: red font	Initial Risk	Lower Risk	Lower Still	Even Lower
Risk	0.1	0.01	0.001	0.0001
Cost of Event if it occurs	$100 $10,000	$100 $10,000	$100 $10,000	$100 $10,000
"Expected" Cost (product of rows above)	$10 $1000	$1 $100	$0.10 $10	$0.01 $1
Savings vs. One Column to Left	-	$9 $900	$0.90 $90	$0.09 $9
Breakeven Cost of Risk Reduction	-	$9 $900	$0.90 $90	$0.09 $9

Lower Risk; Lower Value of One OM Risk Reduction →

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Model For Thinking About "Who Pays" and "Who Performs"

Who Performs the Work \ Who Pays	Gov't (taxpayers)	Private Sector
Private Sector	• Private contractors at airports (some) • Blackwater • Defense Contractors • National Labs	• Air Cargo Screening (under regulation) • Some food inspection (under regulation)
Government	• TSA at airports (most) • DOD • Police • Air Traffic Control	• Unusual, but does exist • FDA PDUFA

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Straw Man for Discussion. Data from sources like WikiPedia, etc. May be wrong or incomplete.

Are there Limits on Liability?

Warsaw Convention (Updated by Montreal Convention, 1999)

Cargo on international flights

- Liability limit: 19 SDR (roughly $30) per kg
- Payload capacity of 747: 112,000kg
- Max liability for cargo, per plane, based on this: $3.4 Million

Human Life on international flights

- $169k per passenger (in absence of negligence; otherwise unlimited (?))
- 500 passengers would be: $84 Million

Value of aircraft itself

- ~$150 million (very rough estimate)

Potential Direct $ Cost to Air Carrier (and/or their insurer) for Total Loss of Plane

- Plane full of cargo only: $153 Million (mostly the plane's value)
- Plane full of passengers: $234 Million

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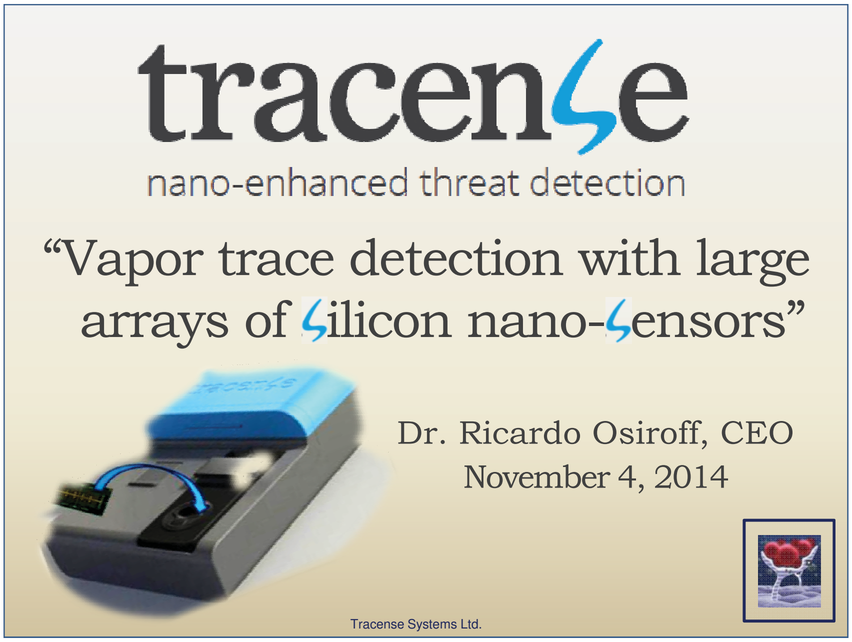
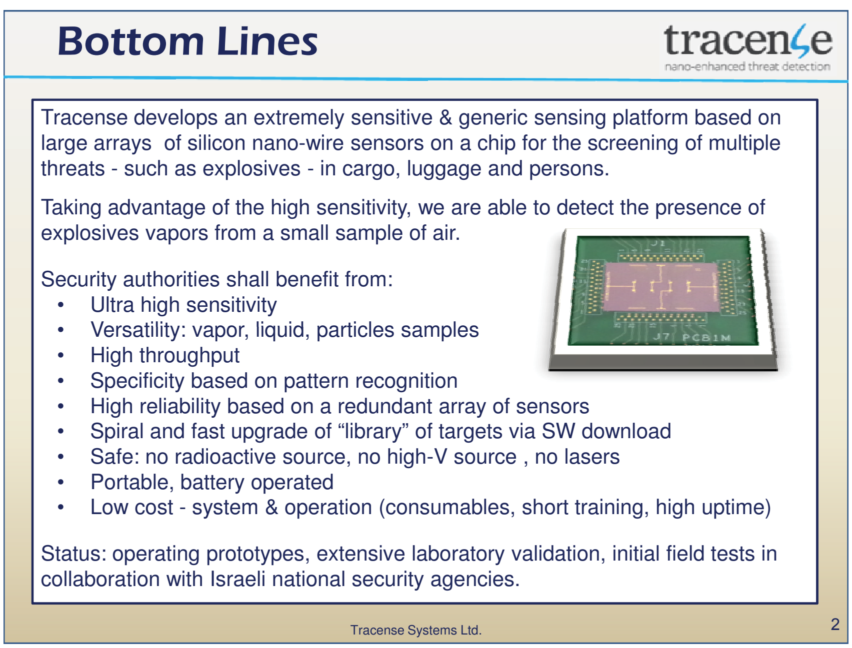
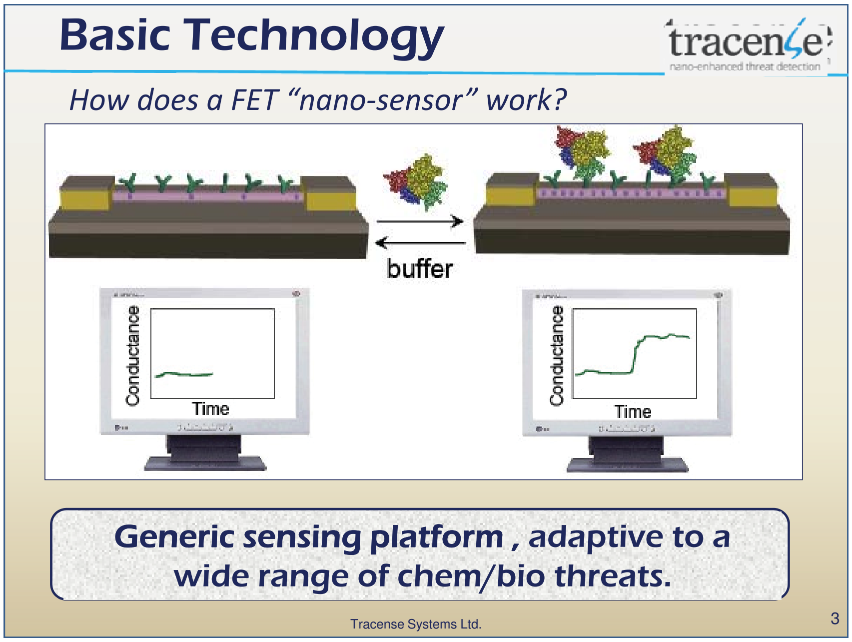
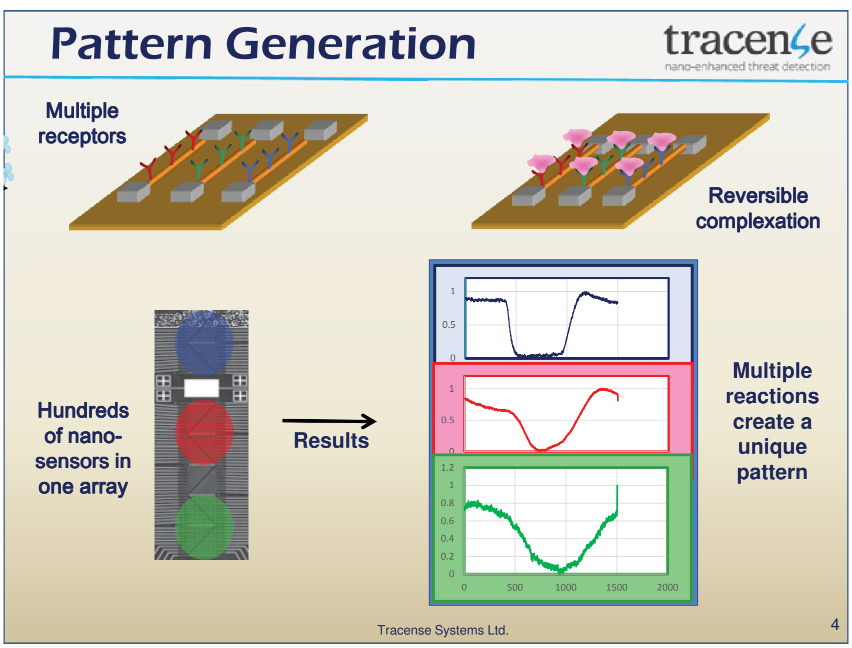
17.9 Ricardo Osiroff: Vapor Trace Detection with Large Arrays of Silicon Nano-sensors



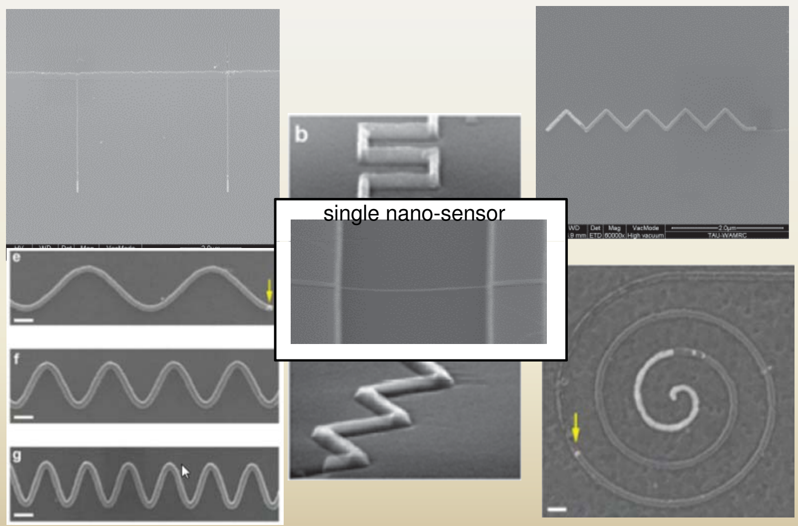



Basic Technology
tracense
nano-enhanced threat detection
How does a FET "nano-sensor" work?
buffer
Conductance
Time
Conductance
Time
Generic sensing platform , adaptive to a wide range of chem/bio threats.
Tracense Systems Ltd.
3


Pattern Generation
tracense
nano-enhanced threat detection
Multiple receptors
Reversible complexation
Hundreds of nano-sensors in one array
Results
Multiple reactions create a unique pattern
0
500
1000
1500
2000
Tracense Systems Ltd.
4

In-Plane Nanowire Growth

tracense
nano-enhanced threat detection



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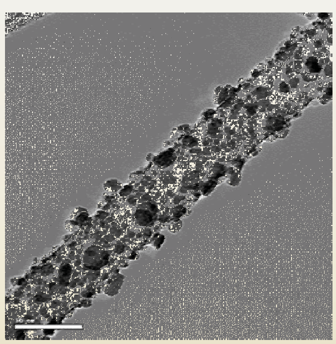
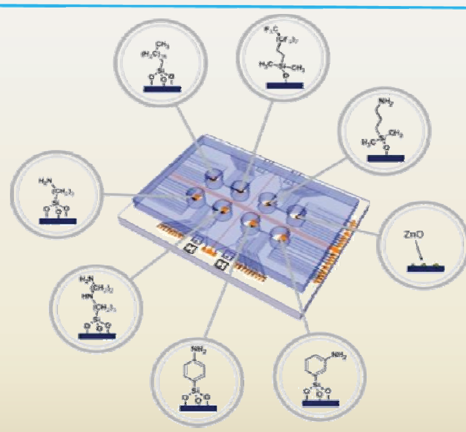
Multiple Receptors

tracense
nano-enhanced threat detection





Match & optimize receptor set to application

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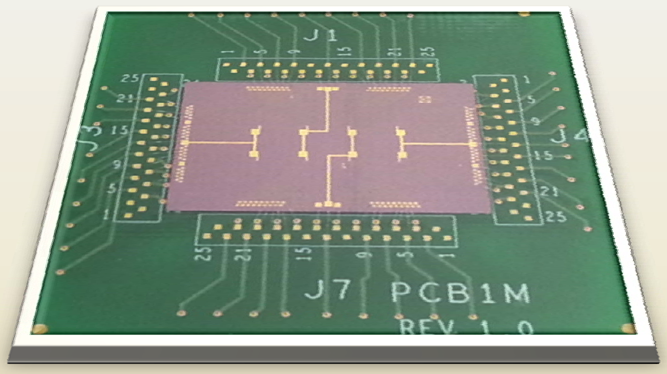
Multiplex Chip

tracense
nano-enhanced threat detection



Multiple simultaneous reactions on a chip

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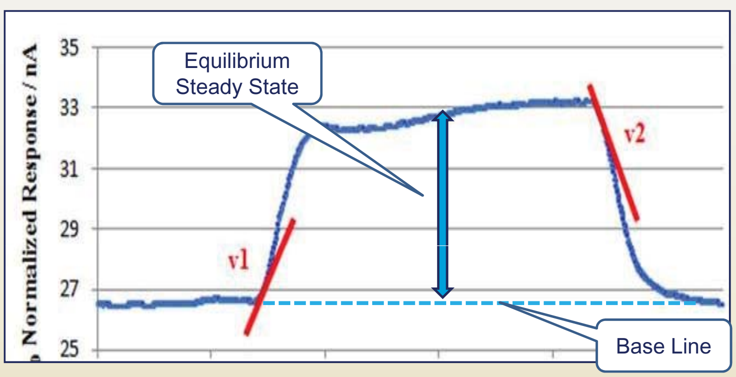
ID Principles

tracense
nano-enhanced threat detection



Onset Kinetic Ratio Independent of Concentration

Complimentary identification methods: thermodynamics & kinetics

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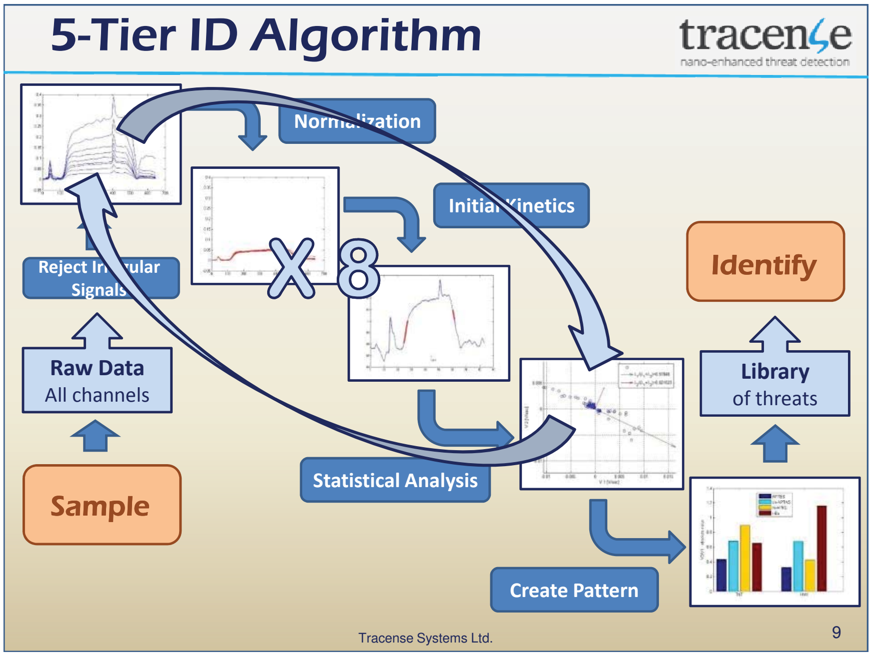
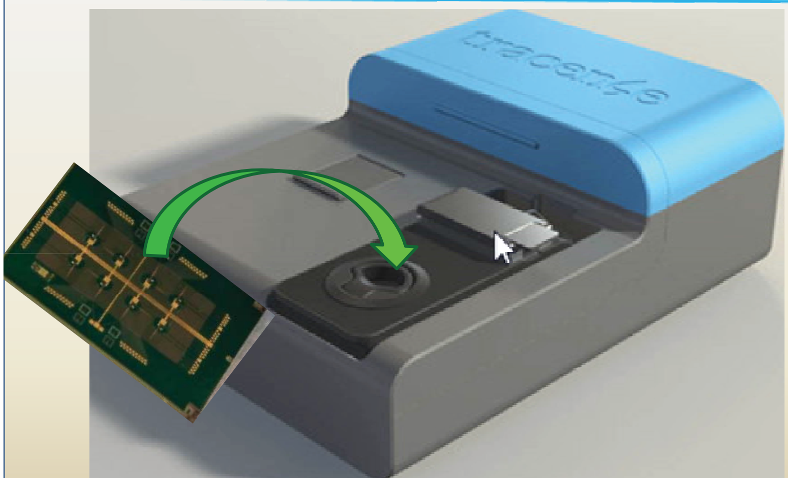

5-Tier ID Algorithm
tracense
nano-enhanced threat detection
Identify
Library
of threats
Raw Data
All channels
Sample
X 8
Statistical Analysis
Create Pattern
Tracense Systems Ltd.
9


Vapor Collection
tracense
nano-enhanced threat detection
Collection of calibrated volume
Whatman
SKC
Collection of larger volumes
Tracense Systems Ltd.
10

Explosives Detector

tracense
nano-enhanced threat detection



All samples are measured in liquid solution

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Experimental Results

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nano-enhanced threat detection

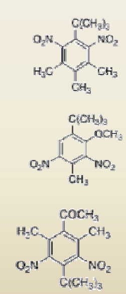
Tested Explosives

- TNT
- RDX
- HMX
- PETN
- DNT
- NG
- Tetryl
- TATP
- HMTD
- AN

Tested Interferents

- 2,4 DNP
- p-nitrophenol
- Aniline
-
-

Musk matl's in cosmetics and fragrances



Samples: vapor, particles & solutions: 1 ng/ml (1ppb) to 1 fg/ml (1ppq)

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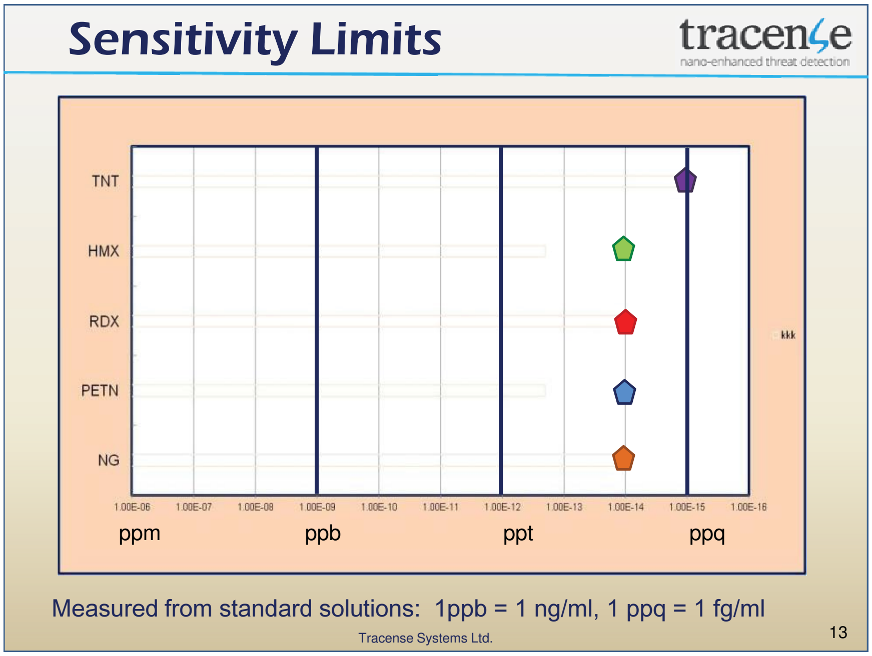
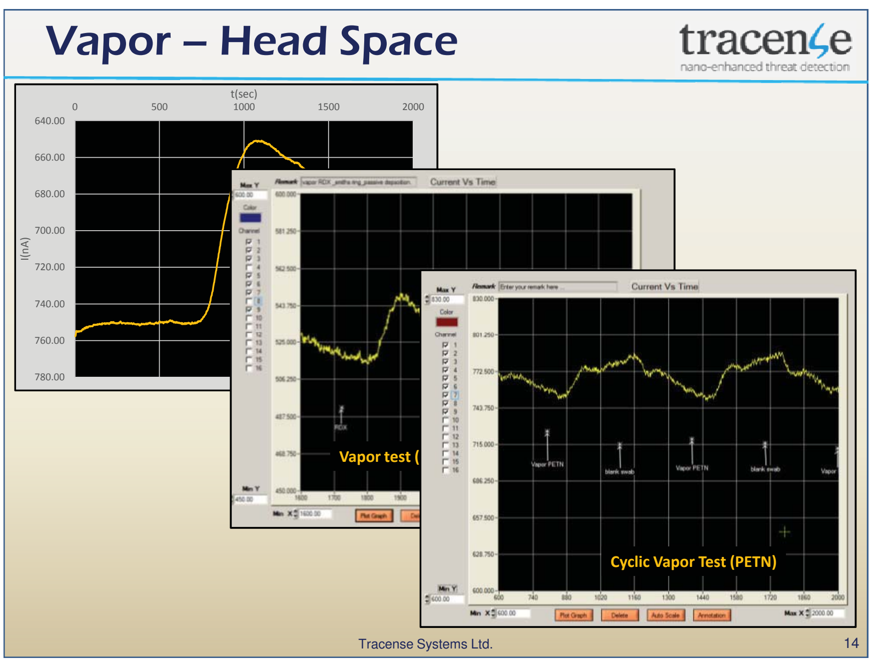
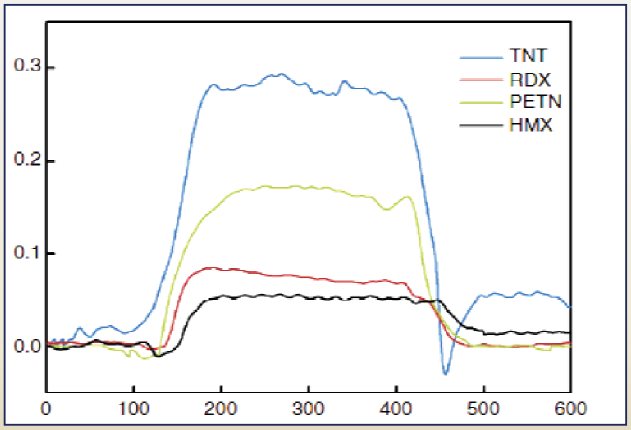

Sensitivity Limits
tracense
nano-enhanced threat detection
TNT
HMX
RDX
PETN
NG
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13
1.00E-14
1.00E-15
1.00E-16
ppm
ppb
ppt
ppq
Measured from standard solutions: 1ppb = 1 ng/ml, 1 ppq = 1 fg/ml
Tracense Systems Ltd.
13


Vapor – Head Space
tracense
nano-enhanced threat detection
t(sec)
0
500
1000
1500
2000
640.00
660.00
680.00
700.00
720.00
740.00
760.00
780.00
I(nA)
Current Vs Time
Vapor test (
Current Vs Time
Cyclic Vapor Test (PETN)
Tracense Systems Ltd.
14

4 Explosives - 1 Receptor



Calibrated responses of a modified nano-device to 4 different explosives at 10 ppt concentration

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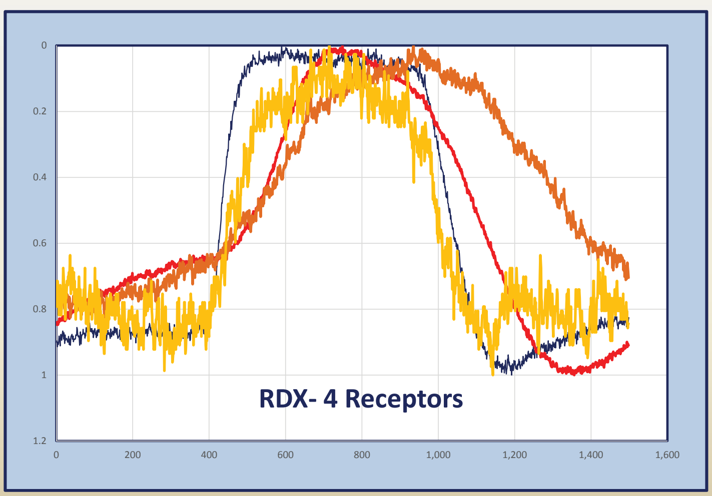
15

1 Explosive - 4 Receptors



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16

Pattern Library

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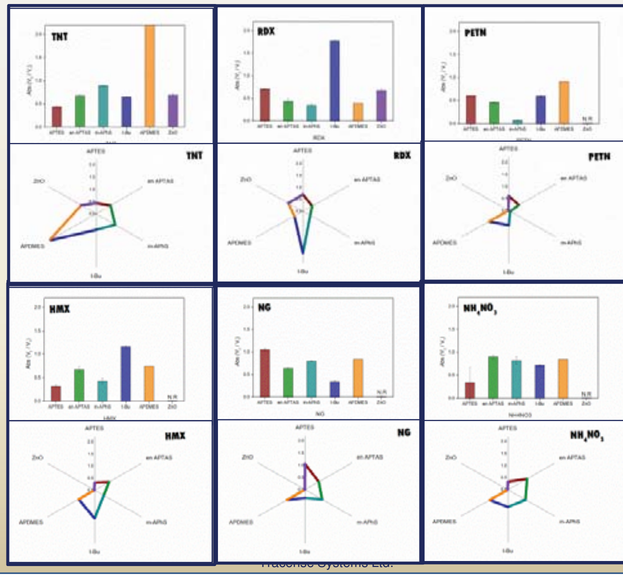
nano-enhanced threat detection



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17

Preliminary Field Test

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nano-enhanced threat detection

We received close to 70 samples collected in different sites by the IPMO

They included a variety of merchandise, regular baggage and objects contaminated by the IPMO using a variety of explosive materials.

The samples were collected via:

(1) swiping with our filters

(2) vapor collection.

After reviewing the results with the IPMO, we reached these conclusions:

- There were no false positive alarms. All non-contaminated samples showed no alarm of explosives.
- 14 out of 15 contaminated objects were detected*

  Note: we learned later that the missed object was a commercial box of medical drugs contaminated intentionally with 1 ng of AN.
- Detection via swipe and air collection were equally successful.

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18

Next Steps

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- Install calibrated air/explosive vapor mixtures generator and determine the actual limits of effective vapor sampling (volume/conc.) in simulated and "dirty" environments
- Expand library of threats
- Automate, optimize and accelerate* data analysis
- Extensive field testing and validation in realistic environments with existing and new prototypes
- Industrialize all manufacturing methods
- Design, build and test first commercial systems (α)
- Submit α to IPMO for independent qualification
- Submit α to TSL/TSIF for US qualification

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nano-enhanced threat detection

Questions?

Thank You!
Ricardo Osiroff, CEO
ricardo@tracense.com
+972-525390424
www.tracense.com

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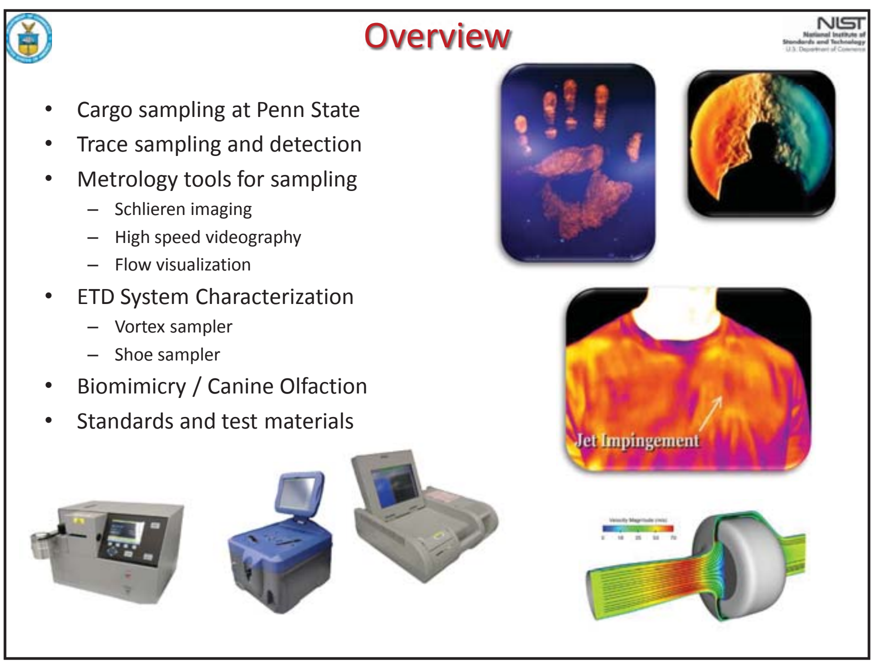
17.10 Matthew Staymates: Novel Investigations in Trace Explosives Collection



Penn State Gas Dynamics Lab

"Internal Aerodynamics and Explosive Trace Sampling of Sea-Cargo Containers"

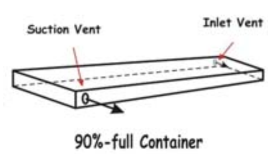
- Sea-cargo container characterization
- Scale model construction
- Computational Fluid Dynamics
- Experimental flow visualization
- Explosive trace detection experiments

3

Cargo Container Flow Visualization

What happens when you withdraw air from one vent?

Computational model

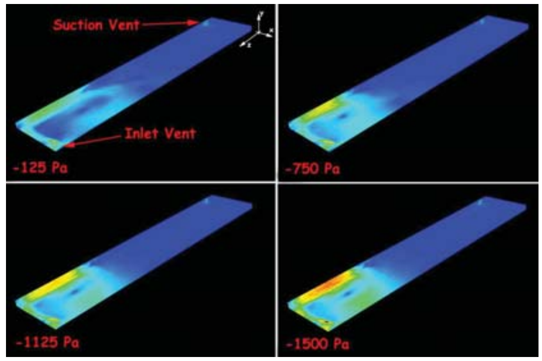


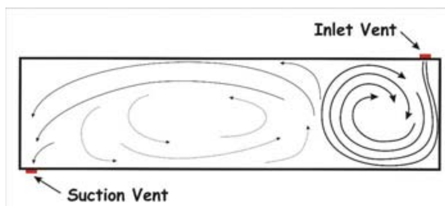
40% scale model

4

Cargo Container Flow Visualization – CFD results

- 0.5-21" H_2O
- Conclusion: No significant changes in aerodynamic flow patterns
  - Visualized by contours of wall shear stress
  - Increase in wall shear stress with suction pressure (as expected)

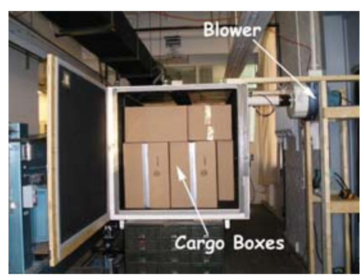


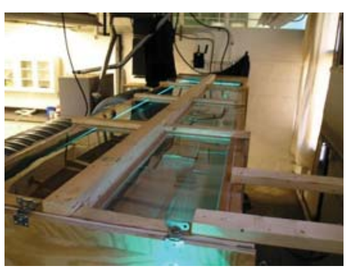


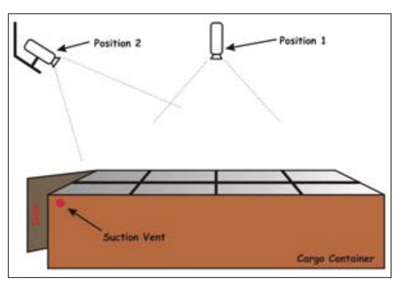
5

Cargo Container Flow Visualization

- Modeled 90%-full cargo container
- Used 1 Hp blower as air mover
- Theatrical fog (smoke) and laser light sheet illumination
- Suction pressure of 3" H_20

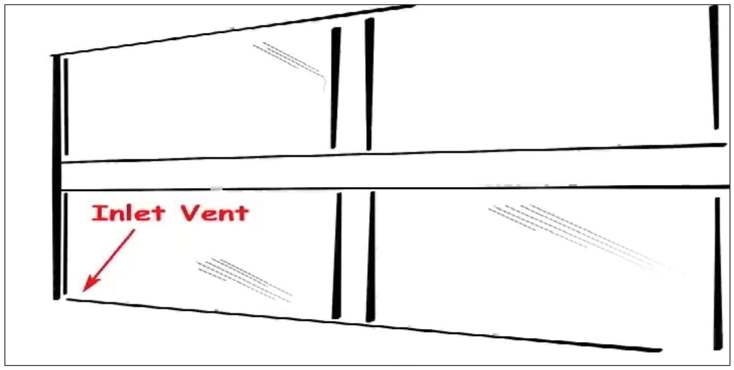






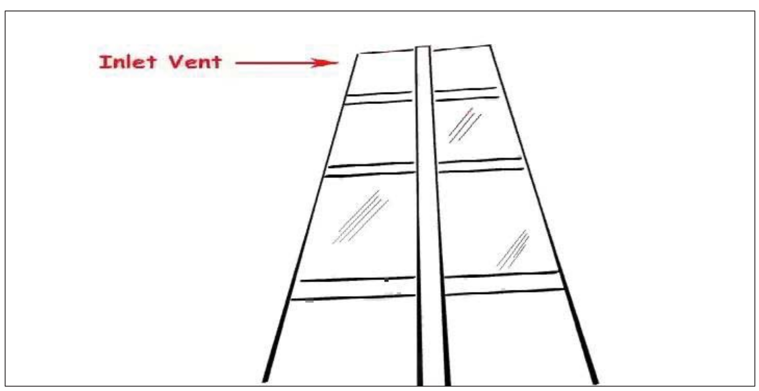
6

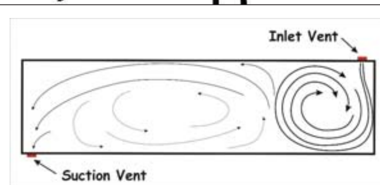
Cargo Container Flow Visualization



7

Cargo Container Flow Visualization

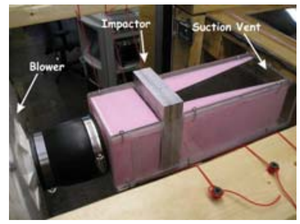




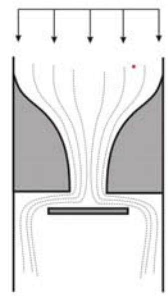
8

Explosive Sampling Experiments

- Cartridge heater used as particle generator
  - 5 µg of RDX for each experiment
- Metal-mesh tab on impactor surface
- Procedure:
  - Reach steady state conditions
  - Vapor release
  - Sample for 2 minutes
  - Analysis into Itemiser[3]
- All locations repeated 3 times
- Test for contamination after each run



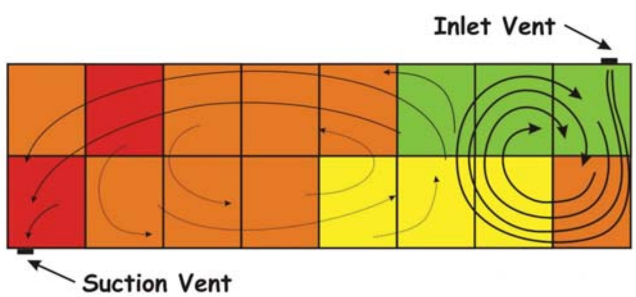
Particle impactor

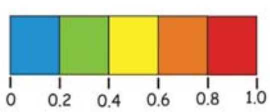


9

Explosive Sampling Results

- All locations were detectable
- Signal strength is a function of location from suction vent
  - May be due to deposition on surfaces





10

Suggestions and Conclusions

- Apply pressure to create inlet jet, then reverse the flow
- If possible, sample from both vents
- Three potential designs (Backpack mounted, Truck mounted, Stationary)


- Typical sea-cargo container is 40 feet in length, 90%-full by volume, with two vents
- Two distinct flow patterns emerge when suction is applied to one vent
  - -Inlet jet/vortex, Should be considered a tool to liberate particles
- Experiments show signal strength is a function of location inside container
  - -Suggests a logical sampling strategy

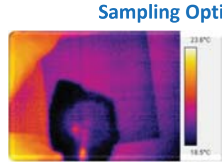
Many thanks to Gary Settles, PSU Gas Dynamics Lab

11

NIST Trace Detection Program

What is being sampled?


Sampling Optimization

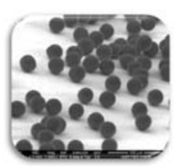



Operational Improvements / Training


Detection System Performance


Standard Test Materials





5

Summary

Over the last several years NIST has developed a unique suite of metrology tools and acquired the experience necessary to address the measurement and standards issues in the application of trace contraband detection.

Acknowledgements

- Our group at NIST includes:
  - Greg Gillen, Jessica Staymates, Matt Staymates, Jennifer Verkouteren, Robert Fletcher, Mike Verkouteren, Marcela Najarro, Tim Brewer, Eric Windsor, Tom Forbes, George Klouda, Jeff Lawrence, Shin Muramoto, Edward Sisco

The Science and Technology Directorate of the U.S. Department of Homeland Security sponsored the production of this work under an Interagency Agreement with the National Institute of Standards and Technology.

Certain commercial equipment, instruments, or materials are identified in this document. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products identified are necessarily the best available for the purpose.

17.11 Michelle Clark: Compound Specific Challenges Associated with Trace Detection

This project was made possible by Department of Homeland Security, Science and Technology Directorate funding

Compound Specific Challenges Associated with Trace Detection

Michelle L. Clark

November 4-5, 2014

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This work is sponsored by Department of Homeland Security, Science and Technology Directorate under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, recommendations and conclusions are those of the authors and are not necessarily endorsed by the United States Government.

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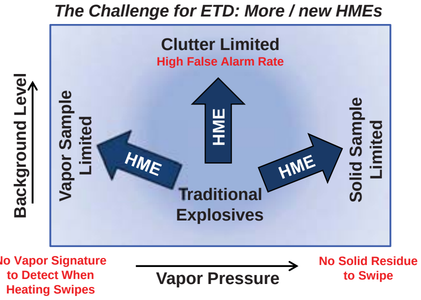
The Evolution of Trace Detection

- The explosive threat is evolving
  - More materials to detect
- Trace detection systems are evolving as well…
  - Improved sampling methods
  - Evolution from IMS to dual-polarity IMS to MS
  - See DHS S&T BAA 13-03 titled "Advanced Trace Detection Instrumentation and Methodologies"

The Challenge for ETD: More / new HMEs



MITLL is providing knowledge to help trace detection systems evolve

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The Growing List of Explosives

- Widely varying physical properties
  - Vapor pressures vary by up to eight orders of magnitude
  - Range of morphology (liquids, gels, crystalline solids, moldable plastics, machinable plastics, powders)
- Additional challenges
  - For some HMEs, their constituents may be present in the background environment





Focusing on detection of the main charge is not a single detection problem

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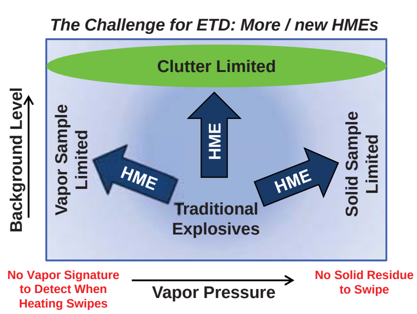
ETD Challenges: Clutter Limited Example



- Challenge: HMEs constituent chemicals may be common in the background
- Case study: Ammonium nitrate
  - Common fertilizer
  - NH_3 (g) exists at ppb levels and HNO_3 (g) at ppt concentrations in the atmosphere
- AN exists in equilibrium with its precursors NH_3 and HNO_3

$$NH_4NO_3\ (s) \leftrightharpoons NH_3\ (g) + HNO_3\ (g)$$



ETD performance may be background limited

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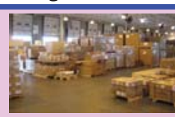
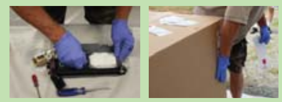
Method for Assessing Impact of Clutter

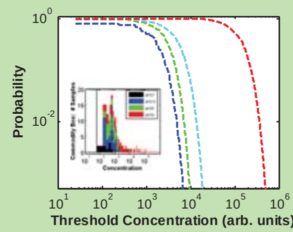
Background levels



- Background levels of salts similar for all cargo contents, cargo facility locations, seasons
- Simultaneous detection of nitrate and ammonium lowers P_{FA} by an order of magnitude

Threat Signatures





Examine clutter levels relative to signatures to set threshold requirements and identify algorithms/schemes for enhancing detection

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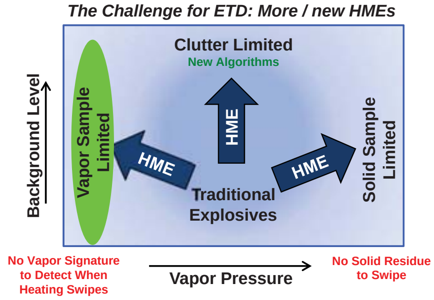
ETD Challenge: Sample Desorption for Chlorates and Perchlorates

The Challenge for ETD: More / new HMEs



Perchlorate and Chlorate Melting and Boiling Points

Compound	M.P. (°C)	B.P. (°C)
Potassium Perchlorate	525	600
Sodium Perchlorate	468	482
Potassium Chlorate	356	400
Sodium Chlorate	248	300
Perchloric Acid	-17	203
Chloric Acid	?	40

Industrial preparation: Salt Metathesis Reactions
$NaClO_4 + HCl \rightarrow NaCl + HClO_4$
$Ba(ClO_3)_2 + H_2SO_4 \rightarrow 2HClO_3 + BaSO_4$

- **High melting and boiling points translate into <u>low</u> vapor pressures at typical thermal desorption (TD) temperatures, 150 – 200 °C**
- **Low vapor pressures of chlorates and perchlorates limits TD based ETD**
- **However, perchloric acid ($HClO_4$) and chloric acid ($HClO_3$) have relatively high vapor pressures**

Convert chlorate and perchlorate salts into chloric and perchloric acids to enable thermal desorption based detection strategies

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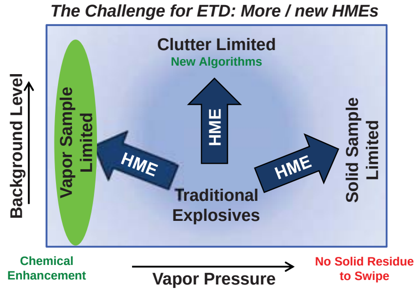
ETD Challenge: Sample Desorption for Chlorates and Perchlorates

The Challenge for ETD: More / new HMEs



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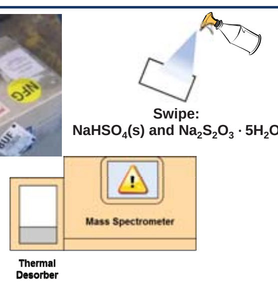
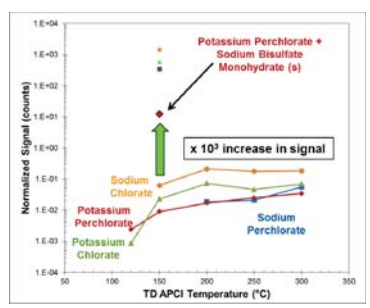
Acid Enhanced Detection of Chlorates and Perchlorates





- **Solution:**
  - **Add sodium bisulfate ($NaHSO_4$(s)); source of acidic protons and the sulfate anion**
  - **Codeposit sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) as a 'dry' source of water upon thermal desorption**
- **Pros: Easy handling of dry swipes, desired chemistry is thermally activate**
  - **Sodium bisulfate and thiosulfate are safe**

Dry swipe with embedded safe solid compounds will enhance detection of chlorates and perchlorates

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Patent Appls. US2014/0030816A1; WO2014/058507A2; US13/832,905; WO2104/058508A3; US61/975,275

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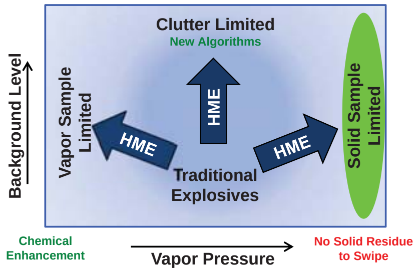
ETD Challenge: High Vapor Pressure Regime

The Challenge for ETD: More / new HMEs



- **TATP has a high vapor pressure**
- **Traditional sampling methods may need to be updated**

Fate, Persistence, Composition

Robert G. Ewing, Melanie J. Waltman, David A. Atkinson, Jay W. Grate, Peter J. Hotchkiss, TrAC Trends in Analytical Chemistry, Volume 42, January 2013, Pages 35-48.

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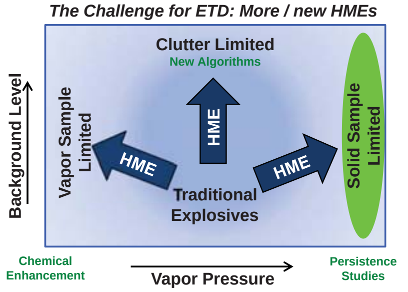
ETD Challenge: High Vapor Pressure Regime

The Challenge for ETD: More / new HMEs



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Robert G. Ewing, Melanie J. Waltman, David A. Atkinson, Jay W. Grate, Peter J. Hotchkiss, TrAC Trends in Analytical Chemistry, Volume 42, January 2013, Pages 35-48.

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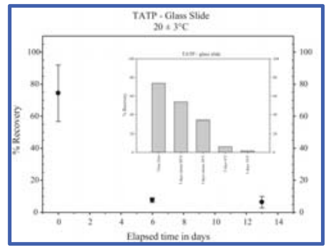
ETD Challenge: Persistence of Residues

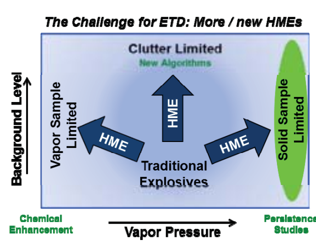


Nopporn Song-im, Sarah Benson, Chris Lennard, Forensic Science International, Volume 226, Issues 1–3, 10 March 2013, Pages 244-253

- **TATP residues evaporate/decompose**
  - **Recent study showed that after 12 days at 20°C, 5% of TATP deposited on a glass slide remained (approximately ~1 μg still available for detection)**
  - **Current MITLL work aimed at assessing requisite detection thresholds**
- **Additional Detection Mitigation Measures**
  - **Vapor sensor**
  - **Detect presence of associated chemicals (main charge, or decomposition products)**
  - **Bulk screening**

Summary

- **Chemical diversity of IEDs presents challenges for ETDs**
- **These challenges are being met two ways:**
  - **Improved instrumentation (industry focus)**
  - **Increased knowledge of trace phenomenology and background levels, leading to new methods and algorithms (MIT LL focus)**
- **The evolution of ETDs will ensure their future role in our counter-explosives architecture for air cargo security**



Acknowledgements

- **This work is sponsored by the Explosives Division of the Science and Technology Directorate of DHS under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, recommendations and conclusions are those of the authors and are not necessarily endorsed by the United States Government.**
- **We would like to acknowledge: Department of Homeland Security, Science and Technology Directorate, Explosives Division and Department of Homeland Security, Transportation Security Administration**

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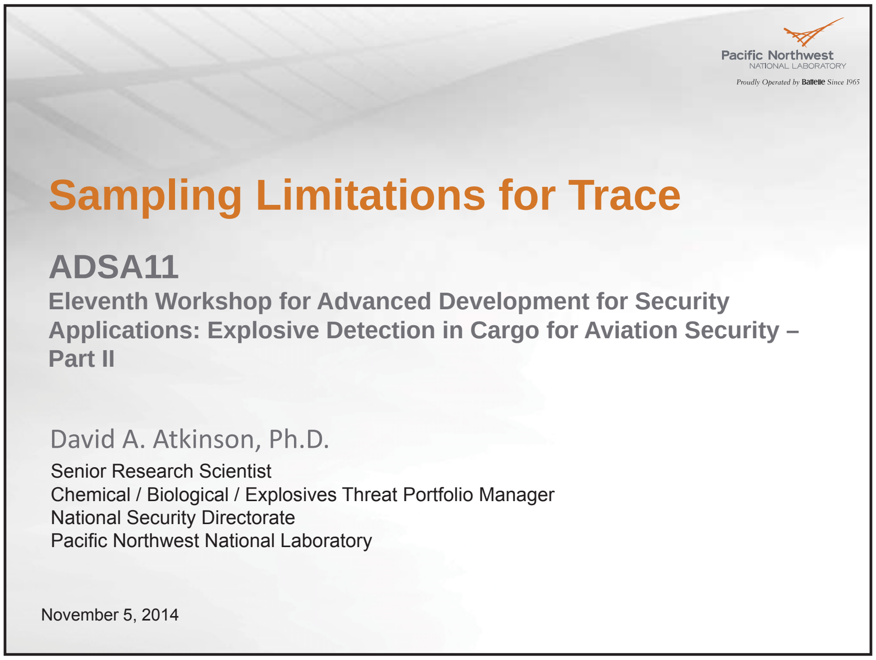
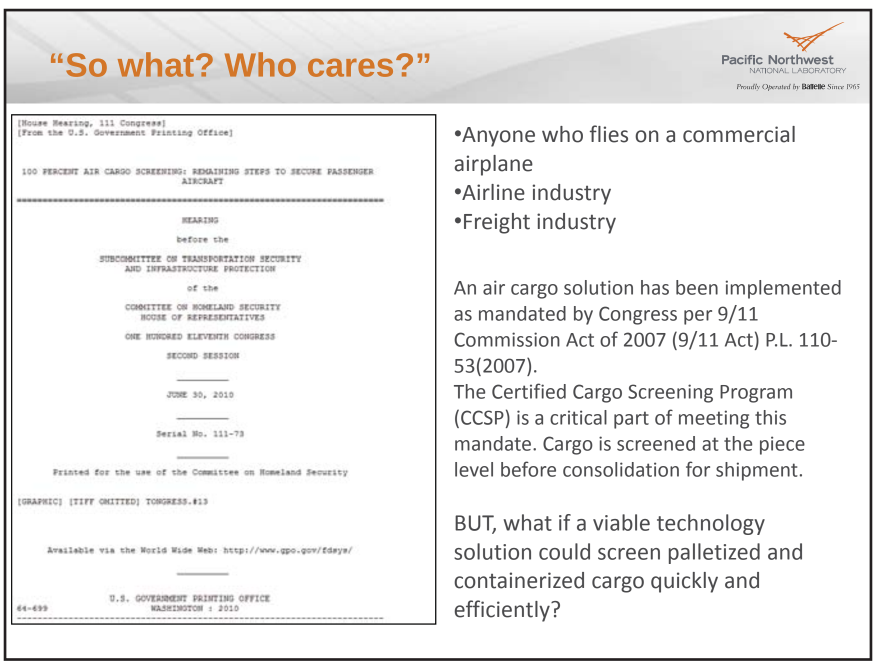
17.12 David Atkinson: Sampling Limitations for Trace





This is not an easy problem

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- Huge volumes of cargo are moved daily.
- The "just in time" aspect of air freight make the problem temporally difficult.
- Delays or additional handling have economic impact on the enterprise
- Cargo can have unpredictable shapes and sizes
- Imaging palletized and containerized cargo has issues with clutter and penetration

Trace solution

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Trace detection can be an effective solution to consolidated cargo.

However, there are issues and limitations that need to be addressed:

- Vapor versus particle
- Sampling method
- CONOPS – time and access
- Detection limits
- Which detection signature?

The vapor pressure issue

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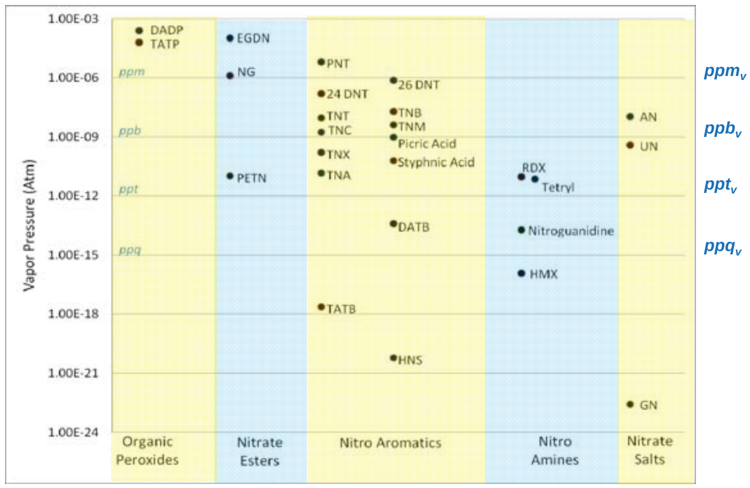

Ewing, Robert G., Melanie J. Waltman, David A. Atkinson, Jay W. Grate, and Peter J. Hotchkiss. "The vapor pressures of explosives." *TrAC Trends in Analytical Chemistry* 42, 35-48, 2013.

Vapor versus particle

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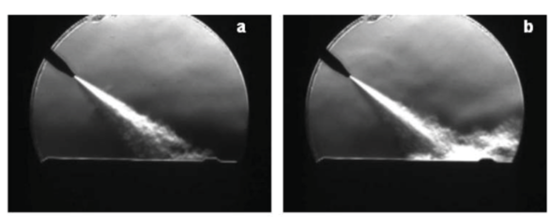
Realistically, collecting both would be optimal.

However, removing particles from surfaces AND transporting them across the inside of a cargo container space is difficult.

Aerosol Science and Technology, 42:1052–1061, 2008
Copyright © American Association for Aerosol Research
ISSN: 0278-6826 print / 1521-7388 online

Measurements of Air Jet Removal Efficiencies of Spherical Particles from Cloth and Planar Surfaces

Robert Fletcher,[1] Nathanael Briggs,[1] Erin Ferguson,[2] and Greg Gillen[1]
[1]*National Institute of Standards and Technology, Gaithersburg, Maryland, USA*
[2]*Clemson University, Chemistry Department, Clemson, South Carolina, USA*



Vapor versus particle

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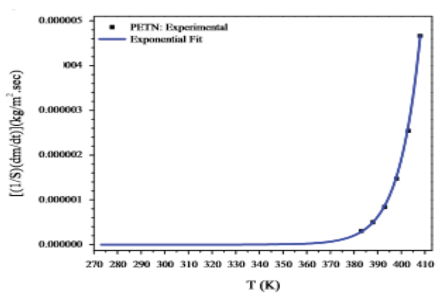
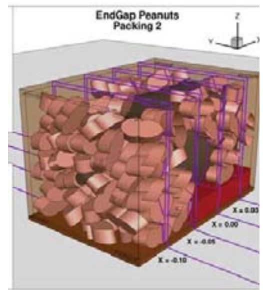
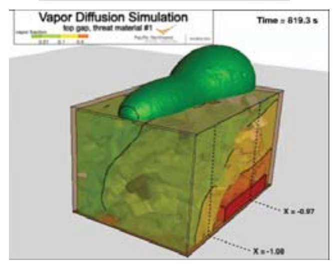
Vapor collection not only has the vapor pressure issue, but also has a surface area issue, of both the explosive and the surrounding materials.



Hikal, Walid M., and Brandon L. Weeks. "Sublimation kinetics and diffusion coefficients of TNT, PETN, and RDX in air by thermogravimetry." *Talanta* 125 (2014): 24-28.





Vapor sampling

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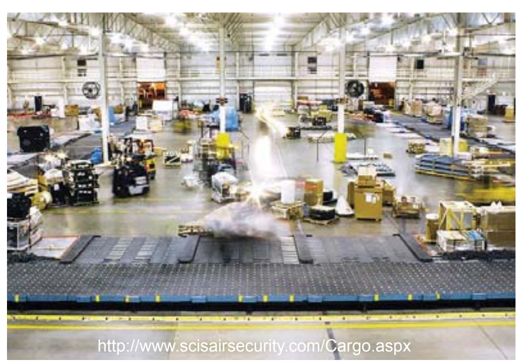
- Volume of sample needed (and thus time) is dependent on detection limits and preconcentrator efficiency
- Operational constraints such as time available per item and cargo configuration (container? shrink wrap? open pallet?) play a role in sampling approach
- Background issues?
- Analysis time versus sampling time (e.g. GC)
- Threats of interest (e.g. PETN vs. NG) will affect sampling parameters
- Sublimation enhancements such as heat, flash lamps, lasers



Commercial approaches - Teknoscan

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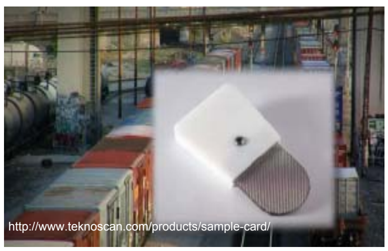
Obviously, large volume will be needed unless a detection capability is revolutionary.

Large volume increases the probability of capturing a particle



http://www.teknoscan.com/products/high-volume-aspiration-system//

Commercial approaches - Sedet

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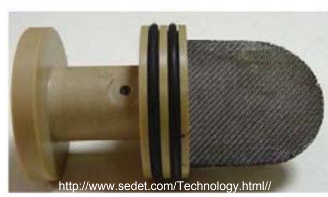
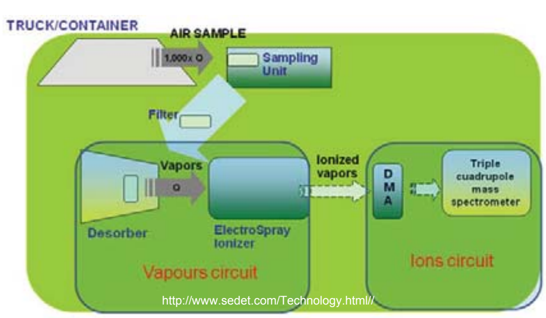
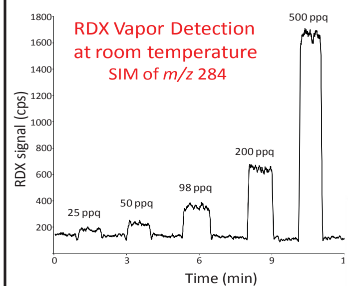
Using metal screens as high volume sampling preconcentrator is common.

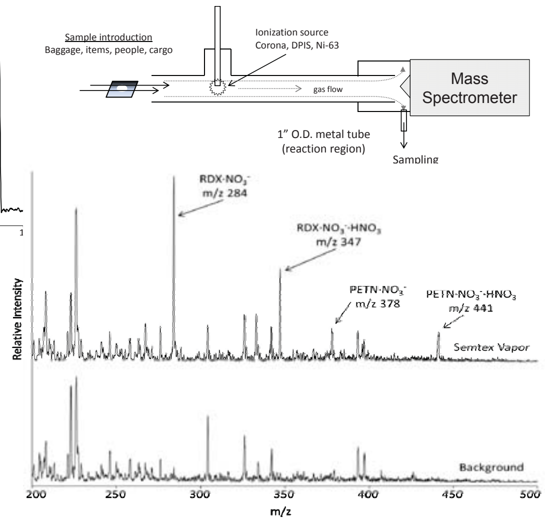
Differences in approach arise in the detection end point.





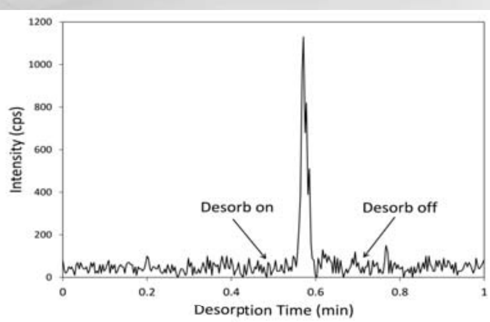
PNNL vapor detection technology





Vapor from mass in cargo container

- Sampled air from within a cargo container with 2 closed explosives magazines that contain a variety of explosives including RDX and C-4
- Sampled for 5 min at ~ 20 L/min onto a wire filament
- Sample was analyzed by the AFT-MS
- Estimated concentrations within the cargo container ~ 10-50 ppq



Cargo Container

High-speed desorption sampling tubes

Summary

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Proudly Operated by Battelle Since 1965

- Direct trace analysis of consolidated cargo is an attractive approach
- If detection limits do not allow for direct, real time detection (e.g. canines), then sampling will be a critical step
- Cargo configurations are widely variable, leading to difficulties in sampling methods
- Preconcentration must be robust, efficient, operationally suitable, and efficient
- Detection limits are important!
- Backgrounds and environment need to be considered
- It's all about surfaces

17.13 Susan Rose-Pehrsson: Trace Explosives Sensor Testbed (TESTbed)

Trace Explosives Sensor Testbed (TESTbed)

Dr. Susan Rose-Pehrsson

Navy Technology Center for Safety and Survivability

Naval Research Laboratory

ADSA11 - Explosives Detection in Air Cargo – Part II November 4-5, 2014

NRL's Role in DHS S&T Overall Mission

- **Trace Explosives Sensor Testbed** designed and constructed for the evaluation of a broad range of detection systems, materials and sensors.
- **Independent validation and verification (IV&V)** of the new materials, sensors and detection systems (TRL 2-6) under development by DHS S&T for explosives vapor detection
  - prior to TSL certification testing
  - critical guidance to DHS and sensor developers early in project development
- **Promote advancement of explosives sensor development in wider community via**:
  - -documentation in refereed journals
  - -new hardware for vapor generation
  - -new analytical verification approaches for trace explosive levels
- **Consultation and experimentation for solving any immediate and timely issues** that may arise for DHS S&T/TSA

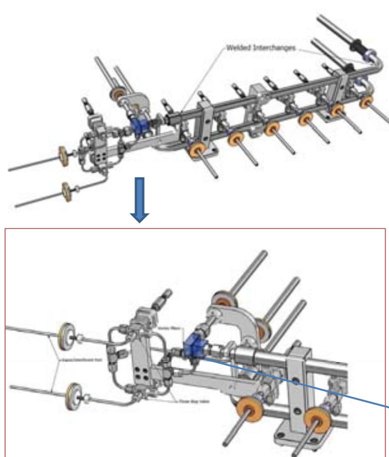
TESTbed

The TESTbed has dedicated computer control of a standardized vapor delivery system with an automated data collection system suitable for obtaining high quality data for sensor validation.

Key Features:

- Six identical sample ports
- Zero air source
- Four vapor generation sources
  - Permeation Tubes
  - Certified Gas Standards
  - Nebulizer/Pneumatic Flow System
  - Dynamic Headspace chamber
- Fully automated with a custom graphical user interface
- Housed in an Oven
  - Operational Temperature Range: 20 - 130 °C
  - Bake out to 150 °C
- Humidity control 0-85%

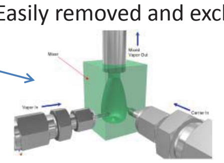
TESTbed Manifold



Three way inlet/bypass valves

Manifold key features:

- Sulfinert^{TM} treated stainless steel tubing
- Dual distribution manifolds, one for clean air and the other for analytes
- Rapid switching between manifolds
- Two inputs to the analyte manifold
- Custom mixer for uniform mixture on analyte manifold
- Three way inlet/bypass valve
- Six sample ports for individual or simultaneous testing of multiple sensors
- Easily removed and exchanged



Vortex mixer

Conditioned Air

Environics and Miller-Nelson

Key features:

- Environics Series 7000 Zero Air Generator
  - Delivers up to 20 liters per minute, 30 psi of dry, contaminant-free air.
  - Free from
    - Water vapor
    - Particulates
    - <0.5 ppb Sulfur dioxide, hydrogen sulfide, oxides of nitrogen, nitrogen dioxide, ozone, carbon monoxide and hydrocarbons
- Miller-Nelson Test Atmosphere Generator controls and monitors the initial Flow Rate, Temperature, and Humidity level
    - Flow Rate : 2 - 20 L/min
    - Temperature : 20 - 35 °C
    - Humidity : 20 - 85 %RH

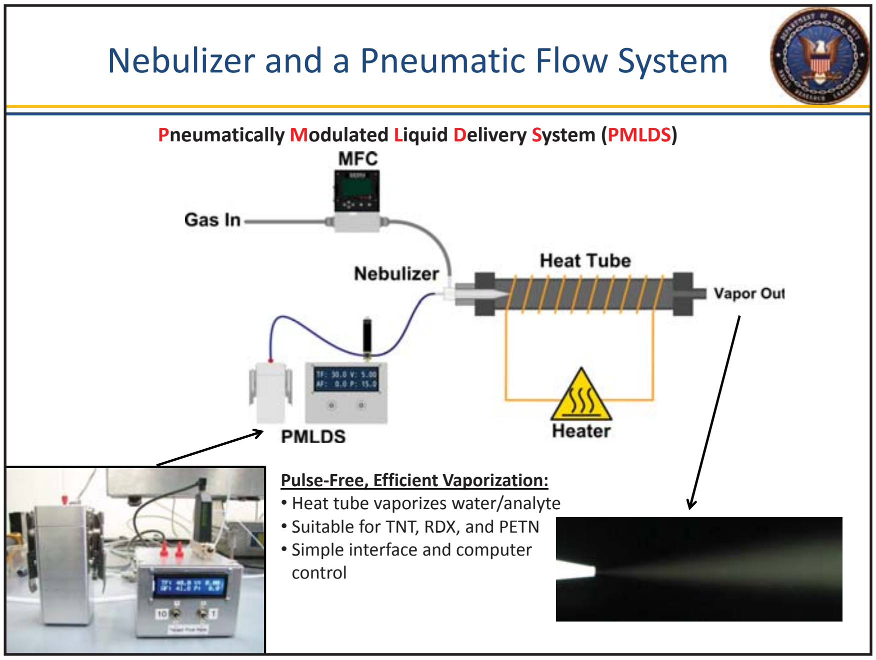
Commercial Test Vapor Sources

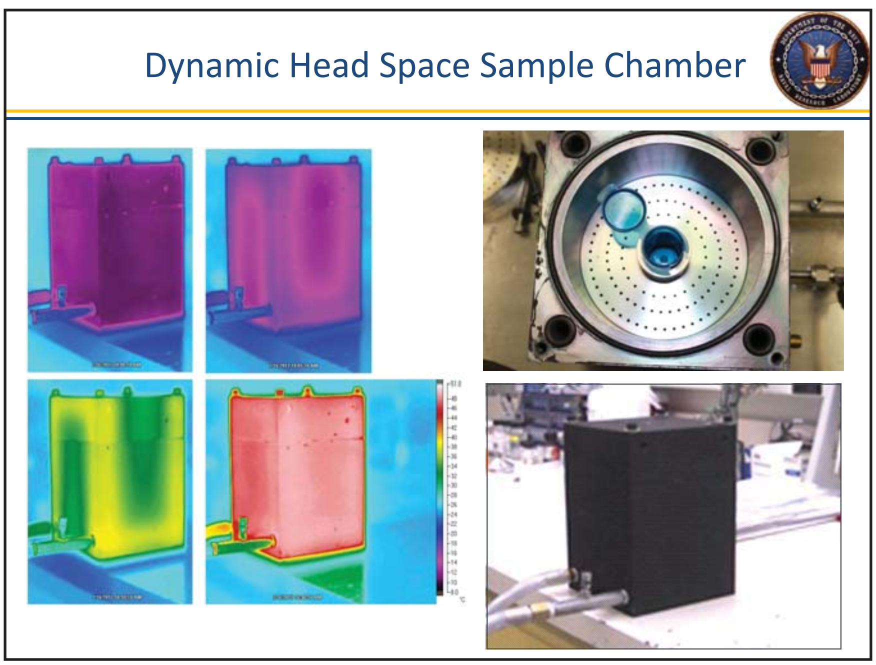
Kin-Tek FlexStream Automated Permeation Tube Oven

Calibrated Gas Standards

Permeation Tubes

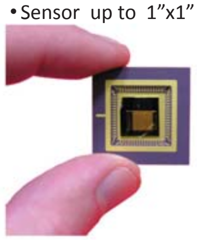
- The FlexStream Automated Permeation Tube System controls both its oven temperature as well as the carrier gas flow rate through the oven module
  - 500 permeation tubes available
    - NH_3
    - HNO_3
    - DNT
  - Custom tubes optional
- Auxiliary flow controller for calibrated gas standards (Flow Rate: 10 - 1000 mL/min)

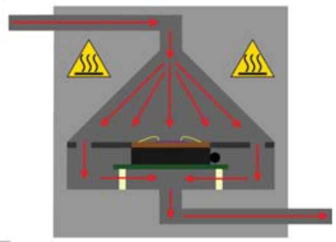

Nebulizer and a Pneumatic Flow System
Pneumatically Modulated Liquid Delivery System (PMLDS)
MFC
Gas In
Nebulizer
Heat Tube
Vapor Out
PMLDS
Heater
Pulse-Free, Efficient Vaporization:
• Heat tube vaporizes water/analyte
• Suitable for TNT, RDX, and PETN
• Simple interface and computer control

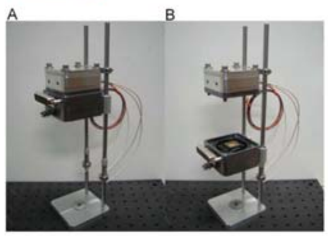

Dynamic Head Space Sample Chamber

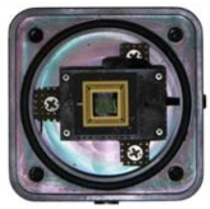
Impactor Chamber

- Chamber for electronic sensors such as chemiresistors, SAW
- Temperature controlled, Sulfinert™ coated sample chamber
- Sensor up to 1”x1” in a PGA chip, connected with a ZIF





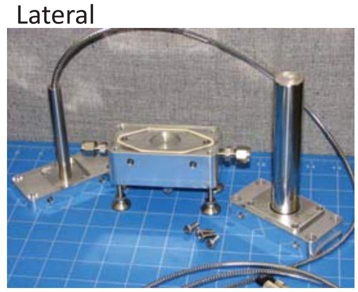




Optical Chamber

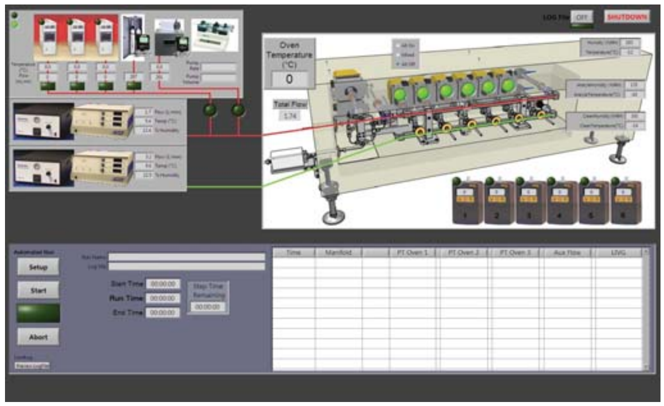
Impactor

Lateral



- Chemiluminescence and fluorescence or fluorescence quenching
- Temperature controlled, Sulfinert™ coated chamber
- Sample Size 1”x1”
- Photomultiplier tube (Hamamatsu R1288A-27) for chemiluminescence
- Fiber optic probe for the fluorescence
    - Avantes and features 12 illumination fibers of 200 µm surrounding a single detection fiber of 600 µm

Computer Control



- Touch screen interface allows user to control/monitor/store system parameters for all components
- Standard test protocols preloaded
- Custom test protocols easily developed, implemented and stored

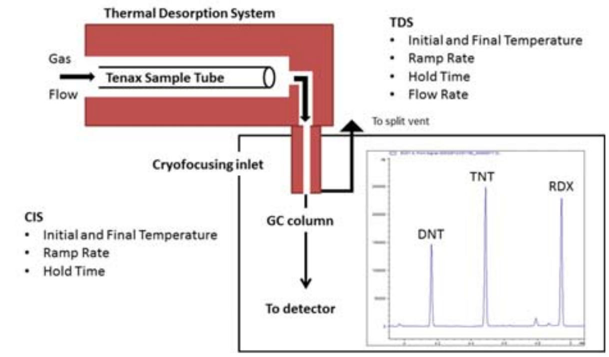
TESTbed Validation

System has been characterized with the following analytes

- Ammonia from 10 ppb-10 ppm
- Nitrogen Dioxide from 10 ppb-10 ppm
- Carbon Monoxide from 1 ppm – 1000 ppm
- Methyl Salicylate
- Hexane
- DNT from 10 ppt_v - 50 ppb_v
- TNT from 640 ppq_v – 10 ppb_v
- RDX from 850 ppq_v – 1 ppb_v
- PETN from 12 ppt_v - 1 ppb_v
- TATP from 5 ppb_v – 5 ppm_v

Confidence Check: Standard protocol developed using 2,4-DNT

Analytical Validation Method



Explosives validated using Tenax/TDS-CIS-GC-ECD showing accuracy and precision within the experimental limits of the protocol

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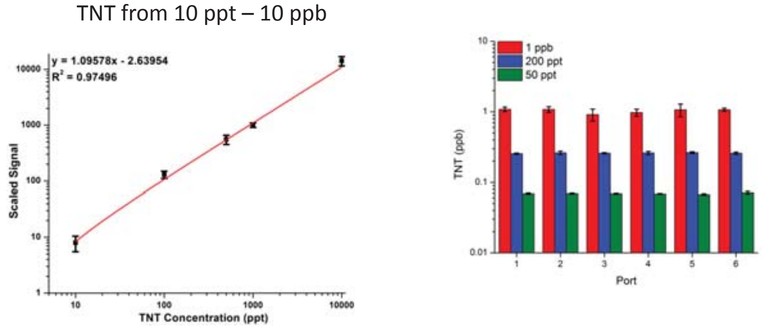
Analytical Validation Method using Tenax/TDS-CIS-GC/ECD

TNT from 10 ppt – 10 ppb

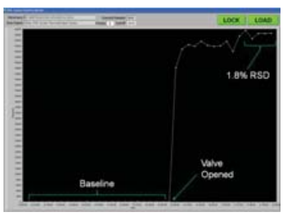


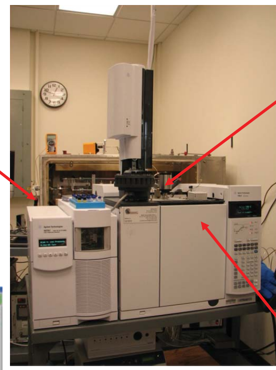
- Analytical methods developed for **DNT, TNT, RDX, PETN, TATP**
- Manuscripts submitted and/or published for each of these analytes

Online Verification

Agilent 5975C MSD

- Electron Impact
  - Rapid Identification of 1000 compounds
- Chemical Ionization
- Negative CI
  - Selectivity
  - Low Limits of Detection
    - ➢TNT = 40 fmole
    - ➢RDX = 100 fmole





Gerstel Online Cooled Inlet

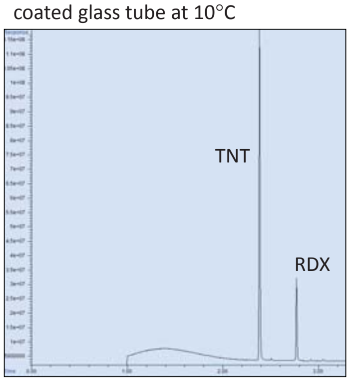
- Adsorbs at 250 mL min^{-1}
  - 10 mL-10 L adsorption Vol.
- Cyro-cooled sorbent bed
- Rapid desorption (12°C sec^{-1})
- Variety of sorbents
  - Tenax TA™
  - CarboTrap C
  - CarboTrap B
  - Silanized Glass

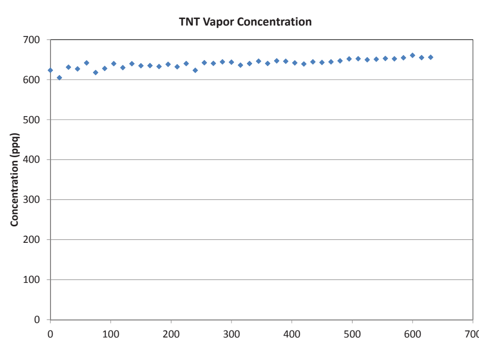
Agilent μECD

- Selectivity
- Low Limits of Detection
  - ➢TNT = 440 fmole
  - ➢RDX = 1.1 pmole
  - ➢PETN = 1.5 pmole

Parts per Quadrillion Generation of TNT

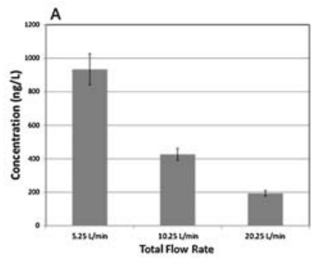
A representative GC chromatogram of TNT and RDX collected on a Siliconert coated glass tube at 10°C

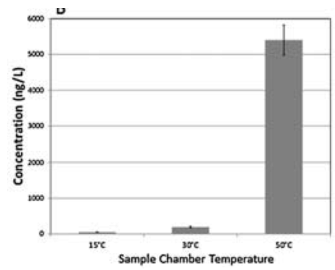




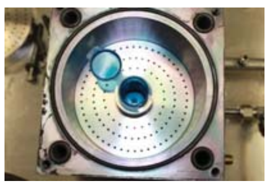
Average Concentration – 640 ppq
RSD – 1.7%

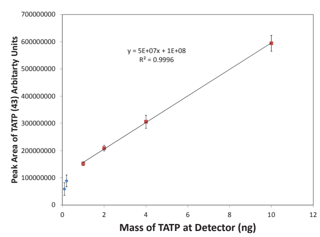
Online Programmable Temperature Vaporization (PTV) GC/MS for TATP





- TATP dynamic range of 50-5400 ng/L
- Verified using TDS-CIS-GC/MS





Vapor Validation – Lowest Concentration Quantified (LCQ)

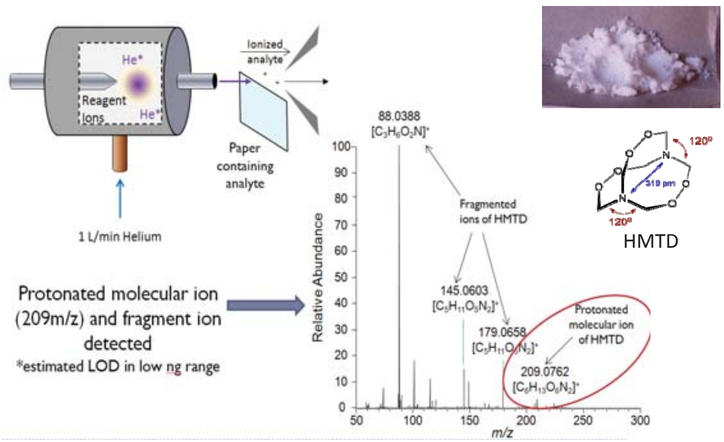
Summary of the vapor concentrations detected in our laboratory. Realize that lower vapor concentrations are achievable with longer sample times.

Explosive	Sat. Vapor Conc.*	TDS-CIS-GC		On-line CIS-GC	
		Sample Time (Vol.)	LCQ	Sample Time (Vol.)	LCQ
TNT	~9 ppb_v	60 min (6 L)[a]	3.4 ppt	13 min (0.66 L)[b]	640 ppq
RDX	~5 ppt_v	60 min (6 L)[a]	4.3 ppt	13 min (0.66 L)[b]	850 ppq
PETN	~11 ppt_v	30 min (3 L)[a]	12 ppt		
TATP	~63 ppm_v			1 min (0.025 L)[a]	5.5 ppb

[a] Sample was collected on Tenax-TA sorbent at or near 25°C
[b] Sample was collected on a Silconert coated glass tube at 10°C

* From "The Vapor Pressure of Explosives," Ewing *et al.* Trends in Analytical Chemistry, Vol. 42, 2013, 35-48

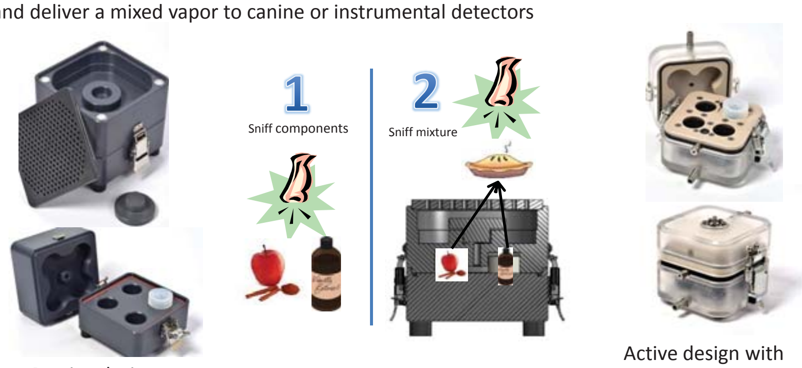
HMTD: Ambient Ionization using FAPA



HMTD parent molecule observed using Flowing Atmospheric-Pressure Afterglow-Mass Spectrometry (FAPA-MS) with sample deposited onto a piece of paper at the nanograms/mm^2 level

Related Program:
Mixed Odor Delivery Device (MODD)

A device has been designed to safely contain separated binary explosive components and deliver a mixed vapor to canine or instrumental detectors

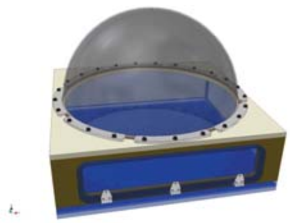


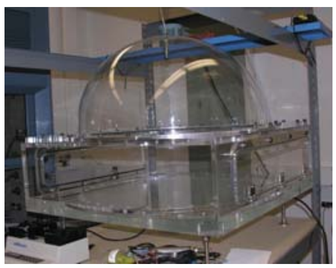
Passive design

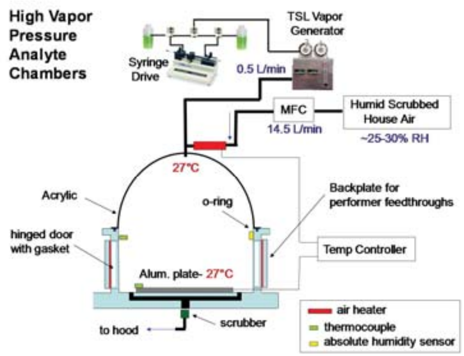
Active design with heated chamber

- Safely monitor dangerous IED mixtures: e.g., ANFO or AN/Al
- Vapor mixed from four separate PFA jars

Related Program:
Trace Explosives Dome Testbed







The testbed provides uniform, reliable methods for evaluating large scale, explosives detection systems for personnel and platforms protection.

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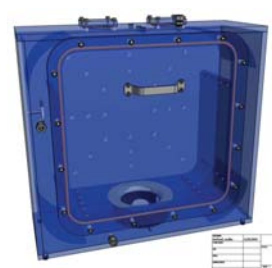
Related Program:
Trace Explosives with Particles Dome Testbed

Horizontal Chamber Design for Particles



Vertical Chamber Design

- Evaluation of large scale explosive detection systems for personnel and platforms' protection
- Fan included to promote circulation
- Particles can be introduced, e.g. Arizona Road Dust, to generate explosive/particle mixtures

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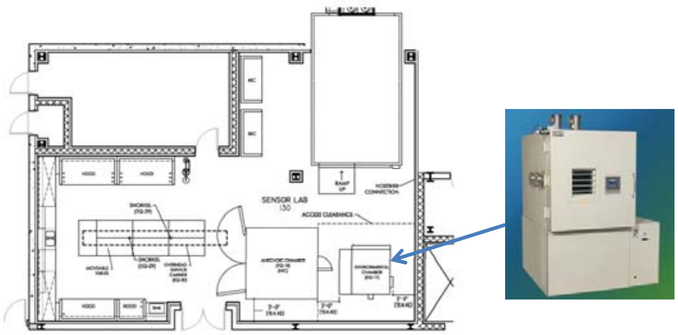
LASR-Sensor Lab

Sensor Lab Facilities

- Walk-in environmental chamber
  - 10’ X 15’
  - Temp: -30-50ºC, Humidity: 10-95% RH
  - Walls that can be washed down
- CSZ Temperature/Humidity /Altitude Chamber
- Aerosol Lab with wind tunnel

Other Facilities

- Desert High Bay
- Littoral High Bay
- Tropical High Bay
- Reconfigurable Prototyping High Bay
- Power and Energy Lab
- Human-System Interaction Labs



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Co-Authors:

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Related programs funded by DARPA and ONR

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17.14 Danny Fisher: Air Cargo Screening Requirements and Test Methodology

PRIME MINISTER'S OFFICE

Air Cargo Screening
Requirements and Test Methodology

ISRAEL PRIME MINISTER'S OFFICE

Nov 4th, 2014

Danny Fisher dannyf@project.gov.il
Erez Attias sec.tec@012.net.il

Background

1. Israeli cargo is divided into two main paths:
   1. Sea Ports: 99%
   2. Air Cargo: 1% - through three main cargo terminals
2. ~160,000 Tons (160 X 10^6 Kg) via aircrafts
3. ~60% by passengers aircrafts
4. IPMO is initiating a high priority program for Air Cargo Screening

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Northeastern University Boston MA

Main Technical Requirements

- The system will not require disassembling the cargo on the pallet (1.1 X 1 X 1.6 m).
- The system will not require the opening or separation of an individual piece of cargo.
- The screening must in no way harm the contents of the commercial cargo
- False Alarms - Low percentage – Less than 0.5%

Main Operational Requirements

- Screening time - up to 10 minutes
- Mean time between screens - 5 minutes at the most
- Mean recovery time after alarm - no more than 15 minutes
- Time required to begin screening including calibration and checks – less than 30 minutes

Approaches and Principals

- **Trace Vapor Detection**
  - HVS – Preconcentration – Analysis
  - Direct sniffing
- **Detection of Initiation Device**
- **Bulk Detection**
  - TBD (next ADSA?)

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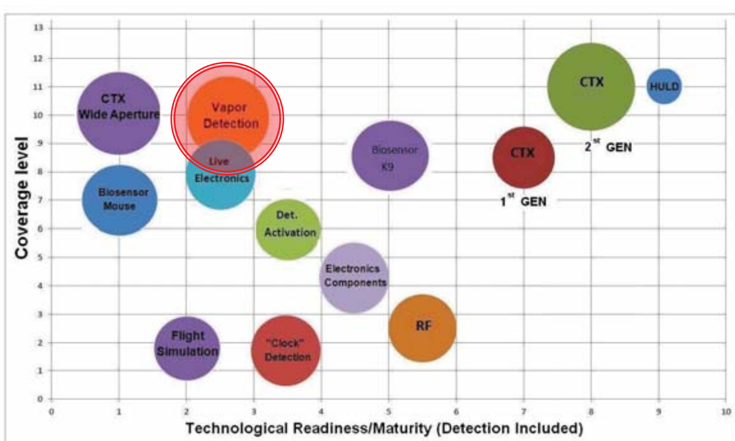
Technology Comparison



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Vapor Pressure

Name	Vapour Pressure (rel. | Torr)	Preferred Trace Det.
TNT	7.7 ppb | $5.8 \cdot 10^{-6}$ (25 °C)	Particle (Vap.)
RDX	6.0 ppt | $4.6 \cdot 10^{-9}$ (25 °C)	Particle
HMX	3.95 ppt | $3 \cdot 10^{-9}$ (100 °C!)	Particle
Tetryl	7.5 ppt | $5.7 \cdot 10^{-9}$ (25 °C)	Particle
PETN	18 ppt | $1.4 \cdot 10^{-8}$ (25 °C)	Particle

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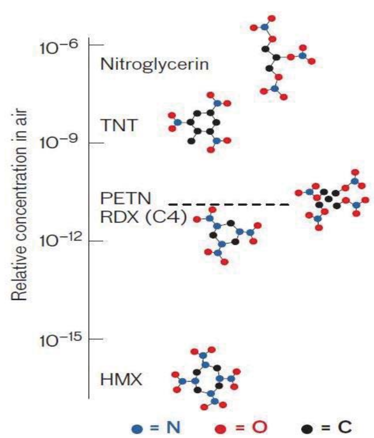
Relative Conc. in Air



Well,
how much is it?

Novel Method for Remotely Detecting Trace Explosives
C. M. Wynn, S. Palmacci, R. R. Kunz, M. Rothschild

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Basic Calculation

Vapor pressures are often expressed as **relative concentrations in saturated air, rather than in true pressure** units.

Usually expressed in units of ppm, ppb or ppt.

For an ideal gas we have the following relationship between the (vapor) pressure ***p*** *(in Pascal, with 1 Torr = 133 Pa), the volume* ***V*** *(m3), the quantity of gas* ***n*** *measured* in moles (e.g. 1 mole TNT = 227.13 grams), and the absolute temperature ***T*** *in Kelvin:*

pV = nRT => n/V = p/RT

With ***R*** *being the universal gas constant (8.31 J·mol–1·K–1).*

The TNT relative concentration at 25 °C for example amounts to 5.8·10–6 torr, or 7.7 ppb, **corresponding to about 0.07 ng/cm³**

An order of magnitude figure for *TNT of 0.1 ng/cc is often encountered*

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A potential for 1microgram / 10 liter saturated air

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What can be done?

Look for other molecules?

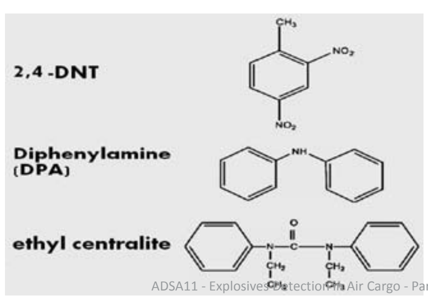
Preconcentration – integrated or separated for the detector

Better sensitivity? – are these available? (SPR, EC, TR…)

A combination is well preferred.

Other ingredients of Energetic Materials [smokeless powders]

The detection of **diphenylamine**, ethyl and methyl centralite, 2,4-DNT, diethyl and dibutyl phthalate by IMS is suggested as a method to indicate the presence of smokeless powders (Analysis of the headspace composition of smokeless powders using GC–MS, GC-μECD and IMS. [Forensic Science International (2010) **Almirall** et al]



DNT & DPA are 15-140 X 10^3 more likely to be found at vapor phase (vs. PETN or RDX)

Other ingredients of Energetic Materials [Explosives]

Two major groups of compounds can be found:

- Taggants (such as NG, EGDN, DMNB)
- Starting materials or additives (solvents, plasticizers, binders)

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Trace Headspace Sampling with Cryoadsorption

		recovered mass (ng/L)	
	compounds in the headspace	(20 °C)	(40 °C)
semtex-1A	isophorone	102	440
	γ-butyrolactone	51.0	205
	DMNB	2240	8850
tagged-C-4	bis(2-ethylhexyl)adipate	1.1	17.5
	DMNB	4460	13560
detaflex	γ-butyrolactone	116	250
	tributyl acetalcitrate	37.3	367
detcord	γ-butyrolactone	0.35	4.07
	nitroglycerin	224	1110
	diethyl phthalate	0.0006	0.03

T.M. Lovestead, T.J. Bruno *Anal. Chem.*, 2010, *82* (13)

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Characterization of Three Types of Semtex (H, 1A, and 10)

Comparison of SPME components for Semtex samples.

Component	1A	10	H
EGDN (detected as ethyl nitrate)[a)]	X	X	
4-Phenylcyclohexene[a)]	X		
Butyl benzoate[a)]		X	
2,6-Ditertbutyl-1,4-benzoquinone[a)]	X		
2,4-DNT			X
TNT[a)]			X
N',*N*-Butylphthalimide[a)]		X	
4-Formyl-2,6-ditertbutylphenol	X		
3,5-Ditertbutyl-4-hydroxyacetophenone	X		
Ethyl centralite[a)]	X	X	
Dibutyl phthalate[a)]	X	X	X
i-Propylhexadecanoate	X	X	X
Hydrocarbons[a)]	X	X	X

S. Moore, M. Schantz, W. MacCrehan *Propellants Explos. Pyrotech*. 2010, 35, 1 – 10

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Pre-Concentrators

- COTS

- Tailored Made (usually it COST)

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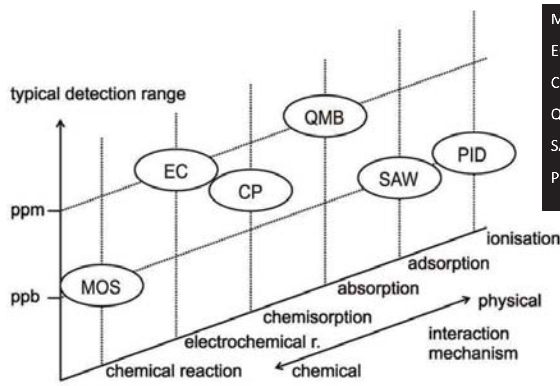
On 'Electronic Nose' Methodology



MOS: metal oxide semiconductor
EC: electrochemical cell
CP: conducting polymer
QMB: quartz micro balance
SAW: surface acoustic wave
PID: photo ionization detector

P. Boeker, On ,Electronic Nose' Methodology
Sensors and Actuators B: Chemical (2014)

17

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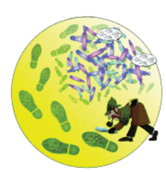
Vapor Detection - Program Schedule

- Q1/2014
  - Technology survey
- Q3/2014
  - 'First Impression' test – FAR oriented
    - 1st Detect – MS / Cylindrical Ion Trap (later this year)
    - Bruker – MS
    - SEDET – 3Q MS
    - PNNL – MS / Real-time vapor detection
    - Teknoscan – GC/IMS
    - Tracense – Silicon nanowires
- Q4/2014
  - Real Life Scenario (concealments)
- Q3-4/2015
  - Field test and Certification



18

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Full access to filed/cargo terminal

Chemicals

Electronics

Fish

19 ADSA11 - Explosives Detection in Air Cargo - Part II Nov 4-5, 2014
Northeastern University Boston MA

	LOD [pg]			UN type 1	FAR
	PETN	RDX	TNT		
Vendor 1	10-100	1-10	10-100	+++	<5%
Vendor 2	1000	100	1000	--	>5%
Vendor 3	1000	100	100	--	<5%
Vendor 4	1000	100	1000	+	>5%

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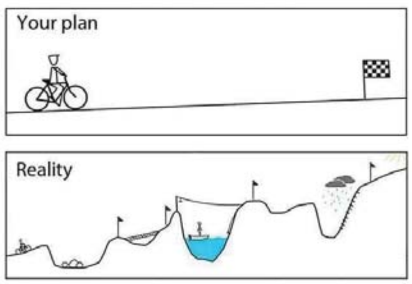
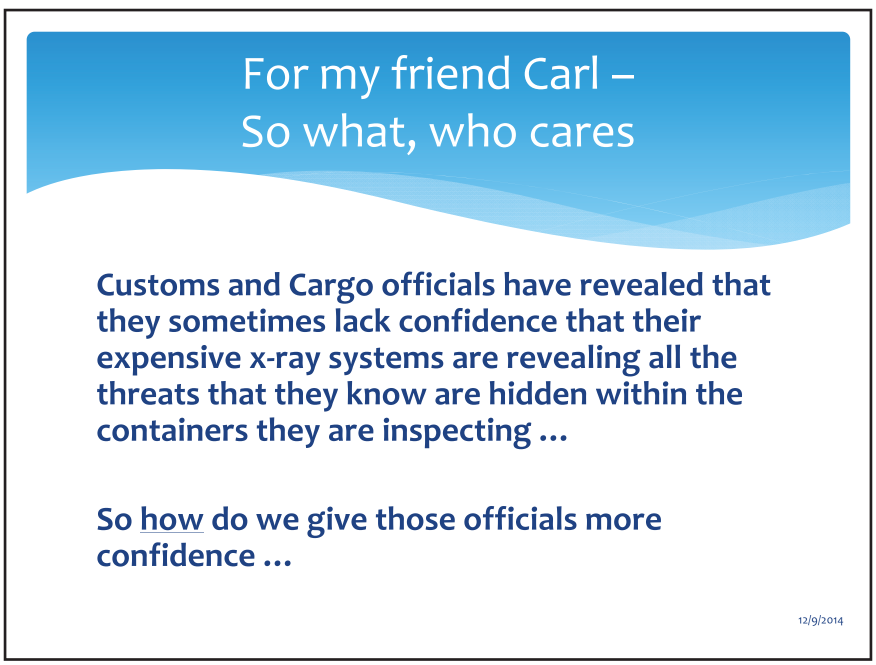
Summary

- It's the tip of the iceberg
- But we are prepared for the hard way



17.15 Peter Harris: A New Standard for Testing and Evaluating Cargo X-ray Technologies

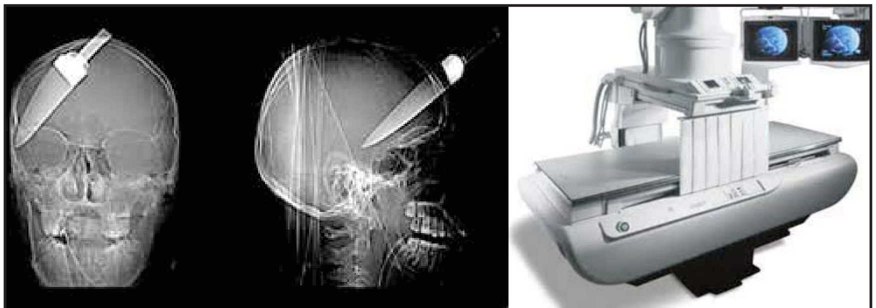


First, a question – at today's US airports, what do TSA officers do every day to ensure their baggage x-ray systems are working properly to ensure the best detection?

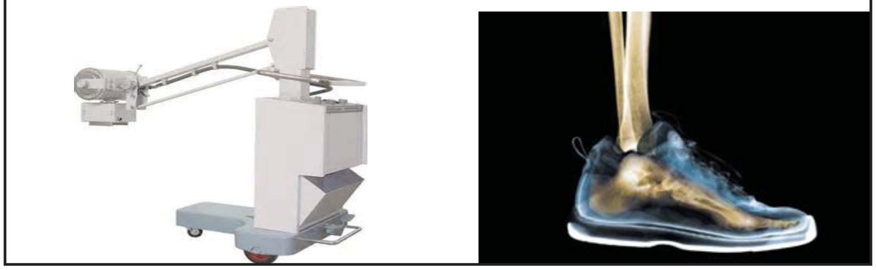
They calibrate the x-ray device with an Image Quality Phantom suitcase as part of mandatory SOP …

- **Used at all 2400 checkpoints across 450 Airports in the US on a daily basis to calibrate systems**
- **Used for all CT checked baggage systems across the US**
- **Tests for OPTIMAL Imaging performance, i.e. DETECTION!**

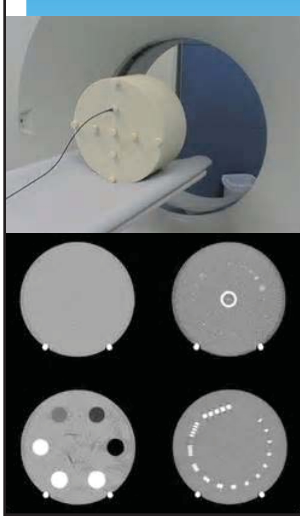
synergy4tech



What do Doctors do on a daily and weekly basis to ensure their X-rays are working to optimum performance?



They calibrate the x-ray device with an Image Quality Phantom



- **To check for optimal imaging performance**
- **To ensure appropriate radiation dosage**
- **To ensure image consistency**

"The IQ Phantom is a critical quality assurance and control instrument tool ideal for physicians who want to ensure superior patient care …"

synergy4tech

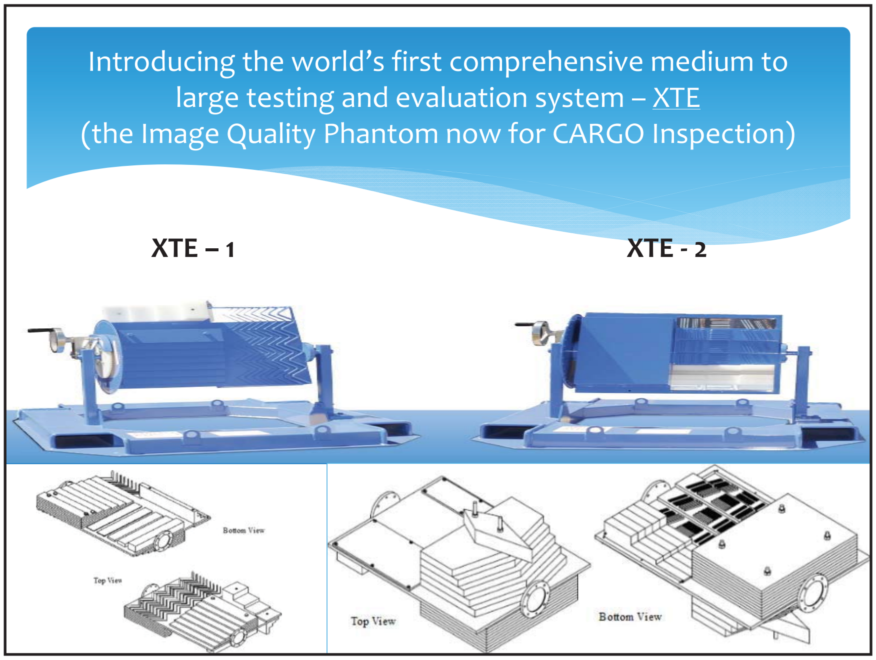
Okay, what about CARGO inspection?

Until

synergy4tech

Came Along …

12/9/2014


Introducing the world's first comprehensive medium to large testing and evaluation system – XTE
(the Image Quality Phantom now for CARGO Inspection)
XTE – 1
XTE - 2
Bottom View
Top View
Top View
Bottom View


Independently tested by:
US - (DHS – TSA)
UK - Defense Science & Technology Lab ((DSTL)
AUS – Australian Nuclear Standards Org (ANSTO)
XTE-1
XTE-2
XTE-1 resolution test
XTE

XTE-1 and XTE-2 together evaluate the performance of all scanners (from 120 keV and above)

They provide:

* 9 standard tests (Image resolution, material discrimination, spatial resolution, penetration, etc.)
* Fast and accurate evaluation (20 minutes)
* And compliant with ANSI and NIST standards

First Customer:

AUSTRALIAN CUSTOMS SERVICE

12/9/2014

How Australian Customs use XTE

- ✓ **Calibrate their many medium to large x-ray systems (120keV to 2.5MeV)**
- ✓ **Mitigate equipment failure**

  Identify performance issues as x-ray generators and detectors degrade over time

- ✓ **Make better purchase decisions**

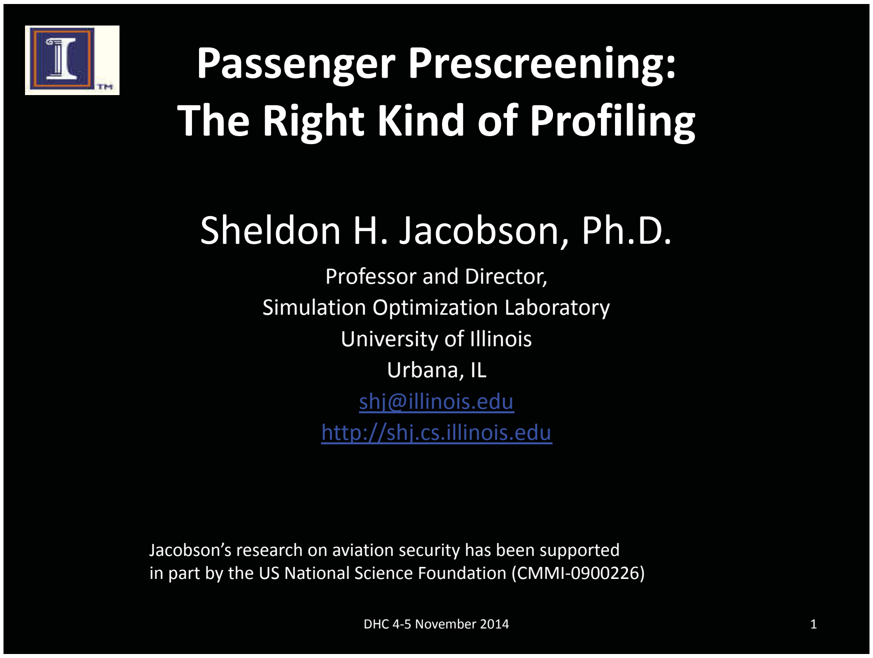
  Use XTE for acceptance testing
  Use it inclusively for RFP criteria

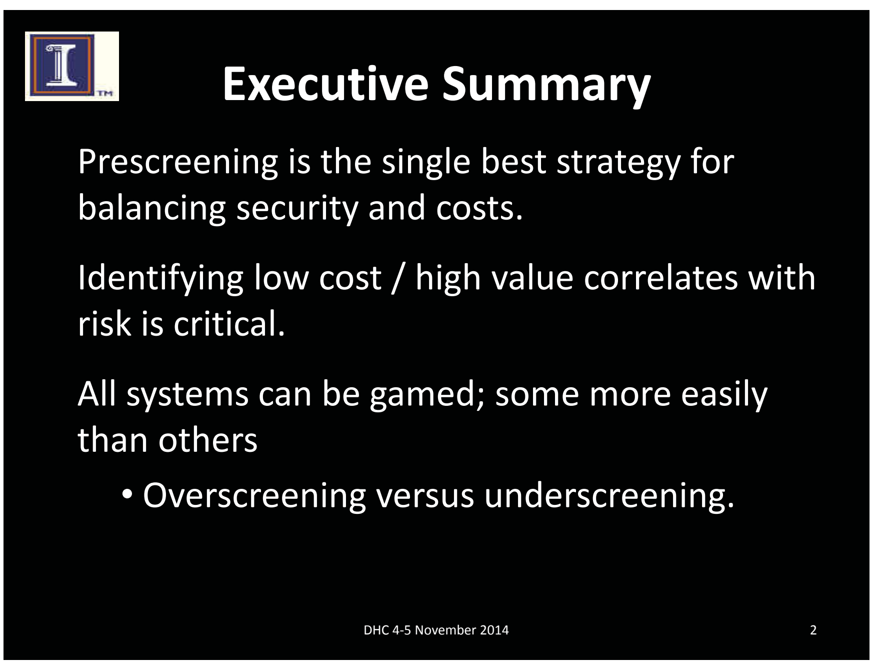
\+ 威视 NUCTECH

12/9/2014


Summary -
X-rays need to be calibrated
If Airports and Doctors are using image quality phantoms on a daily basis ensuring their devices are performing at their optimal best, then why isn't every port using standardized calibration to ensure superior detection?
Now they can with synergy4tech and XTE
12/9/2014

17.16 Sheldon Jacobson: Passenger Prescreening: The Right Kind of Profiling





My Background

Researched aviation security since 1996

Operations Research (Math, Comp. Sci., Economics)

Areas of Research

- Optimal Security System Design & Analysis
  - Security device deployment and utilization
- Cost-Benefit Analyses
  - 100% checked baggage screening
  - Intelligence versus technology assessment
- Risk Assessment and Mitigation
  - Real-time passenger security assignment

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Motivating Research Questions

- What is aviation security?
- How should aviation security be measured?
- How should aviation security be implemented?
- How much should aviation security cost?
- Who should pay this cost?

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Aviation Security Objectives

Minimize impact of willful human intent

Detect and terminate planned attacks (primary)

Deter potential attacks (secondary)

On-going assessment and readjustment of aviation security operations at airports

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Passenger Screening

- Most visible aspect of aviation security
- Many changes in aviation security since 9/11
  - New technologies (AITs)
  - New prescreening strategies (PreCheck)
- Passenger prescreening tools
  - CAPPS, selectees, nonselectees
  - No fly list
- TSA committed to a risk-based paradigm

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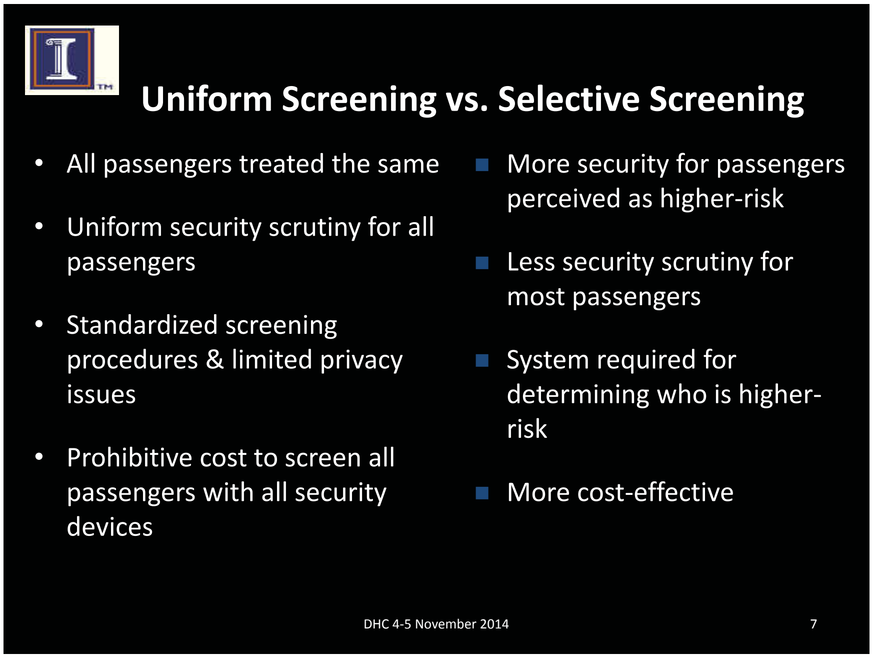
Uniform Screening vs. Selective Screening
• All passengers treated the same
• Uniform security scrutiny for all passengers
• Standardized screening procedures & limited privacy issues
• Prohibitive cost to screen all passengers with all security devices
■ More security for passengers perceived as higher-risk
■ Less security scrutiny for most passengers
■ System required for determining who is higher-risk
■ More cost-effective
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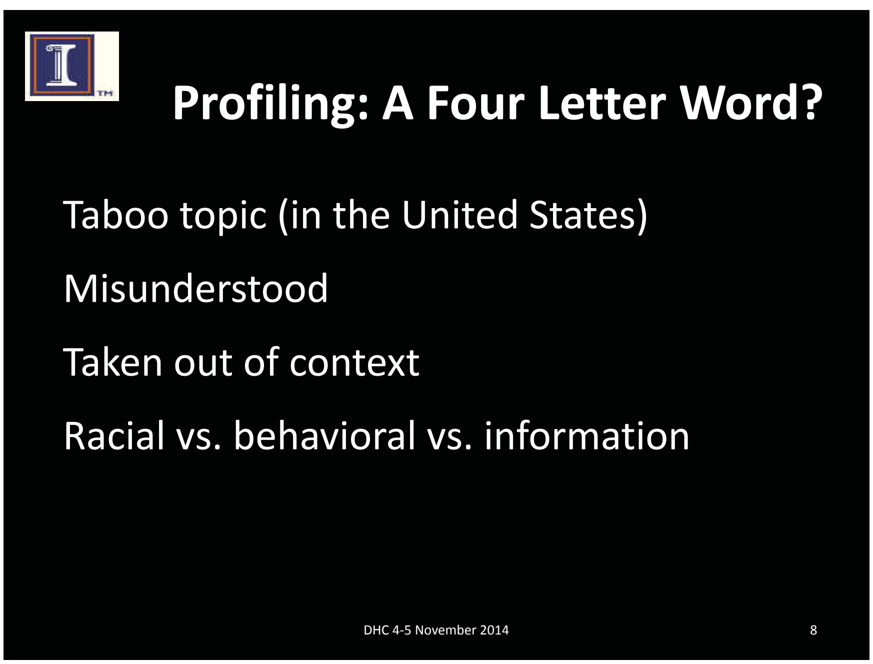
Profiling: A Four Letter Word?
Taboo topic (in the United States)
Misunderstood
Taken out of context
Racial vs. behavioral vs. information
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8

Passenger Prescreening

Profiling done the right way

Focuses on what is known and NOT KNOWN about a passenger

Aligns security resources based on the risk of the passengers

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Example #1

Passenger A

Travels 1-2 times per year

Always checks her bag

Flies the same route, round trip

Not a member of a frequent flyer program

Requires assistance when boarding/deplaning

Tickets purchased with a credit card that is not in her name

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Example #2

Passenger B

Travels 30-36 times per year

Rarely checks bag

Flies multiple routes

An elite member of several frequent flyer programs

Tickets purchased with a business credit card

Usually purchases refundable tickets

Often upgraded to first class

Many last minute changes to reservations

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Example #3

Passenger C

Travels 3-5 times per year, sometimes just one way

Never checks bag

Flies multiple routes, typically long haul domestic

Not a member of any frequent flyer programs

Has been known to pay cash for one way tickets

Has missed flights due to arriving late to gate

Typically uses fully refundable tickets

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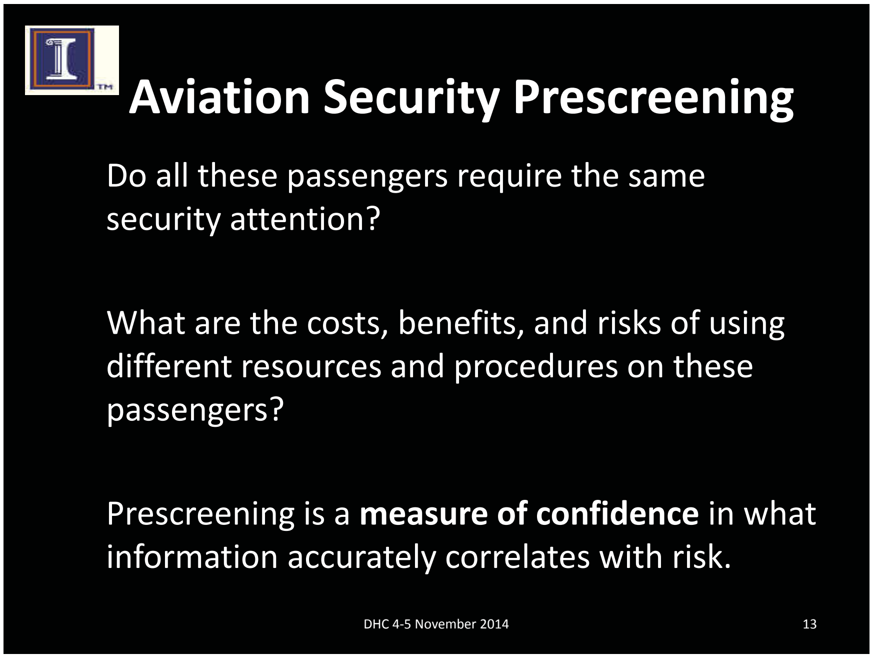
Aviation Security Prescreening
Do all these passengers require the same security attention?
What are the costs, benefits, and risks of using different resources and procedures on these passengers?
Prescreening is a **measure of confidence** in what information accurately correlates with risk.
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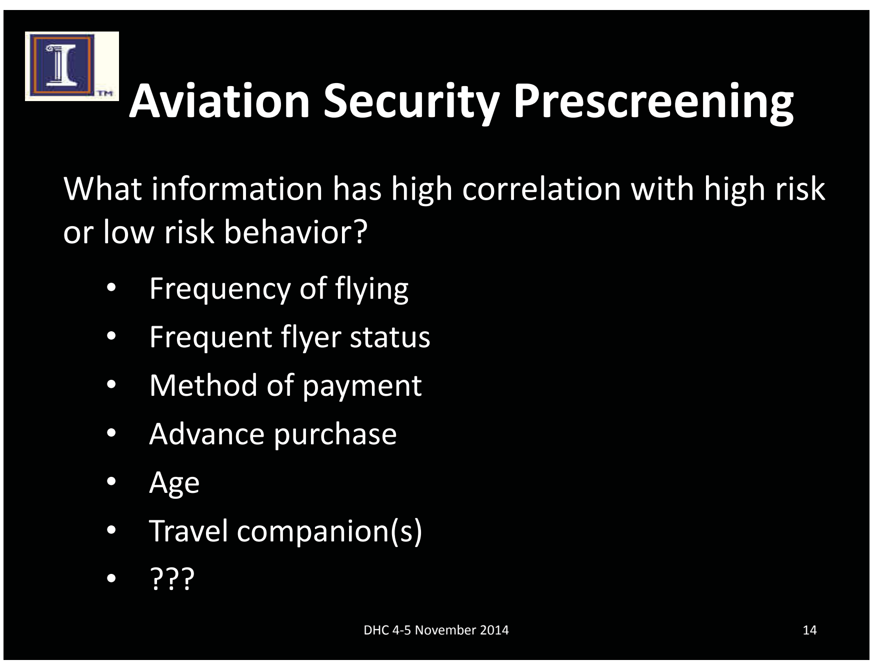
Aviation Security Prescreening
What information has high correlation with high risk or low risk behavior?
• Frequency of flying
• Frequent flyer status
• Method of payment
• Advance purchase
• Age
• Travel companion(s)
• ???
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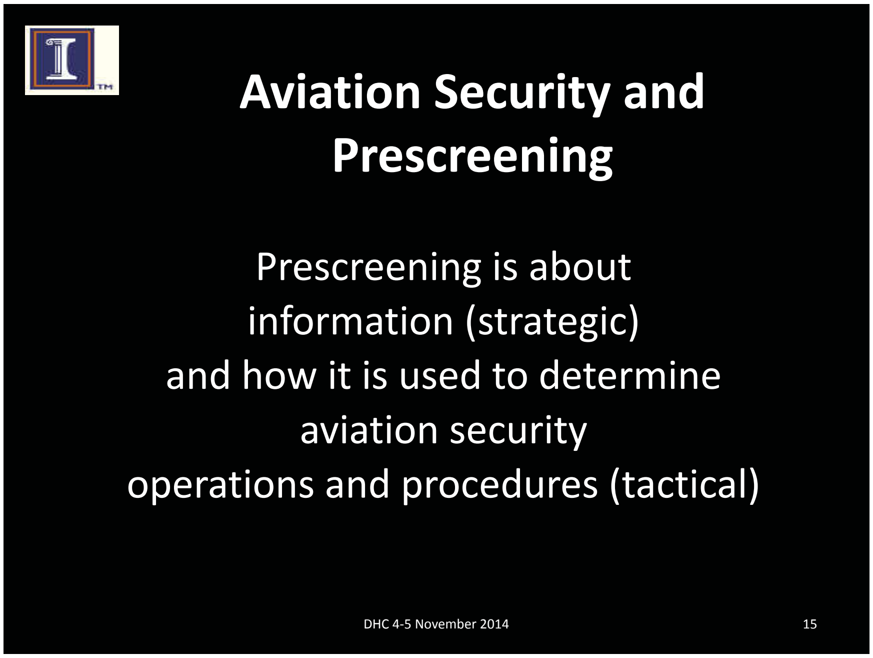
Aviation Security and Prescreening
Prescreening is about
information (strategic)
and how it is used to determine
aviation security
operations and procedures (tactical)
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15


The Three I's
Items (threats)
Identity (passengers)
Intent (people)
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The Reality

Most passengers pose no threat to the air system

Finding the few threats is akin to finding a few "needles in a haystack"

Any information that moves passengers into the *nonthreat* category is of enormous value and benefit to the air system

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Passenger Prescreening

Assumes that past events are predictive of future events

Information	*******
Behavioral	****
Racial	*

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Passenger Prescreening

No one type is sufficient on its own

* Information, Behavioral, Racial

Collectively, they can be used to put a sizeable portion of enplanements (60%-70%, maybe 80%) into the *non-threat* category

* a single person can account for 200 enplanements per year

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Advanced Imaging Technologies

If perfect correlates for risk and intent were available, then they (and all screening procedures) would be superfluous

Using AITs for primary screening creates a ***false*** sense of security

TSA PreCheck moves the use of AITs closer to the appropriate level

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Observations

Strategic vs. tactical breakthroughs

Information prescreening trumps technological advances

Align passenger risk footprint with security procedure/technology footprint

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Underscreening vs Overscreening

Underscreening: Use lower levels of screening procedures / technologies than the risk may warrant

Overscreening: Use higher levels of screening procedures / technologies than the risk may warrant

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Practical Tendencies

Underscreening will tend to occur with medium risk passengers

* Works best in low risk environment

Overscreening will tend to occur with low and medium risk passengers

Rightscreening is the ideal

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Underscreening

- May lead to more false clears (negligible)
- May underutilize resources

+ May provide greater flexibility when more security attention is needed

*In low risk environments, may provide some deterrence value

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Overscreening

- May lead to more false alarms
- May overtaxes resources / limits flexibility
- May divert attention from and obfuscate true risks

Natural tendency is to overscreen (emotional response, lack of information)

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Gaming

Decoys
- Low Risk (not a problem)
- High Risk (can lead to underscreening)

Timing
- Follow high risk passengers (similar to decoys)

Trial and Error
- Gains insight into passenger risk

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References

McLay, L.A., Lee, A.J., Jacobson, S.H., 2010, "Risk-Based Policies for Aviation Security Checkpoint Screening," *Transportation Science*, 44(3), 333-349.

Lee, A.J., Jacobson, S.H., 2011a, "Evaluating the Effectiveness of Sequential Aviation Security Screening Policies," *IIE Transactions*, 43(8), 547-565.

Lee, A.J., Jacobson, S.H., 2012, "Addressing Passenger Risk Uncertainty for Aviation Security Screening," *Transportation Science*, 46(2), 189-203.

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Thank you

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http://shj.cs.illinois.edu

217-244-7275

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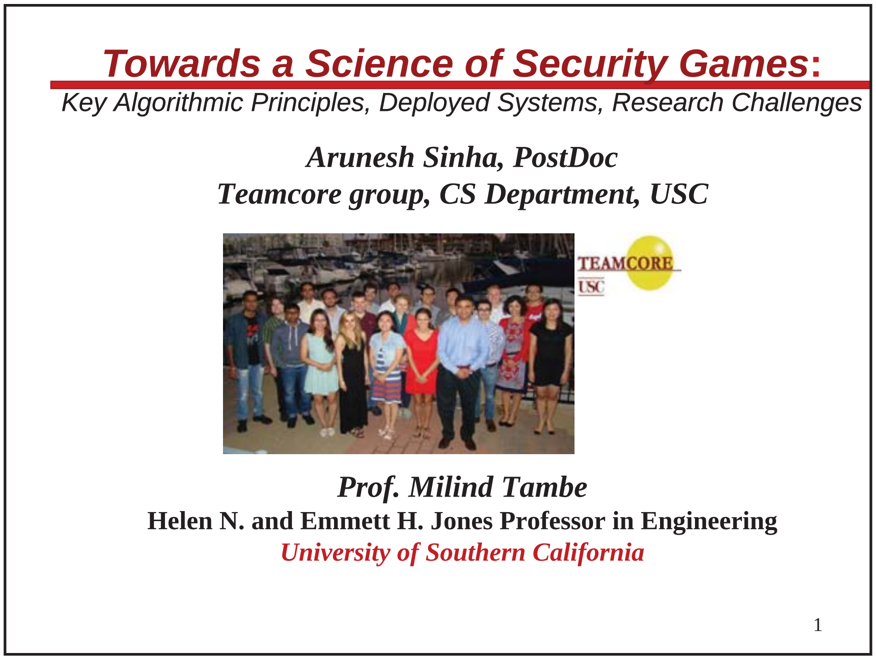
17.17 Arunesh Sinha & Milind Tambe: Towards a Science of Security Games



Example Model: Stackelberg Security Games

Security allocation:

- Targets have weights
- Adversary surveillance

Adversary

Defender

	Target #1	Target #2
Target #1	4, -3	-1, 1
Target #2	-5, 5	2, -1

3

Example Model: Stackelberg Security Games

Security allocation:

- Targets have weights
- Adversary surveillance

Adversary

Defender

	Target #1	Target #2
Target #1	4, -3	-1, 1
Target #2	-5, 5	2, -1

4

Example Model:
Stackelberg Security Games

Security allocation:

- Targets have weights
- Adversary surveillance

Adversary

Defender

	Target #1	Target #2
Target #1	4, -3	-1, 1
Target #2	-5, 5	2, -1

5

Stackelberg Security Games
Security Resource Optimization: *Not 100% Security*

- Randomized strategy:
  - *Increase cost/uncertainty to attackers*
- Stackelberg game:
  - *Defender commits to mixed strategy*
  - *Adversary conducts surveillance; responds*
- Stackelberg Equilibrium: Optimal random?

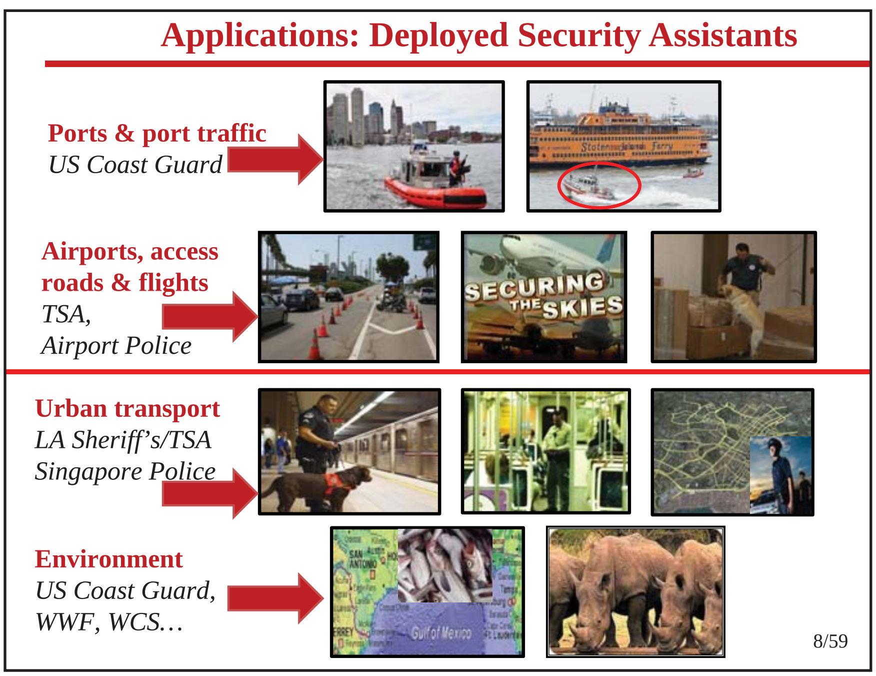
Adversary

Defender

	Target #1	Target #2
Target #1	4, -3	-1, 1
Target #2	-5, 5	2, -1

6


Research Contributions:
Game Theory for Security
Computational game theory:
• Massive games
Behavioral game theory:
• Exploit human behavior models
+ Planning under uncertainty, learning…
Computational Game Theory in the Field
7


Applications: Deployed Security Assistants
Ports & port traffic
US Coast Guard
Airports, access roads & flights
TSA,
Airport Police
SECURING THE SKIES
Urban transport
LA Sheriff's/TSA
Singapore Police
Environment
US Coast Guard,
WWF, WCS…
Gulf of Mexico
8/59

Key Lessons: Security Games

Decision aids based on computational game theory in daily use

- Optimize limited security resources against adversaries

Applications yield research challenges: Science of security games

- Scale-up: Incremental strategy generation & Marginals
- Uncertainty: Integrate MDPs, Robustness, Quantal response

Current applications (wildlife security): Interdisciplinary challenge

- Global challenges: Merge planning/learning & security games

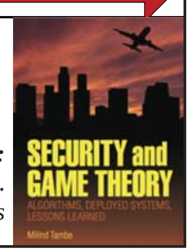
9

Outline: "Security Games" Research (2007-Now)

I: Scale up? Handle uncertainty?

II: Real-world deployments

Publications:
AAMAS, AAAI, IJCAI…
2007 onwards



Airport Security: Mapping to Stackelberg Games

ARMOR: LAX (2007)

- **6 plots against LAX**

GUARDS: TSA (2011)

GLASGOW 6/30/07

ARMOR Operation [2007]

Generate Detailed Defender Schedule

Pita *Paruchuri*

	Target #1	Target #2
Defender #1	2, -1	-3, 4
Defender #2	-3, 3	3, -2

Mixed Integer Program

Pr(Canine patrol, 8 AM @Terminals 2,5,6) = 0.17

Pr(Canine patrol, 8 AM @ Terminals 3,5,7) = 0.33

Canine Team Schedule, July 28

	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6	Term 7	Term 8
8 AM		Team1			Team3	Team5		
9 AM			Team1	Team2				Team4
10 AM		Team3		Team5		Team2		

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ARMOR MIP [2007]

Generate Mixed Strategy for Defender



Pita Paruchuri

	Target #1	Target #2
Defender #1	2, -1	-3, 4
Defender #2	-3, 3	3, -2

$$\max \sum_{i \in X} \sum_{j \in Q} R_{ij} \times x_i \times q_j$$

Maximize defender expected utility

$$s.t. \quad \sum_i x_i = 1$$

Defender mixed strategy

$$\sum_{j \in Q} q_j = 1$$

Adversary response

$$0 \leq (a - \sum_{i \in X} C_{ij} x_i) \leq (1 - q_j) M$$

Adversary best response

ARMOR Payoffs [2007]

Previous Research Provides Payoffs in Security Game Domains

+ Handling Uncertainty

	Target #1	Target #2
Defender #1	2, -1	-3, 4
Defender #2	-3, 3	3, -2

$$\max \sum_{i \in X} \sum_{j \in Q} R_{ij} \times x_i \times q_j$$

Maximize defender expected utility

14

ARMOR MIP [2007]

Solving for a Single Adversary Type

	Term #1	Term #2
Defend#1	2, -1	-3, 4
Defend#2	-3, 1	3, -3

ARMOR…throws a digital cloak of invisibility….

Handling Uncertainty

$$\max \sum_{i \in X} \sum_{j \in Q} R_{ij} \times x_i \times q_j$$ ← Defender expected utility

$$s.t. \quad \sum x_i = 1$$ ← *Defender strategy*

$$\sum_{j \in Q} q_j = 1$$ ← *Adversary strategy*

$$0 \le (a - \sum_{i \in X} C_{ij} x_i) \le (1 - q_j) M$$ ← *Adversary best response*

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IRIS: Federal Air Marshals Service [2009]
Scale Up Number of Defender Strategies

- *1000 Flights, 20 air marshals: 10^{41} combinations*
  - *ARMOR out of memory*
- *Not enumerate all combinations:*
  - *Branch and price: Incremental strategy generation*

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IRIS: Scale Up Number of Defender Strategies [2009]
Small Support Set for Mixed Strategies

Small support set size:

- Most x_i variables zero

1000 flights, 20 air marshals:

10^{41} combinations

$$\max_{x,q} \sum_{i\in X}\sum_{j\in Q} R_{ij} x_i q_j$$

$$s.t. \sum_{i} x_i = 1, \sum_{j\in Q} q_j = 1$$

$$0 \le (a - \sum_{i\in X} C_{ij} x_i) \le (1-q_j)M$$

$$x_i \in [0 \ldots 1],\ q_j \in \{0,1\}$$

x123=0.0

x124=0.239

x135=0.0

x378=0.123

	Attack 1	Attack 2	Attack …	Attack 1000
1,2,3	5,-10	4,-8	…	-20,9
1,2,4..	5,-10	4,-8	…	-20,9
1,3,5..	5,-10	-9,5	…	-20,9
…				
…				

10^{41} rows

17

IRIS: Incremental Strategy Generation
Exploit Small Support

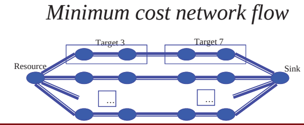
Master

	Attack 1	Attack 2	Attack…	Attack 6
1,2,4	5,-10	4,-8	…	-20,9

	Attack 1	Attack 2	Attack…	Attack 6
1,2,4	5,-10	4,-8	…	-20,9
3,7,8	-8, 10	-8,10	…	-8,10

Slave (LP Duality Theory)

Best new pure strategy:
Minimum cost network flow



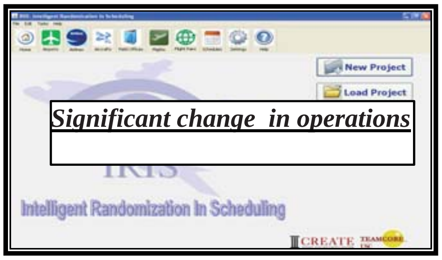
Converge:
GLOBAL
OPTIMAL

	Attack 1	Attack 2	Attack	Attack 6
1,2,4	5,-10			,9
3,7,8	-8, 10			.0
…				

500 rows
NOT 10^{41}

18

IRIS: Deployed FAMS (2009-)



***"…in 2011, the Military Operations Research Society selected a University of Southern California project with* FAMS on randomizing flight schedules for the prestigious Rist Award…"**

-R. S. Bray (TSA)
Transportation Security Subcommittee
US House of Representatives 2012

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Security Resource Optimization:
Evaluating *Deployed Security Systems* Not Easy

- Game theory: Improvement over previous approaches
  - *Previous: Human schedulers or "simple random"*

Lab Evaluation	**Field Evaluation: Patrol quality Unpredictable? Cover?**	**Field Evaluation: Tests against adversaries**
Simulated adversary	Compare real schedules	"Mock attackers"
Human subject adversaries	Scheduling competition	Capture rates of real adversaries
	Expert evaluation	

20

Why Does Game Theory Perform Better? Weaknesses of Previous Methods

- Human schedulers:
  - *Predictable patterns, e.g., US Coast Guard*
  - *Scheduling effort & cognitive burden*
- Simple random (e.g., dice roll):
  - *Wrong weights/coverage, e.g. officers to sparsely crowded terminals*
  - *No adversary reactions*
- Multiple deployments over multiple years: without us forcing them

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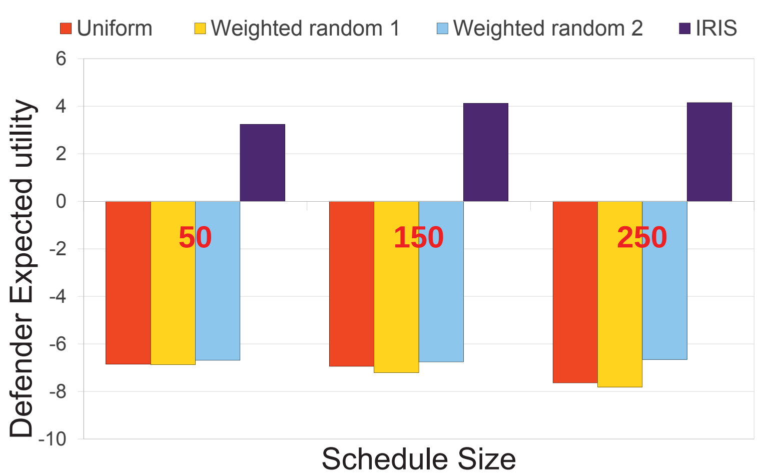
Lab Evaluation via Simulations: Example from IRIS (FAMS)

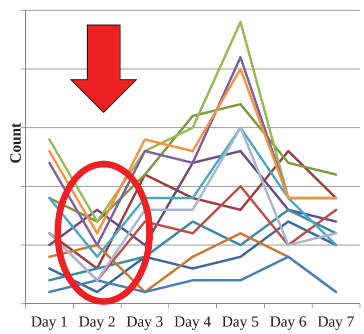


22

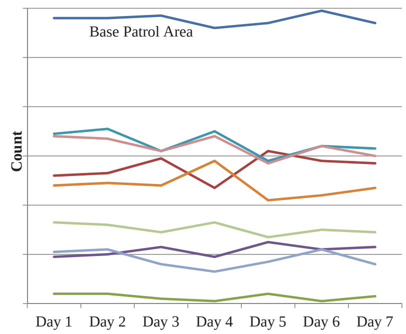
Field Evaluation of Schedule Quality:
Improved Patrol Unpredictability & Coverage

PROTECT (Coast Guard): *350% increase defender expected utility*

Patrols Before PROTECT: Boston



Patrols After PROTECT: Boston



23

Field Evaluation of Schedule Quality:
Improved Patrol Unpredictability & Coverage for Less Effort

IRIS for FAMS: Outperformed expert human over six months
Report:GAO-09-903T

ARMOR at LAX: Savings of up to an hour a day in scheduling

24

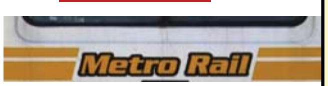
Field Test Against Adversaries: Mock Attackers Example from PROTECT

- "Mock attacker" team deployed in Boston
  - *Comparing PRE- to POST-PROTECT: "deterrence" improved*
- Additional real-world indicators from Boston:
  - *Boston boaters questions:*
    - "..has the Coast Guard recently acquired more boats"
  - *POST-PROTECT: Actual reports of illegal activity*

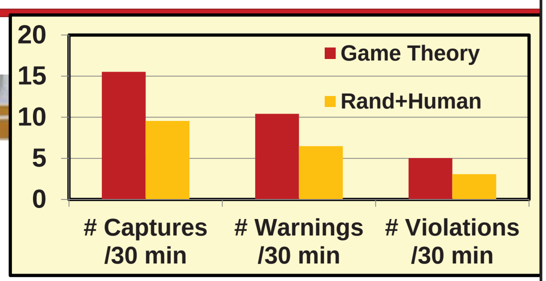
25

Field Tests Against Adversaries Computational Game Theory in the Field

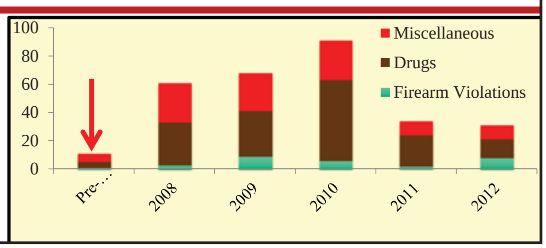
Controlled



- *Game theory vs Random*
- *21 days of patrol*
- *Identical conditions*
- *Random + Human*



Not controlled



Expert Evaluation
Example from ARMOR, IRIS & PROTECT

June 2013: Meritorious Team Commendation from Commandant (US Coast Guard)


July 2011: Operational Excellence Award (US Coast Guard, Boston)

September 2011: Certificate of Appreciation (Federal Air Marshals)


Transportation Security Administration
Office of Law Enforcement/Federal Air Marshal Service
Milind Tambe
In recognition and appreciation of your outstanding achievement in developing the Intelligent Randomization In Scheduling (IRIS) program to advance the mission of the Office of Law Enforcement/Federal Air Marshal Service.
This 2nd day of September, 2011

February 2009: Commendations LAX Police (City of Los Angeles)

27

Summary: Security Games

Decision aids based on computational game theory in daily use

- Optimize limited security resources against adversaries

Applications yield research challenges: Science of security games

- Scale-up: Incremental strategy generation & Marginals
- Uncertainty: Integrate MDPs, Robustness, Quantal response

Current applications (wildlife security): Interdisciplinary challenge

- Global challenges: Merge planning/learning & security games

28

Just the Beginning of “Security Games”….

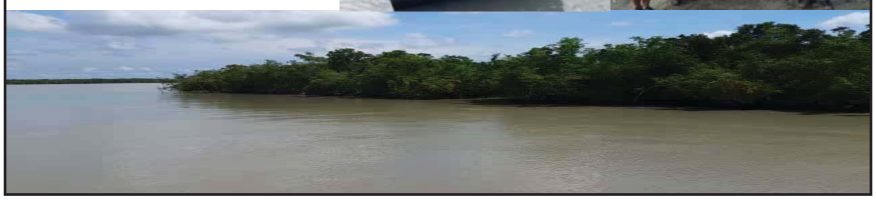
Startup:ARMORWAY

Paying customers; assist security of:

- Ports
- Airports
- University campuses…

Game theory in the field:

- Panthera, WCS, WWF



Just the Beginning of “Security Games”….

tambe@usc.edu
http://teamcore.usc.edu/security

Thank you:

CREATE HOMELAND SECURITY CENTER | National Center for Risk and Economic Analysis of Terrorism Events

Army Research Office

Transportation Security Administration

30

THANK YOU

tambe@usc.edu
http://teamcore.usc.edu/security

31

17.18 Carl Crawford: Call To Order Day 2

Eleventh Advanced Development for Security Applications Workshop (ADSA10):

Explosives Detection in Air Cargo – Part II

Call To Order
Day 2

Carl R. Crawford
Csuptwo, LLC

1

Reminders

- Fill out questionnaire on Survey Monkey
- End at 4:30 PM today
  - Please stay to end if possible
- Comments welcome after conclusion

2

ADSA12 Topics – Version 2

- Risk-based screening
  - Hardening, deterrence, gaming theory
- Computer simulations
  - X-ray transmission, back-scatter, diffraction, MMW, neutrons
  - Standardized phantoms
- Common standards, interfaces
- AIT – XBS dose, advances
- Improving statistical significance of testing

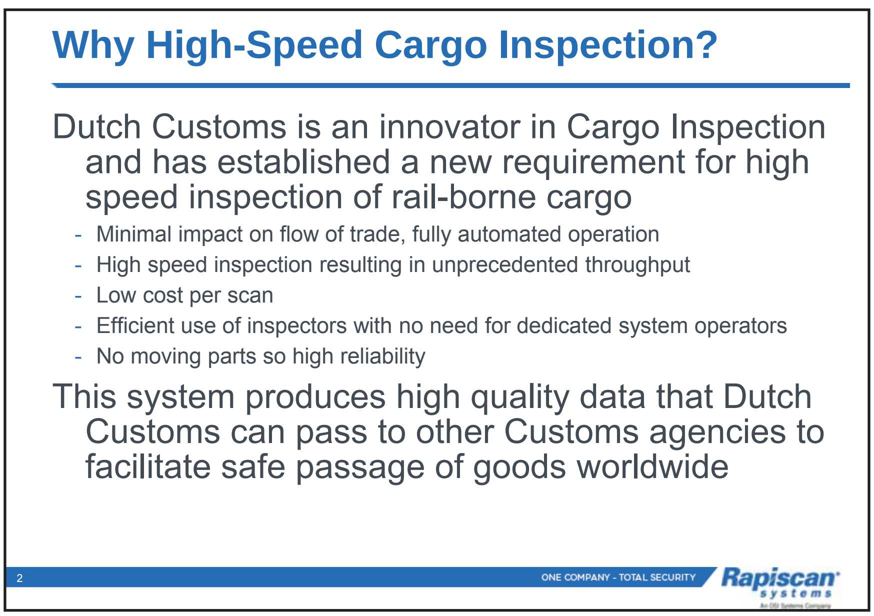
3

ATR Project (Task Order 4)

- Program Review – tomorrow, here at 8:00 AM
- Five research groups developed ATRs for CT-based EDS
- Agenda in folders
- Run-through for participants at 4:45 PM here

4

17.19 Ed Morton: Dutch Customs High Speed Cargo Inspection System



Customer Demand Drivers – geographical mapping of key locations

3 ONE COMPANY - TOTAL SECURITY Rapiscan systems An OSI Systems Company

Cost Per Scan

EU highlights huge cost of scanning

A trial to investigate the impact of implementing US container security legislation has revealed the massive costs that US trading partners would shoulder.

A confidential European Commission memo passed to *Lloyd's List* said that 100% scanning of all inbound boxes so terrorists cannot use them to launch an attack in the US would cost more than US$500 per unit.

Based on initial results from a pilot project in the port of Southampton and on "preliminary contributions from EU member states", the commission concluded that "a simple calculation of total cost relative to the number of scanned US-bound containers gives an average cost per container that exceeds $500."

The six-month Southampton trial involved the checking for radiation of 90,000 containers at the port gates. Another 5,500 US-bound containers were x-rayed for non-intrusive imaging of the container contents.

The trial cost $18m, the Commission's customs ministry told the US authorities in a letter sent last month.

The letter expressed the EU's "strongest concerns" about the "unilateral" US law, which is supposed to be in force by 2012. "It is to be regretted that the US did not await the results of

The pilot was carried out at the port of Southampton

the pilot port of S this legis Scanni false sen "underm from oth "unilater partners were pre the proc standard

Table 4. Unit cost of scanned TEU container in USD by type of scanner

Number of containers scanned per year	Scanner 1: pass-through scanner 6 Mev	Scanner 2: relocatable fixed scanner 6 Mev Double Tunnel
5,000	440	400
35,000	63	57
75,000	31	30
105,000	21	27
140,000	20	21
225,000	12	52
420,000	10	63

- A Standard Cargo and Vehicle inspection system scanning approximately 5,000 containers per annum costs several hundred dollars per scan.

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Source: Carluer, Frederic (2008). Global Logistic Chain Security, Economic Impacts of the US 100% Container Scanning Law. Paris, France: Editions EMS

Dutch Customs Objectives

Scan all rail-borne cargo outbound from Europe from the port of Rotterdam

Provide this image data to receiving Customs agencies initially as a courtesy and eventually in back-to-back arrangements

Inspect a fraction of the image data based on risk analysis and automated inspection algorithms to ensure that outbound cargo is cleared

Minimize operational cost by provide operating and inspection workstation screens in a shared Customs inspection area at the Port of Rotterdam

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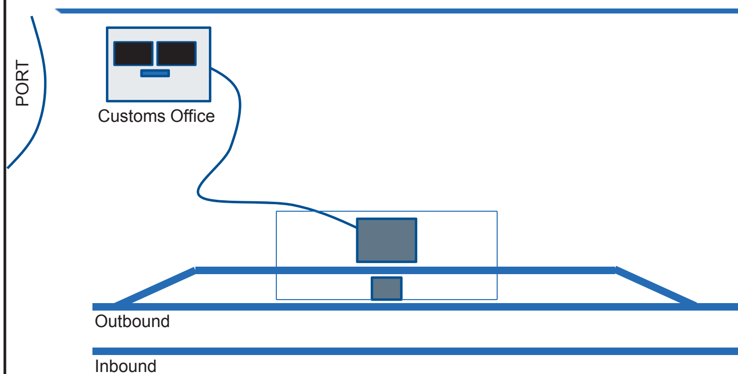
Dutch Customs Project Delivery Concept



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Dutch Customs Imaging Requirements

Ability to detect fraudulent trade

Ability to check declared cargo vs manifest

Ability to execute automatic detection algorithms

Ability to localize suspect items within the cargo

Ability to image from base of container to top of container including doors.

Ability to scan all container types automatically

Ability to scan without loss of image quality at 60 km/hr

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Dutch Customs Dosimetry Requirements

Ability to scan at least 1,000,000 TEU/year

Maximum dose to environment (outside fence surrounding installation) of 40 uSv/year

Minimal dose to cargo to ensure that there is no health impact on stowaways

Automatic scanning of containerized cargo only

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Dutch Customs System Installation

9 ONE COMPANY - TOTAL SECURITY Rapiscan systems

Dutch Customs System Installation

X-Ray Detectors

X-Ray Source

Radiation Shielding Walls

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Dutch Customs Example Images

- Eagle R60HS – 40ft and 20 ft cargo containers scanned between 50 and 60kph

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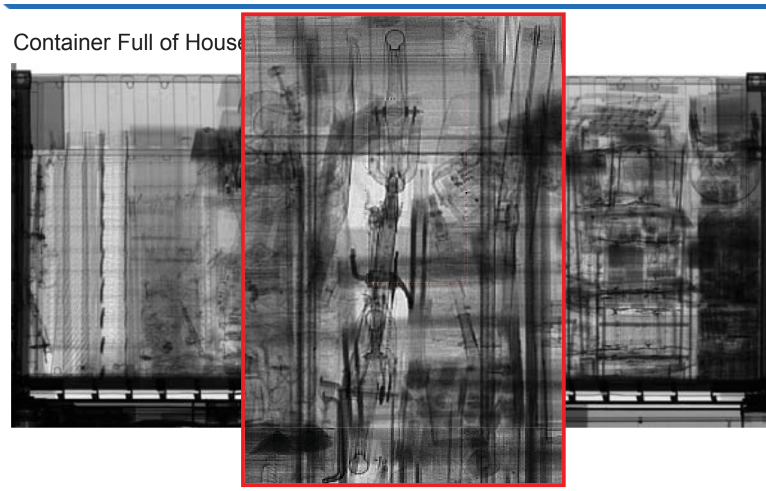
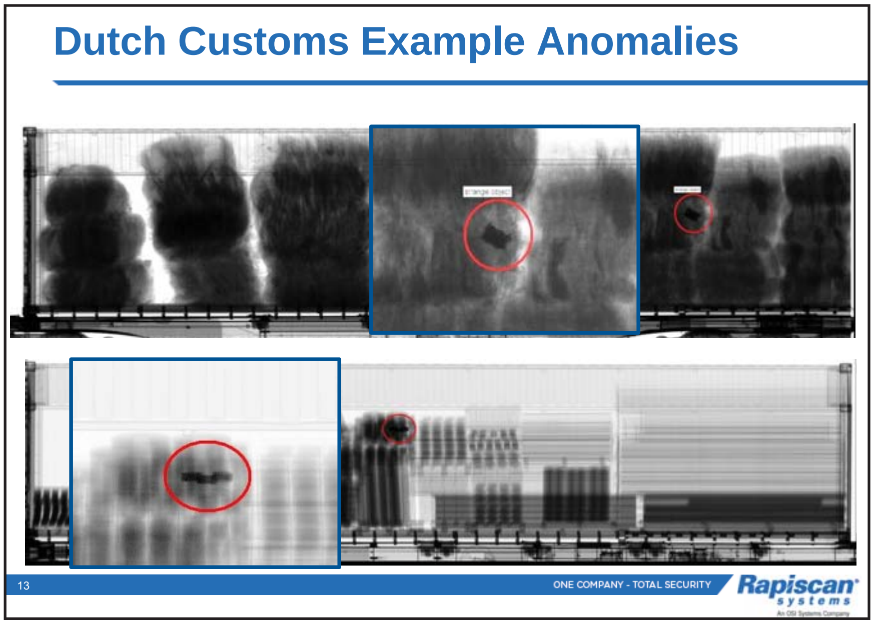
Dutch Customs Example Image

Container Full of House



12 ONE COMPANY - TOTAL SECURITY Rapiscan systems


Dutch Customs Example Anomalies
13
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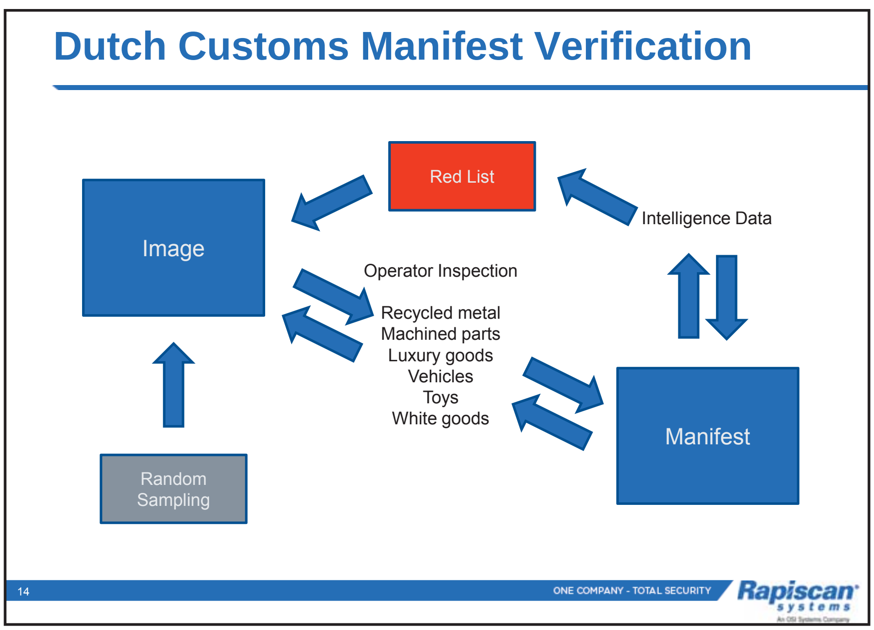
Rapiscan systems
An OSI Systems Company


Dutch Customs Manifest Verification
Red List
Intelligence Data
Image
Operator Inspection
Recycled metal
Machined parts
Luxury goods
Vehicles
Toys
White goods
Manifest
Random Sampling
14
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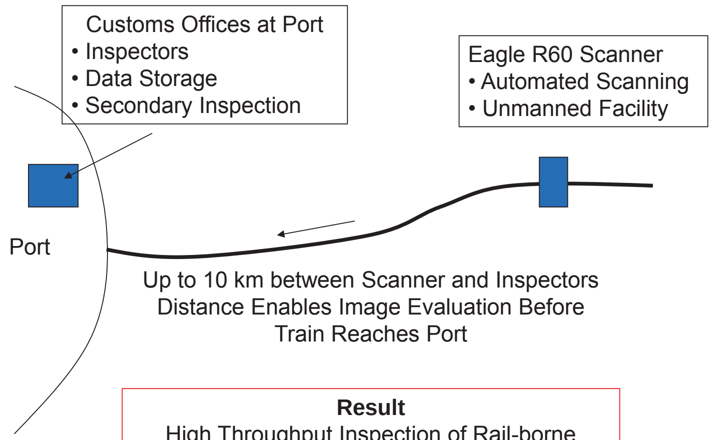
Rapiscan systems
An OSI Systems Company

Dutch Customs System Summary



Result
High Throughput Inspection of Rail-borne Containerised Cargo Outbound from Port

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Summary

Dutch Customs has established a new concept in high throughput, non-invasive, low cost scanning of cargo

The resulting system has already scanned around 1 million TEUs over a couple of years operating period

As the new Maasvlakte 2 extension at the Port of Rotterdam comes on line, the system will only become busier!

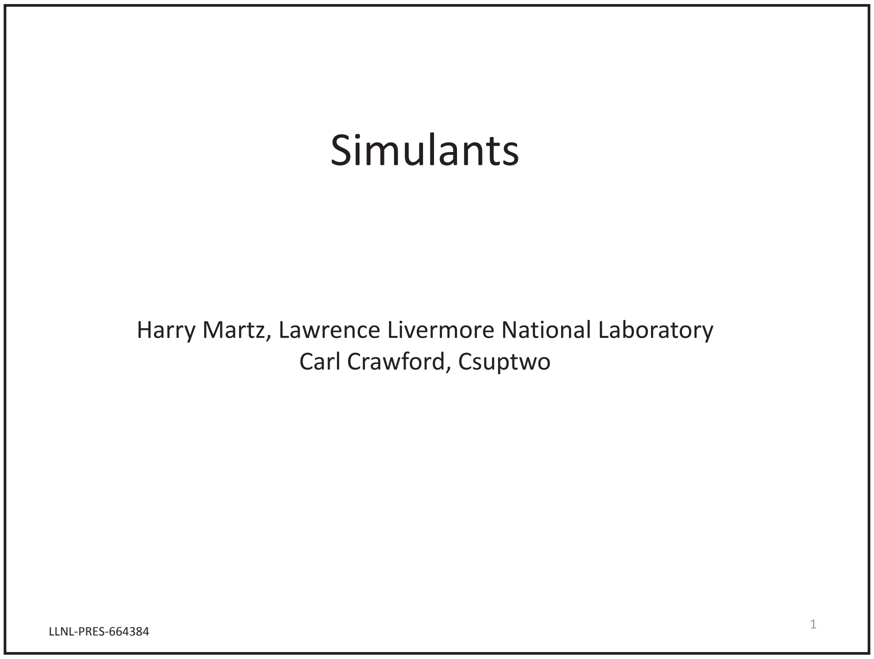
16 ONE COMPANY - TOTAL SECURITY

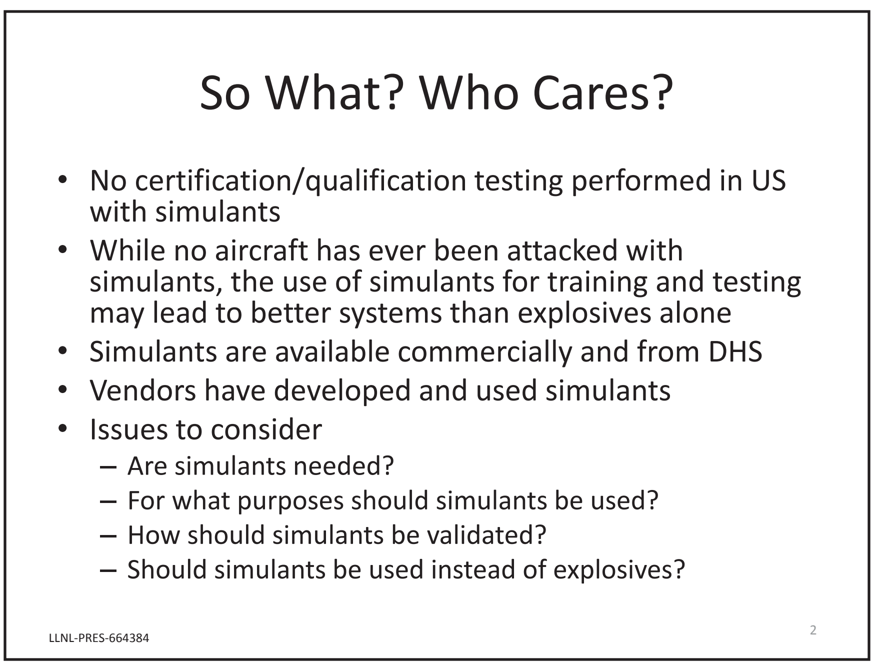
Summary

Check out the system for yourself at Miniworld in Rotterdam!

17 ONE COMPANY - TOTAL SECURITY Rapiscan systems

17.20 Harry Martz: Simulants





Acknowledgements

- DHS funded LLNL to validate explosives
- Science Review Panel - Developing and Validating Simulants for Commercial, Military, and Home Made Explosives, March 8, 2010
  - Mainly addressed x-ray based EDS
  - Final report may be available from DHS Explosive Division (EXD)
  - This presentation derived from the final report

LLNL-PRES-664384 3

Questions - I

- What are the necessary and significant statements of requirements upon which a simulant can be developed?
- What are the specific physical measurements we want simulants to simulate?
- How should texture be addressed in the design of simulants?
- How might simulants model various kinds of heterogeneity?
- How should simulants be manufactured when seeking to represent a material with a continually variable physical criterion (e.g., density, Zeff, etc)?
- How might simulants well represent aging in materials?
- What are the categories of use for simulants (e.g., training, calibration, detection)?

LLNL-PRES-664384 4

Questions - II

- What cautions should attend the use of simulants?
- How best should simulants be validated?
- What can be done to obviate the fabrication of numerous explosives so that their characteristics can be measured in order to synthesize their simulants?
- Who would be able to generate computer models of textures of explosives?
- Who would be able to manufacture simulants?

LLNL-PRES-664384 5

Recommendation 1

- Simulants should be developed for several applications including to help train X-ray based explosive detection equipment.
- Simulants should not be used for Independent Test and Evaluation (IT&E, Certification).
- Simulants should be used at the user's own risk.
- The developers and providers of the simulants should not be held liable for their use.

LLNL-PRES-664384 6

Recommendation 2

- The explosives and their features need to be properly specified so that simulants with appropriate features can be manufactured.
- Manufacturers of commercial explosive simulants, manufacturers of medical phantoms, and manufacturers of phantoms for non-destructive evaluation may be engaged for the development of simulants.

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Recommendation 3

- Third-parties could be engaged to review the process of specifying, manufacturing and deploying simulants.

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Recommendation 4

- Sets of simulants should be created to span the feature space of explosives they represent.
  – This is known as matching clouds to clouds.
  – The correlations among those features of the explosives that can be measured using x-ray imaging devices should be duplicated in the set of simulants.

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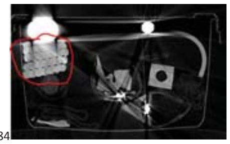
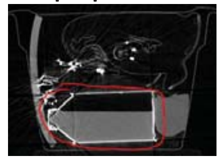
9

Recommendation 5

- Vendors are not required to disclose how they use texture and other features either directly to the DHS or to an independent authority.
- However, voluntary disclosure of how such features are used is welcomed and could lead to simulants that are better analogs for explosives for vendor equipment.





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10

Recommendation 6

- DHS should not recommend how texture and other features should be used.

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11

Recommendation 7

- Simulants should be evaluated after formulation, using a MicroCT (μCT) instrument or other scanner

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12

Recommendation 8

- The LLNL validation plan is a good foundation, but requires revision.
- The LLNL validation plan should be renamed to an evaluation plan.

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13

Recommendation 9

- Known differences between explosives and simulants should be disclosed to users and the users can make their decisions on the usefulness of the simulants.

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14

Recommendation 10

- It must be shown that μCT can be used to predict the values of density and effective atomic number to within ±5%.

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15

Additional Comments

- May be difficult to make simulants for fused systems (e.g., x-ray + neutrons)
- Simulants may need to be custom designed for each scanner
- Simulant may not be useful because scanner's PD may be < 100%
  - May need to dry lab this to get detection

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17.21 Michael Finnin: Analysis of Potential Technologies for Air Cargo Screening: A Progress Report

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Analysis of Potential Technologies for Air Cargo Screening: A Progress Report

Michael Finnin, Shelley Cazares, Isaac Chappell
Institute for Defense Analyses

Advanced Development for Security Applications Workshop (ADSA11)

Boston, MA

November 5, 2014

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IDA | Overview of IDA

- **What is IDA?**
  - IDA runs Federally Funded Research and Development Centers (FFRDCs) for several national security agencies
  - IDA is a non-profit entity sponsored and funded by the government to provide independent, objective analyses
  - IDA does not work for or compete with for-profit entities
- **IDA Staff**
  - Research staff consists mainly of PhD-level scientists and former military
  - Expertise in a wide variety of science and technology (S&T) areas
  - Science and Technology Division (STD) performs many technology assessment functions for government S&T funding agencies such as DARPA, DTRA, DHS S&T, OUSD(AT&L), etc.
- **IDA operates 3 FFRDCs**
  - SAC (Systems & Analysis Center) supports DoD Office of the Secretary of Defense
  - STPI (Science and Technology Institute) supports the White House Office of Science and Technology Policy (OSTP)
  - CCC (Center for Communications and Computing) supports the NSA
  - IDA also operates the SAFETY Act for DHS S&T

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IDA | Overview of Study for DHS S&T EXD

- **Air Cargo Metastudy Project**
  - IDA will collect and review existing test reports and studies on cargo screening technology to assess how well the technology performs against various containers, packaging (substrate), and commodities (content of cargo)
  - ***Focuses on TSA needs and any gaps in technology*** used for air cargo screening that might exist in the current state-of-the-art
  - For each technology (or technology group) and specific system within that technology, IDA will assess:
    - Are there performance metrics?
    - Are they appropriate?
    - Are there detection gaps?
    - Are follow-on studies needed?
  - Sources of Studies
    - Transportation Security Laboratory (TSL)
    - National Labs
    - JHU-APL
    - DHS S&T
    - Others as we discover them…..

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IDA | Air Cargo Metastudy - Methodology

- Many existing studies and tests of technology exist can be applied to air cargo screening
- Meta-analysis attempts to provide a rigorous statistical framework in order to combine and compare the results of disparate studies.
- Key statistic - Effect Size
  - Effect size metrics may include Pd, Pfa, or other performance metrics.
  - The correlation between multiple effect size metrics must be considered.
  - Effect size metrics can be weighted for:
    - Among-study heterogeneity
    - Variance
    - Sample size
  - Moderator variables may influence effect size metrics.
- Meta-analysis should evaluate the effect size metrics across many studies including:
  - Technology
  - Packaging (container, substrate)
  - Cargo contents (Commodity)
  - Threat

Choice of effect size metrics is an important consideration in this study

3

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IDA | Air Cargo Screening - Possible Technical Solutions

- Many potential technologies exists that can be applied to the air cargo problem
  - X-ray backscatter or thermal neutron capture
  - Photon or neutron interrogation that attempts to measure elemental composition signatures to discern threat from non-threat
  - Signatures based on capture or scattering of photon or particle
    - Examples: Nuclear Resonance Fluorescence, Fast Neutron Analysis, Pulsed Fast Neutron Transmission Spectroscopy.
- What current and nascent technology could be applied to the air cargo screening problem?
  - Depends how you want to screen air cargo (CONOPS)
    - Screen as Break-bulk or Bulk (pallet, UDL)?
    - Use the technology for initial screening, resolve a false positive, identification, etc.

Evaluating Technology with Appropriate Performance Metrics is Crucial to Develop an Effective Screening Capability

4

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IDA | Performance Metrics - From the Scientist's Perspective

Total # of Items = 10,100		Notional System	
		"Threat"	"Non Threat"
Ground Truth	Threat	TP = 90	FN = 10
	Non Threat	FP = 500	TN = 9500

Pd = 90 / (90+10) = 90%
(near 1 is better, near 0 is worse)

Pfa = 500 / (500+9500) = 5%
(near 0 is better, near 1 is worse)

From a ***scientist's perspective***, this notional system exhibits ***excellent performance***:

- Pd = 90% → 90% of all true threats correctly cause a "threat" alarm
- Pfa = 5% → Only 5% of all true ***non***-threats ***in***correctly cause a "threat" alarm

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IDA Performance Metrics - From the Operator's Perspective

Total # of Items = 10,100		Notional System	
		"Threat"	"Non Threat"
Ground Truth	Threat	TP = 90	FN = 10
	Non Threat	FP = 500	TN = 9500

Positive Predictive Value:
PPV = 90 / (90+500) = 15%
(near 1 is better, near 0 is worse)

Negative Predictive Value:
NPV = 9500 / (9500+10) ≈ 100%
(near 1 is better, near 0 is worse)

From an ***operator's perspective***, the very same notional system exhibits ***poor performance***:

- NPV ≈ 100% → Approximately all "non threats" (i.e., absences of alarm) turn out to be truly no threat → In the absence of an alarm, the operator can rest assured there's no threat
- PPV = 15% → Only 15% of "threat" alarms turn out to be true threats → When an alarm sounds, the operator cannot trust that there is a threat, since the system cries wolf so often

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IDA Performance Metrics - When the Threat Prevalence is Low

Total # of Items = 10,100		Notional System	
		"Threat"	"No Threat"
Ground Truth	Threat	TP = 90	FN = 10
	No Threat	FP = 500	TN = 9500

Pd = 90 / (90+10) = 90%
(near 1 is better, near 0 is worse)

Pfa = 500 / (500+9500) = 5%
(near 0 is better, near 1 is worse)

Positive Predictive Value:
PPV = 90 / (90+500) = 15%
(near 1 is better, near 0 is worse)

Negative Predictive Value:
NPV = 9500 / (9500+10) ≈ 100%
(near 1 is better, near 0 is worse)

Prevalence =
(90+10) / (90+10+500+9500) =
1%

The dichotomy between the scientist's vs. operator's perspective often emerges when the threat prevalence is very low (or very high).
When the threat prevalence is very low, most alarms are false.

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IDA | Performance Metrics for Tiered Systems

Total # of Items = 10,100		Notional System	
		"Threat"	"Non Threat"
Ground Truth	Threat	TP = 90	FN = 10
	Non Threat	FP = 500	TN = 9500

Prevalence = 1%

Pd = 90%

Pfa = 5%

PPV = 15% NPV ≈ 100%

- From the operator's perspective, our notional system exhibits poor performance (low PPV) when used to differentiate "non threats" vs. "threats"

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IDA | Performance Metrics for Tiered Systems

Total # of Items = 10,100		Notional System1	
		"*Maybe* Threat"	"Non Threat"
Ground Truth	Threat	TP1 = 90	FN1 = 10
	Non Threat	FP1 = 500	TN1=9500

Prevalence1 = 1%

Pd1 = 90%

Pfa1 = 5%

NPV1 ≈ 100%

Total # of Items = 590		Notional System2	
		"Threat"	"Non Threat"
Ground Truth	Threat	TP2 = 88	FN2 = 2
	Non Threat	FP2 = 25	TN2 = 475

Prevalence2 = 15%

Pd2 = 98%

Pfa2 = 5%

PPV2 = 78% NPV2 ≈ 100%

- From the operator's perspective, our notional system exhibits poor performance (low PPV) when used to differentiate "non threats" vs. "threats"
- However, this same notional system could be used as the 1st tier of a ***tiered system***, screening out the "non threats" from the "***maybe*** threats"
  - The 1st tier's low PPV does not matter*****, since all "maybe threats" from the 1st tier would be further assessed in the 2nd tier
  - All that matters for the 1st tier is its high NPV, since the "no threats" from the 1st tier would not get the opportunity to be assessed further in the 2nd tier

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* Provided that the 2nd tier can assess the 1st tier's 590 "maybe threats" relatively quickly & inexpensively

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IDA | Performance Metrics for Tiered Systems

Total # of Items = 10,100		Notional System1: "*Maybe* Threat"	Notional System1: "Non Threat"
Ground Truth	Threat	TP1 = 90	FN1 = 10
Ground Truth	Non Threat	FP1 = 500	TN1=9500

Prevalence1 = 1%

Pd1 = 90%

Pfa1 = 5%

NPV1 ≈ 100%

Total # of Items = 590		Notional System2: "Threat"	Notional System2: "Non Threat"
Ground Truth	Threat	TP2 = 88	FN2 = 2
Ground Truth	Non Threat	FP2 = 25	TN2 = 475

Prevalence2 = 15%

Pd2 = 98%

Pfa2 = 5%

PPV2 = 78% NPV2 ≈ 100%

Overall System:

- **Pd** = 88 / (88+2+10) **= 88%**
- **Pfa** = 25 / (25+475+9500) **≈ 0%**
- **NPV** = (9500+475) / (9500+475+10+2) **≈ 100%**
- **PPV** = 88 / (88+25) **= 78%**

- From the operator's perspective, our notional system exhibits poor performance (low PPV) when used to differentiate "no threats" vs. "threats"
- However, this same notional system could be used as the 1st tier of a ***tiered system***, screening out the "no threats" from the "***maybe*** threats"
  - The 1st tier's low PPV does not matter*****, since all "maybe threats" from the 1st tier would be further assessed in the 2nd tier
  - All that matters for the 1st tier is its high NPV, since the "no threats" from the 1st tier would not get the opportunity to be assessed further in the 2nd tier
- The overall system must be assessed based on ***all*** TP, FN, FP, and TN counts that did not pass to a subsequent tier

* Provided that the 2nd tier can assess the 1st tier's 590 "maybe threats" relatively quickly & inexpensively

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IDA | Performance Metrics - A Summary

- Performance metrics must be carefully selected for our meta-analysis.
  - Pd and Pfa:
    - Reflect the ***scientist's perspective***
    - Are not influenced by threat prevalence
  - PPV and NPV:
    - Reflect the ***operator's perspective***
    - Are influenced by threat prevalence
- The appropriate performance metrics depend on how the system will be used, particularly if the system is only ***one tier of an overall system***
  - ***PPV*** does not matter for the 1st tier (screener), provided that the 2nd tier can operate relatively quickly and inexpensively
    - Keep in mind that the 2nd tier will operate on fewer items than the 1st tier
  - ***NPV*** is the most important metric for the 1st tier (screening tier)
  - The metrics selected for the overall system must include ***all*** TP, FN, FP, and TN counts that did not pass through a subsequent tier
- Other performance metrics may further reflect the operator's perspective, such as ***throughput***, ***workload***, ***usability***, etc.
  - Very few reports have data that could be used to estimate these metrics.

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IDA Testing Documents

- Documents describing tests of different technologies, commodities, and packaging:
  - Cover a testing/reporting period of 1998 - 2013
  - Test procedures, metrics, and types of commodities vary widely among reports
  - Some reports are detailed tests while others are “Quick Looks”
  - Many reports are associated with separate test plans
  - Threats are coded in many later reports for classification reasons
- Technologies Considered
  - Explosive Trace Detectors (ETDs)
    - Trace detection based on chemical signature
    - Examples: Ion mobility spectroscopy or infrared spectroscopy
  - Explosive Detection Systems (EDS)
    - Radiation beam (photons-X-ray, gamma or particles-neutrons) interrogates sample
    - Signatures based on shape, density, or elemental composition of sample

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IDA Testing Documents - Building Matrices

Matrix Axes

- Technology
- Commodities
  - Types and number vary
  - “Standard 8” →
- Packaging
  - Break-bulk
  - Containerized
  - Palletized
- Substrate
  - ETD specific variable
  - Represents the sampling surface the ETD encounters →
- Threats
  - Coded in later reports
  - Quantities expressed in undefined “threat weights”
- Performance Metrics
  - Scientist’s Perspective
  - Operator’s Perspective

EE	Electronic Equipment
WA	Wearing Apparel
PM	Printed Matter
MP	Machine Parts
MDG	Miscellaneous Durable Goods
FF	Fresh Flowers
PR	Fresh Produce
SM	Seafood & Meats

Plywood
Cardboard
Packing Tape
Stretch Wrap
ABS Plastic

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Air Cargo Commodities

Code	Category Description	Typical Commodities
CHEM	Chemicals	Chemicals, alcoholic beverages, glass, chemical and fuel oils, pharmaceuticals
EE	Electronics	Electronic components, computer, medical and lab equipment
FF	Fresh Flowers	Flowers and herbs
HR	Human Remains	Human remains, organs and blood products
LA	Live Animals	Pets, tropical fish, live animals for restaurants
MDG	Miscellaneous Durable Goods	Non-metallic mineral products, base & construction material, furnishings, misc. manufactured products
MP	Machine Parts	Machinery & vehicle parts
MULT	Multiple	Mixed commodities (UDLs)
PM	Printed Materials	Newsprint, magazines, books
PP	Paper Products	Non-printed paper, plastic & rubber products
PR	Produce	Fresh produce, grains & animal feed, perishables, bakery & dried foods
SM	Seafood and meats	Fresh & frozen seafood & meat products
WA	Wearing apparel	Clothing
UNK	Unknown	No commodity info

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Potential Matrix: ETDs Versus Substrate

Technology	Plywood	Cardboard	Packing Tape	Stretch Wrap	ABS Plastic
GE/Morpho Itemiser 2					
GE/Morpho Itemiser DX					
Smiths Ion Scan 400B					
Smiths Ion Scan 500DT					
Smiths Sabre 4000 (vapor)					
GE/Morpho Mobile Trace					
GE/Morpho Hardened Mobile Trace					
Implant Sciences ACSS QS-H300					
Fido XT					
Fido Scout					

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Issues and Interim Findings

- Air cargo environment provides unique challenges for explosives detection
  - Packaging and commodities are highly varied
  - Very little standardization or predictability on how goods are shipped on passenger aircraft.
- No technologies are specifically designed for air cargo screening
  - Technologies are repurposed and optimized for other environments
  - Air cargo has unique technology requirements in density, size, and packaging
  - Air cargo has unique CONOPS requirements
- Testing documents
  - Over 15 years of testing with variable:
    - Protocols
    - Personnel conducting tests
    - Testing goals
    - Metrics for success - if at all
- IDA quick analysis
  - Currently deployed technologies may have a specific role in a multi-tiered screening system which would depend upon their particular performance metrics.
  - Number of technology tiers that would be required depends on how well individual technologies perform to resolve the “maybe threats” issue (see slides 7-13)

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IDA | Air Cargo Screening - Background

- Passenger aircraft transport is “belly-loaded” with cargo for increased revenue
  - Originating and Trans-shipped
    - Originating cargo is cargo that is initially delivered to the air cargo facility
    - Trans-shipped cargo originates at one facility and passes through another facility
  - Exempt and Non-exempt
    - TSA has established rules for cargo that must be screened and cargo that is exempt from screening
- Packaging
  - Containerized
    - Cargo arriving as a bulk shipment in a Unit Load Device (ULD)
  - Palletized
    - Bulk shipment wrapped in plastic on pallets
  - Loose Cargo
    - Individual pieces
    - Can be result of breaking above bulk shipments - “Break-bulk”
- Commodities - Contents of air cargo

Packaging, threat, and commodity type influence the choice of screening procedure and technology employed.

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IDA | Air Cargo Screening vs Baggage Screening

- Passenger bag screening technologies may be applicable to air cargo
  - Mature and deployed at majority of airports
- Differences between air cargo and passenger baggage
  - Pallets and ULDs have different physical characteristics
    - Much larger internal space to be interrogated for air cargo
  - Contents of these packages (commercial commodities vs personal effects)
    - Contents of air cargo vary significantly across the Enterprise
  - Traditional baggage screening systems are not engineered to accommodate air cargo screening

Unit Load Device

Typical Dimensions:
160 x 220 x 320cm^3
Up to 1600kg
Average Density 23 g/cm^3

Suitcase

Typical Dimensions:
50 x 50 x 100cm^3
Up to 25kg
Average Density 5 g/cm^3

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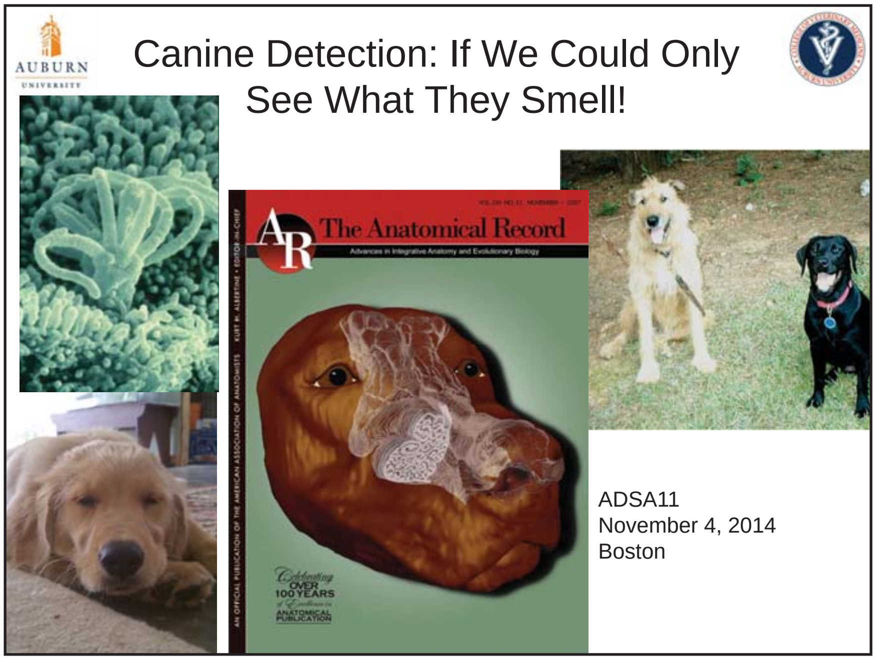
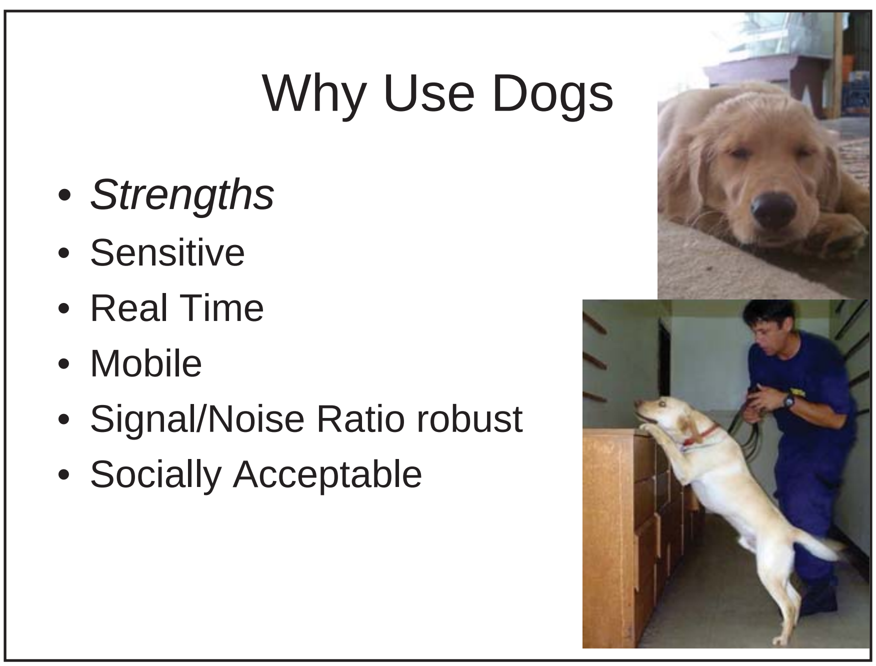
17.22 Edward Morrison: Canine Detection: If We Could Only See What They Smell!





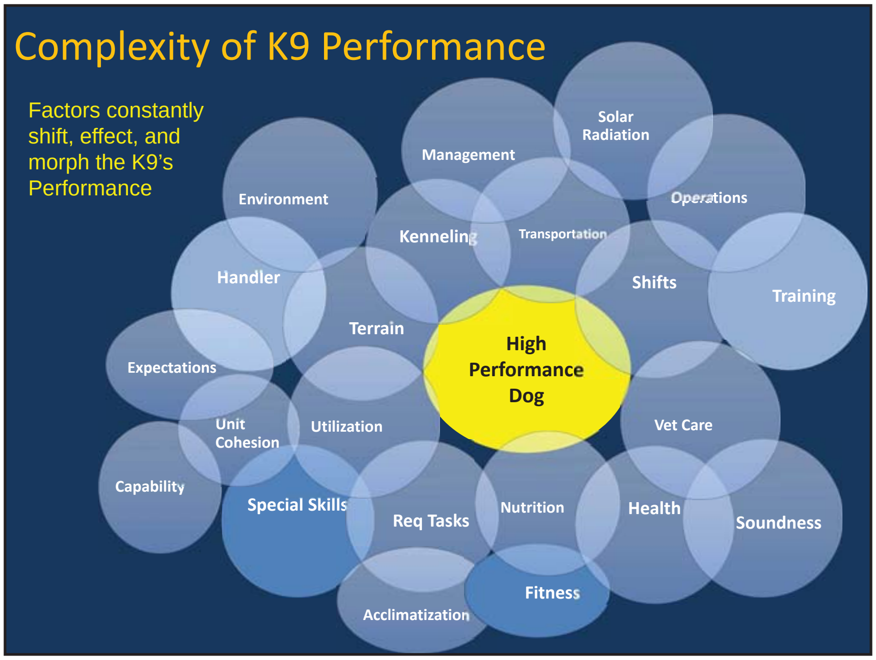
Why Use Dogs

- *Weakness*
- Intelligent
- Susceptible to flaws in training
- Susceptible to intentional/unintentional behavior cueing by trainer
- Variability in Industry
- Sensory capability can be affected by subclinical pathologies
- Can fail to recognize target odors when quantity/concentration differs significantly from training aids

Fundamentals of Detector Dog Behavior: *The Software*
Odor Discrimination, Generalization, Recognition and Context

Preview

- A LOT do not understand about canine / olfactory detection
- Widely accepted across disciplines involved in detection that dog is most capable and versatile chemical vapor detection tool
- How canine detection works…some fundamental and developmental science
- How what is known and not known may inform practice
- Enhancing practice and its credibility



Factors of Performance

Factors we CAN control

1. Breed
2. Bloodline
3. Geographic Region of Bloodline
4. Acclimatization
5. Nutrition
6. Physical Conditioning
7. Environmental Conditioning
8. Handler Special Skills (EDD, Track/Trail, Bite, VW)
9. K9 Special Skills (Same)
10. Dog team compatibility
11. K9-Military Unit Cohesion
12. Operational Tempo
13. Vet Care
14. Structural and Physiological Health
15. Duty Cycle
16. Recovery and Rest
17. Olfaction
18. Operational Strategy

Factors we CANNOT control

1. Radiant Heat
2. Altitude
3. Terrain
4. Temperature
5. Humidity
6. Olfaction (target variables and odor noise)
7. Visual and Auditory Distractors

Summation of Factors

1. Breed
2. Bloodline
3. Geographic Region of Bloodline
4. Acclimatization
5. Nutrition
6. Physical Conditioning
7. Environmental Conditioning
8. Handler Special Skills (EDD, Track/Trail, Bite, VW)
9. K9 Special Skills
10. Dog team capability
11. K9-Military Unit Cohesion
12. Operational Tempo
13. Vet Care
14. Structural and Physiological Health
15. Duty Cycle
16. Recovery and Rest
17. Olfaction
18. Operational Strategy

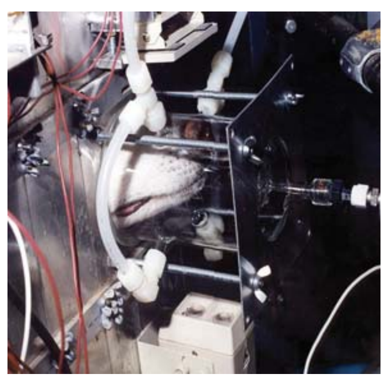
+

1. Radiant Heat
2. Altitude
3. Terrain
4. Temperature
5. Humidity
6. Odor Noise
7. Visual and Auditory Distractors
8. Olfaction (target variables)

= ≤ Optimal Performance

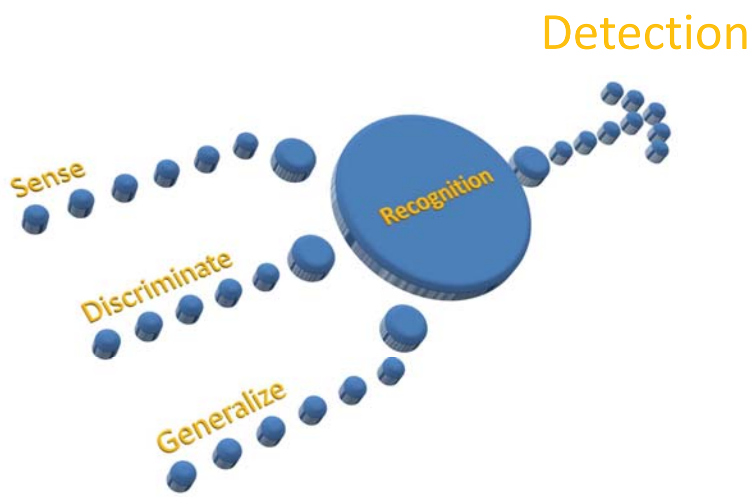
Determining Odor Detection Signatures

(What controls dog's recognition of odor?)



Odor detection signature
constituent(s) of a substance to which dog responds more on the "target" lever than to the "air" or "non-target levers"

Target Odor



Generalization Testing

- 20 or 10 positions
- Odor position changed each trial
- Partial reinforcement of Hits
- Repeat position for misses / Time-out for FA
- equal number target and non-targets (i.e., distractors & blanks)
- Probe (no consequences) untrained variants (1 or 2 positions)

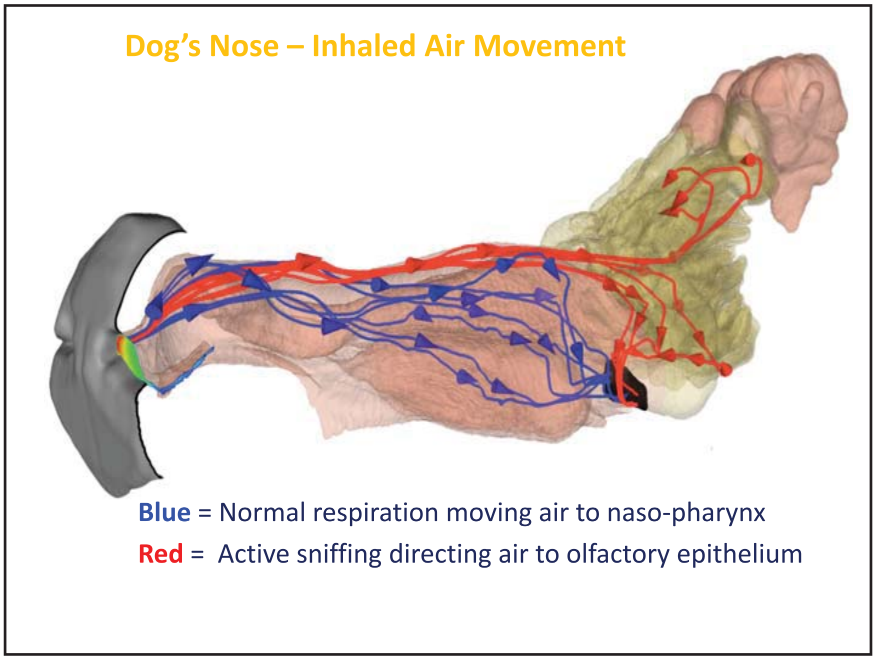
Need balance of specificity (discrimination) and generalization for optimum explosives detection

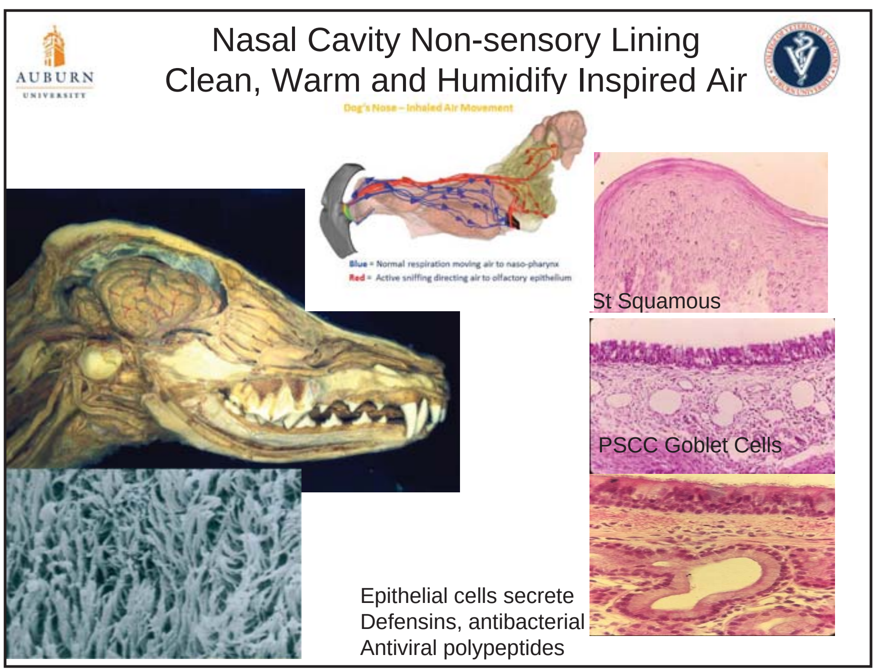
- The success of detector dogs lies not just in discriminating a target, such as an explosive, from non-target substances, but in the complimentary process of generalizing from the specific target odor on which they have been trained to other target odors that are similar, but not exactly the same

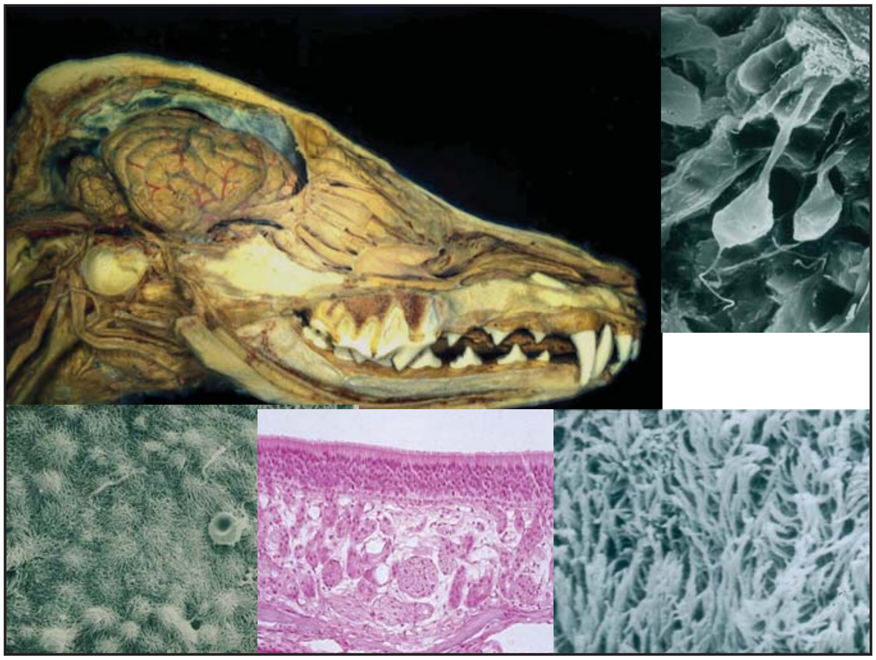
Working End of the Trace Detector

Human Vs. Dog Olfactory System

Characteristics	Human	Dog	Difference
Olfactory region	4-5 cm^2	92-170 cm^2	30X
Olfactory receptors	5 million	125-300 million	50X
Cilia	6-8 per receptor	100-150 per receptor	20X
Olfactory bulb as percentage of total brain	5%	35%	7X


Dog's Nose – Inhaled Air Movement
Blue = Normal respiration moving air to naso-pharynx
Red = Active sniffing directing air to olfactory epithelium


AUBURN
UNIVERSITY
Nasal Cavity Non-sensory Lining
Clean, Warm and Humidify Inspired Air
St Squamous
PSCC Goblet Cells
Epithelial cells secrete
Defensins, antibacterial
Antiviral polypeptides

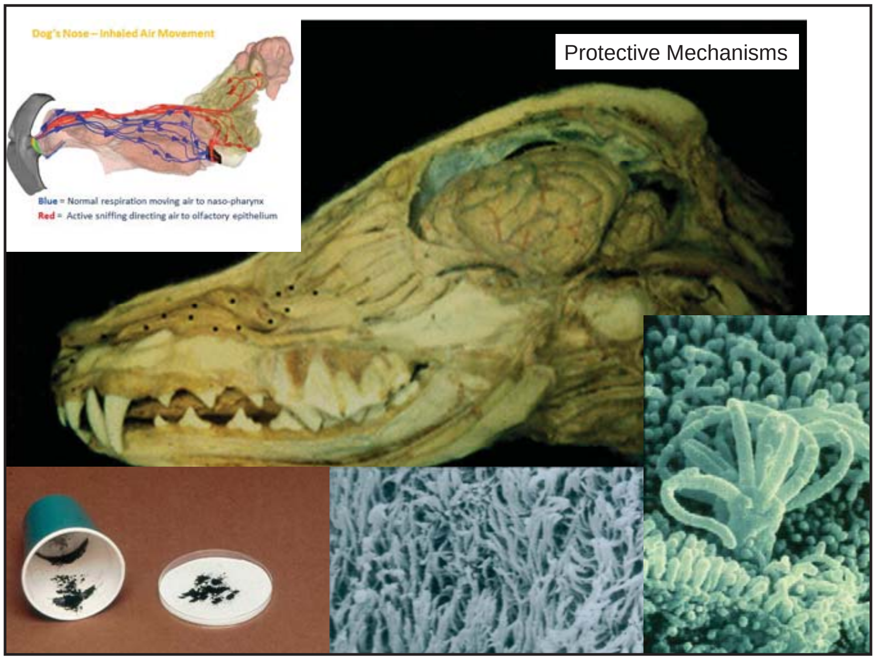


Characteristics of the Olfactory System

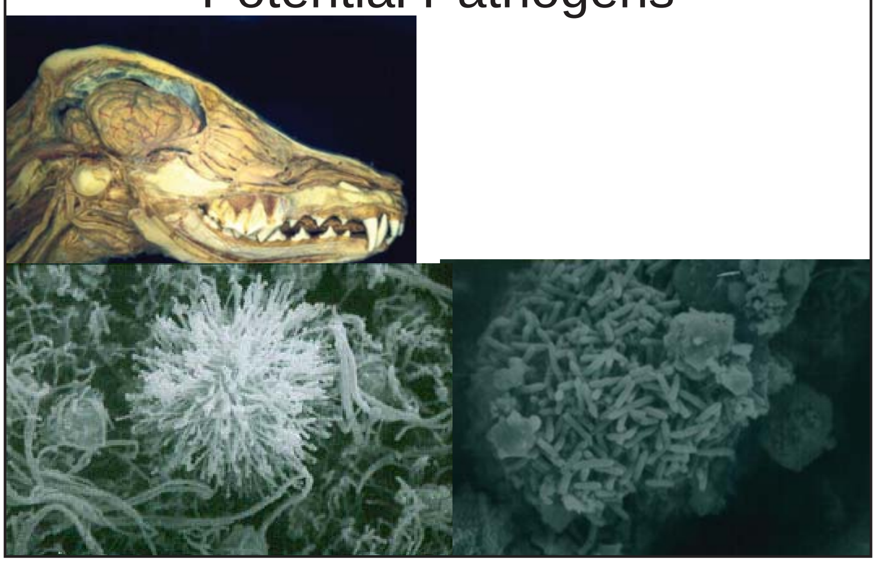
Consists of three cell types
- columnar supporting cells (glial-like cell)
- olfactory receptor neuron (true bipolar neuron)
- basal cells (neuroblast stem cell)

Olfactory System capable of replacing neurons
normally or following injury
via neurogenesis for the life of the individual

These new neurons grow a new axon and dendrite and establish new synaptic connections and function



Potential Pathogens

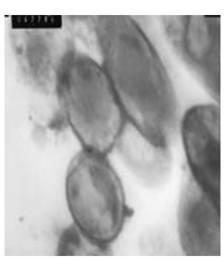


Canine Defensins

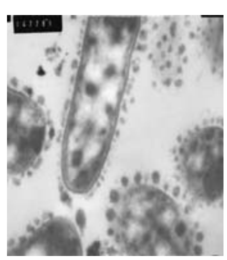
- Defensins are naturally occurring peptides that kill bacteria, fungi, yeast and parasites.
- Canine nasal tissues expresses defensin 1, 103 and 108 RNA.
- A common mutation of cBD103, cBD103ΔG23, is responsible for the dominant black coat color in breeds such as Labradors and German Shepherds.
- cBD103ΔG23 binds the melanocortin receptor 1 to induce black coat color, but can potentially bind other MCRs which are important in energy homeostasis, endocrine regulation, and many others systems.

Morphological Changes Induced by cBD103

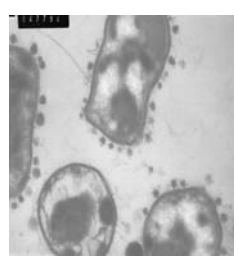
- Membrane blebbing
- Cellular fragmentation
- Cytoplasmic condensation
- Cells unviable when plated



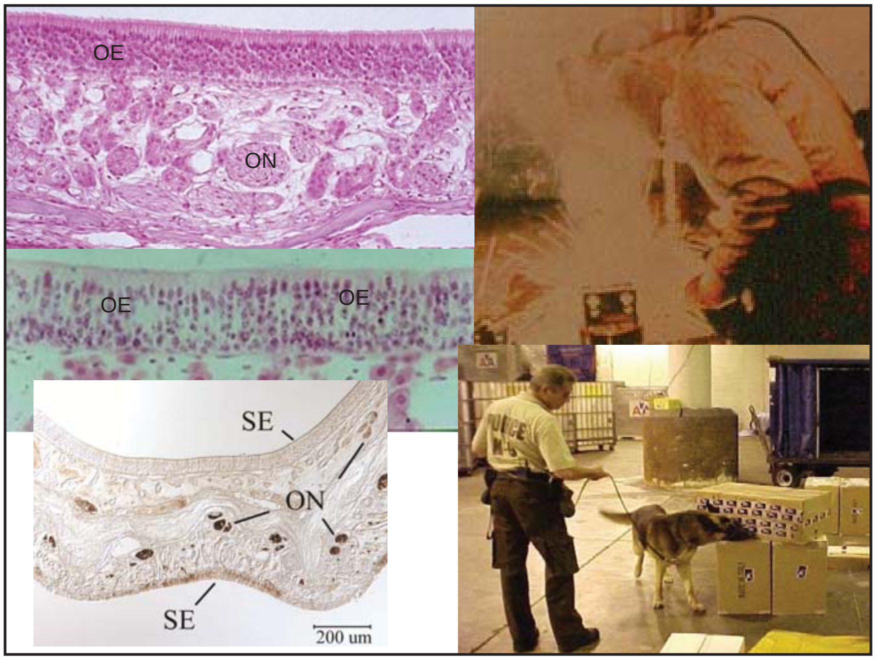
E. coli negative control

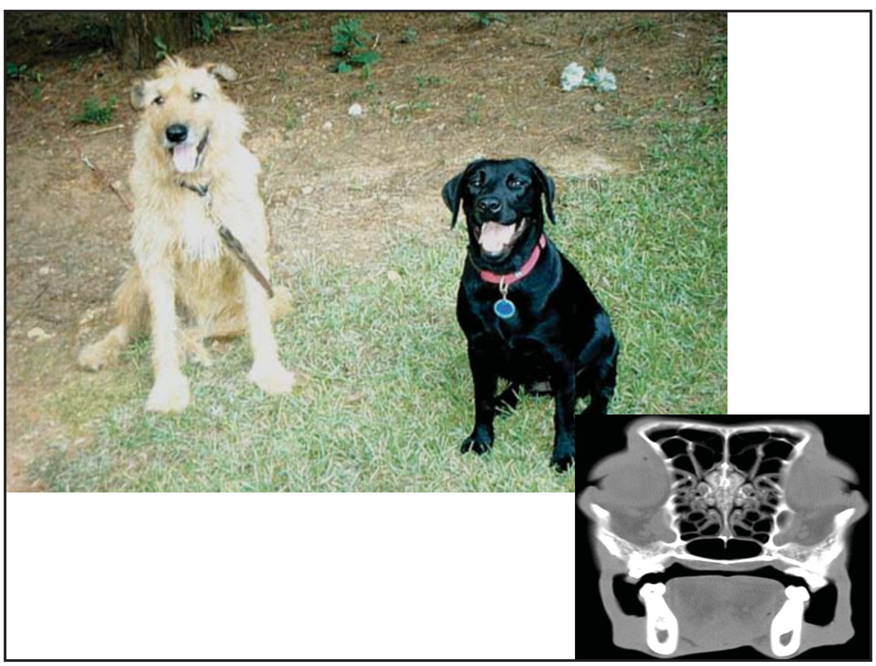


E. coli + cBD103

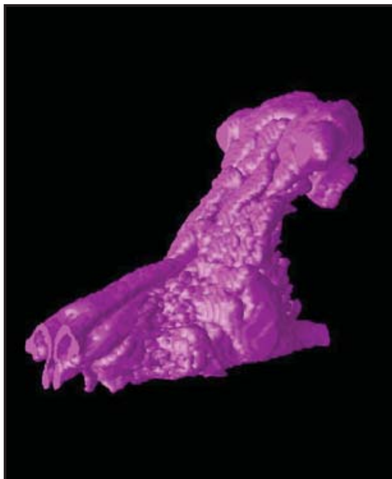


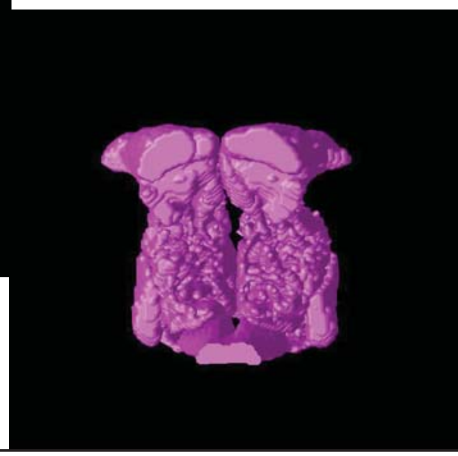
E. coli + cBD103ΔG23


OE
ON
OE
OE
SE
ON
SE
200 um

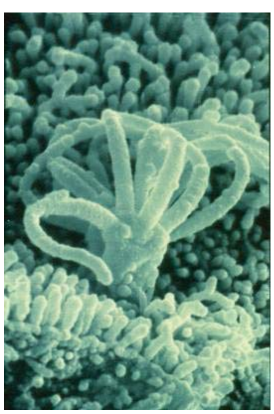


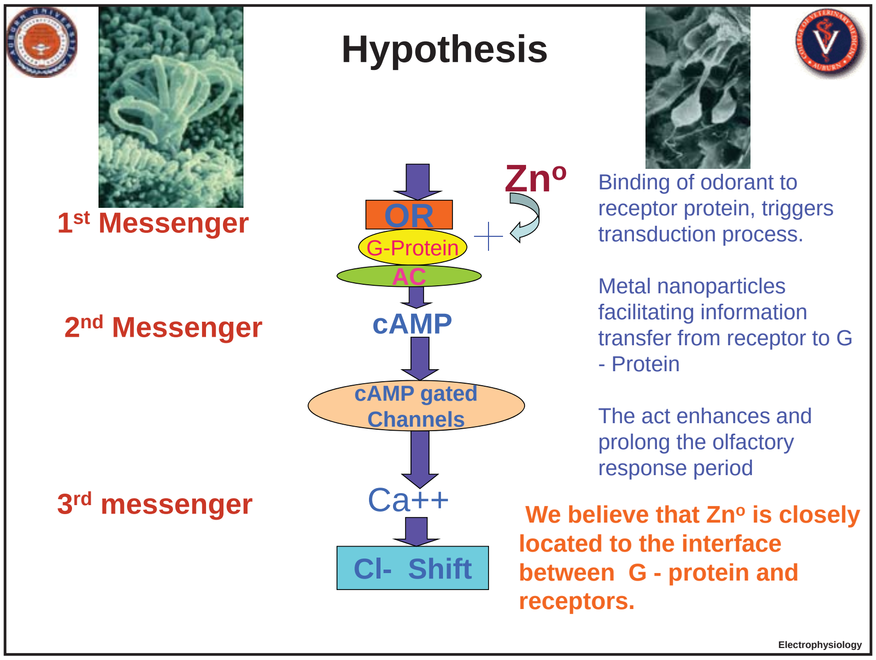
Canine nasal cavity reconstructed from serial CT scans

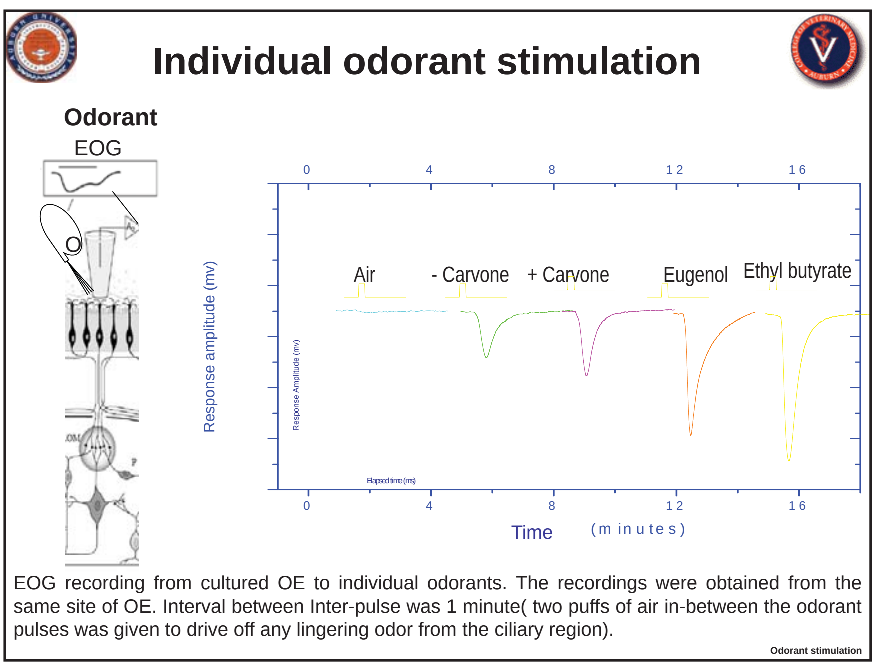




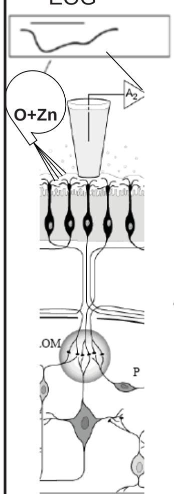
Bigger Bang for the Odorant!!



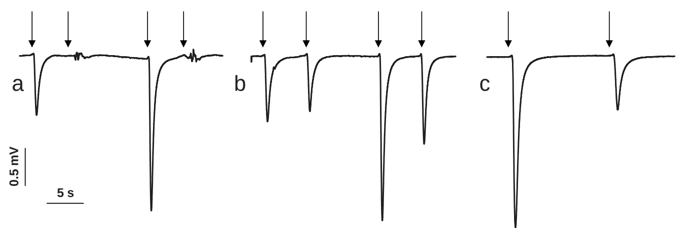

Hypothesis
1st Messenger
2nd Messenger
3rd messenger
Znº
OR
G-Protein
AC
cAMP
cAMP gated Channels
Ca++
Cl- Shift
Binding of odorant to receptor protein, triggers transduction process.
Metal nanoparticles facilitating information transfer from receptor to G - Protein
The act enhances and prolong the olfactory response period
We believe that Znº is closely located to the interface between G - protein and receptors.
Electrophysiology


Individual odorant stimulation
Odorant
EOG
Response amplitude (mv)
Air
- Carvone
+ Carvone
Eugenol
Ethyl butyrate
0
4
8
12
16
Time (minutes)
EOG recording from cultured OE to individual odorants. The recordings were obtained from the same site of OE. Interval between Inter-pulse was 1 minute(two puffs of air in-between the odorant pulses was given to drive off any lingering odor from the ciliary region).
Odorant stimulation

Enhancement by Zn particles



EOG recordings



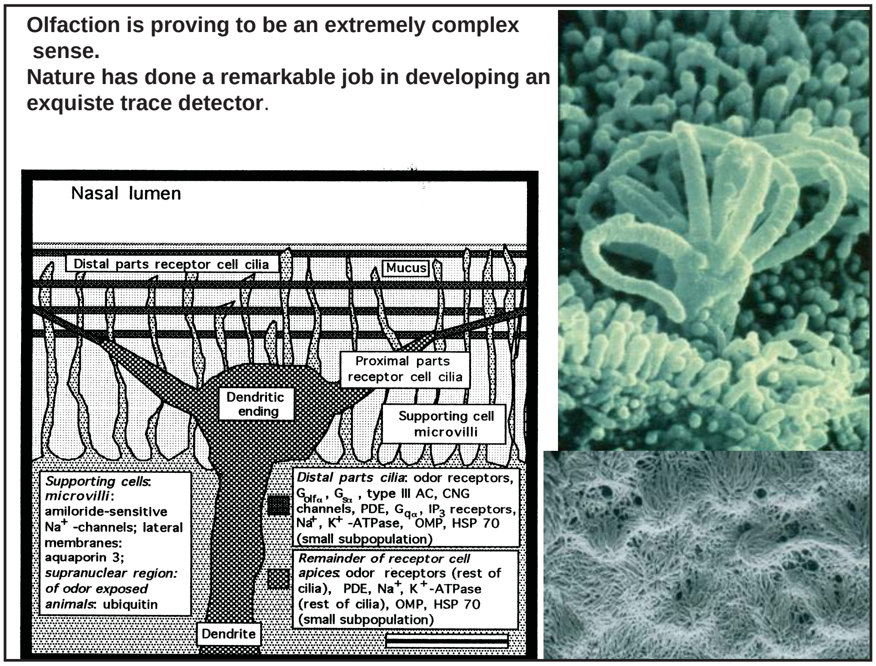
O – odorant mixture. [O] = 1.6 $\times 10^{-2}$ M
Zn – Zn metal nanoclusters. [Zn] = 9.4×10^{-15} M

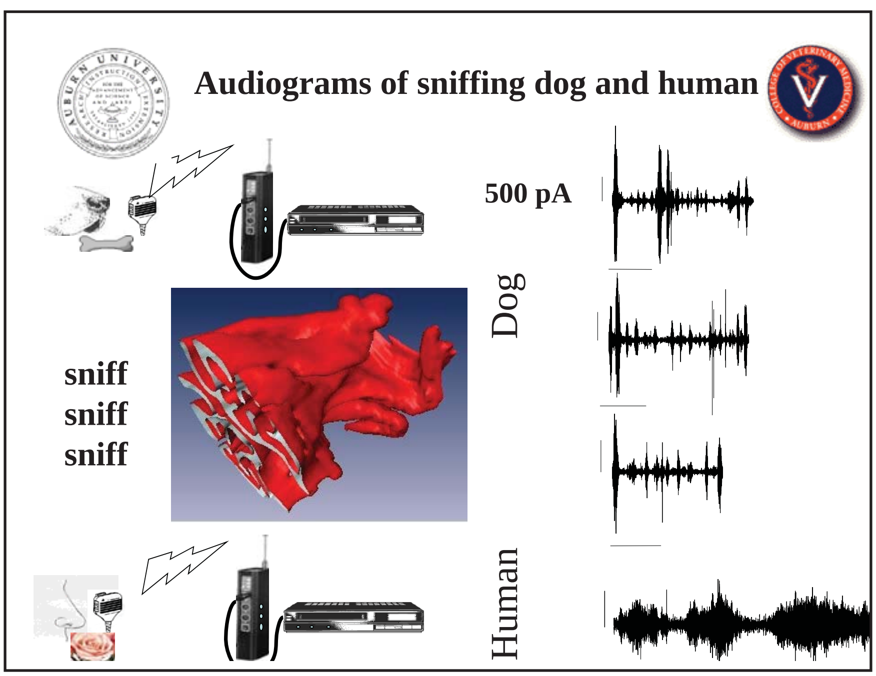
The responses were induced by air odorants and mixture of odorants and zinc metal particles.
•odorant puff (O)
•odorant and small concentration of zinc metal particles (O+Zn)

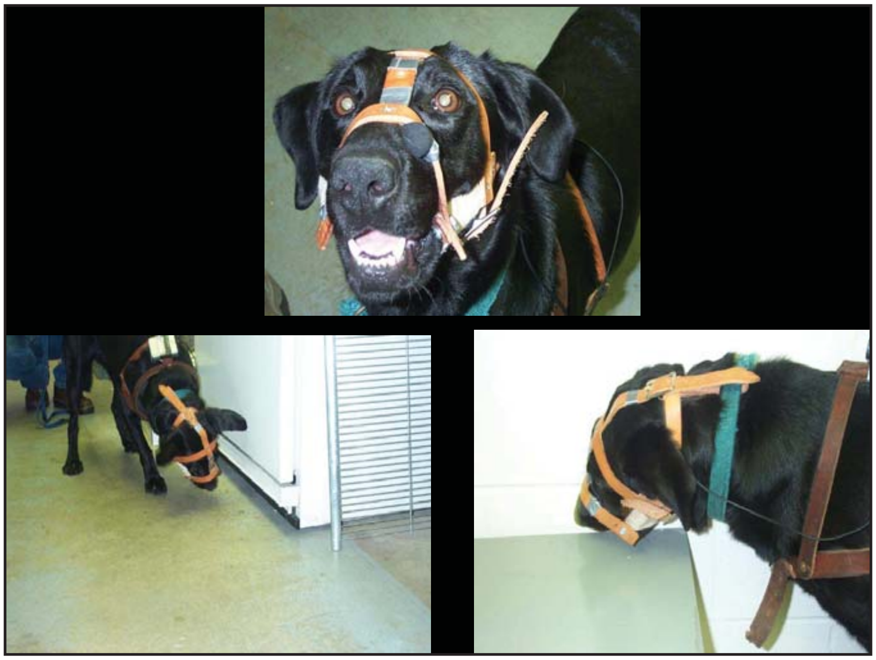
Specific explosive odor character

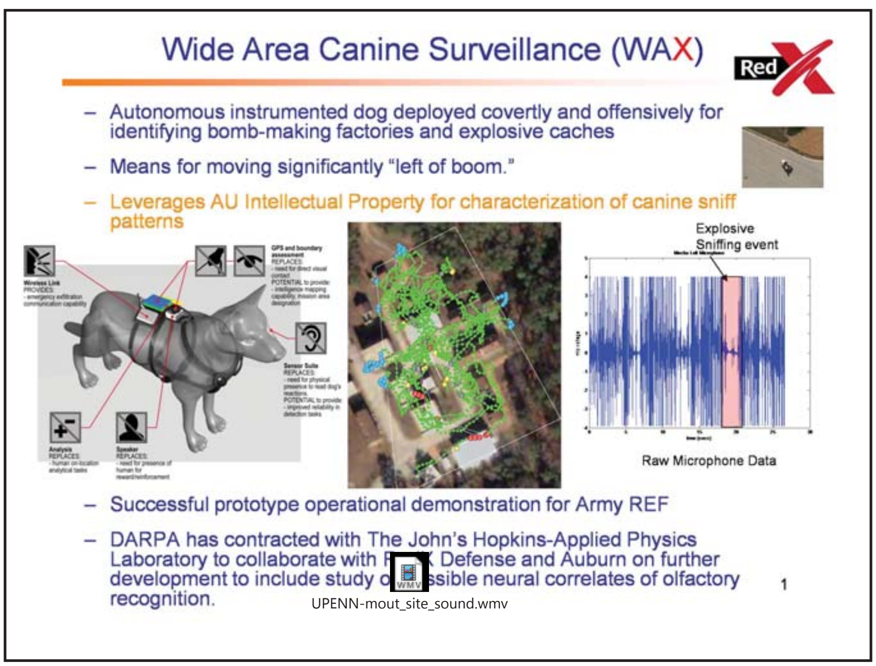
Odorant	Odor	LOD ppb	Concentration in air, M/l	[e]K_{aw}	Conc. in mucus, M/l
Cyclohexanone	Acetone	[a]10	4.45×10^{-10}	9.14×10^{-4}	4.87×10^{-7}
Methyl benzoate	Fragrant	[a]10	4.45×10^{-10}	1.33×10^{-3}	3.36×10^{-7}
2,4 DNT	Almond	[a]0.5	2.22×10^{-11}	5.98×10^{-5}	3.72×10^{-7}
Amyl Acetate	Banana	[a]0.002	8.9×10^{-14}	1.44×10^{-2}	6.17×10^{-12}
+/-Limonene	Turpentine	[a]10^3	4.45×10^{-7}	0.99	4.46×10^{-7}
Heptanal	Dairy	[b]1.2	5.3×10^{-11}	0.17	3.11×10^{-10}
Acethophenone	Orange	[c]1.0	4.45×10^{-11}	4.18×10^{-4}	1.06×10^{-7}
Eugenol	Spicy	[d]0.2	8.9×10^{-12}	8.08×10^{-5}	1.10×10^{-7}
Ethyl vanillin	Vanilla	[c]0.1	4.45×10^{-12}	2.80×10^{-6}	1.59×10^{-6}
2-Heptanone	Fruity	[c]10	4.45×10^{-10}	5.51×10^{-3}	8.07×10^{-8}

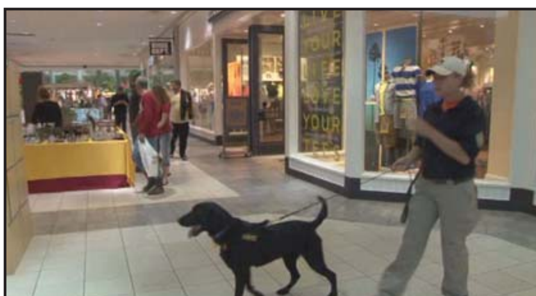
aCanine levels of detection given by Agency. bLOD in mice(Laska *et al.*, 2006). cLOD estimated by a model (Hau *et al.*, 2000; Abraham *et al.*, 2002). d Canine LOD (Myers, 2008). eAir/water partition coefficient (Eq.1).


Olfaction is proving to be an extremely complex sense.
Nature has done a remarkable job in developing an exquiste trace detector.
Nasal lumen
Distal parts receptor cell cilia
Mucus
Proximal parts receptor cell cilia
Dendritic ending
Supporting cell microvilli
Supporting cells: microvilli: amiloride-sensitive Na^+ -channels; lateral membranes: aquaporin 3; supranuclear region: of odor exposed animals: ubiquitin
Distal parts cilia: odor receptors, $G_{olf\alpha}$, $G_{s\alpha}$, type III AC, CNG channels, PDE, $G_{q\alpha}$, IP_3 receptors, Na^+, K^+ -ATPase, OMP, HSP 70 (small subpopulation)
Remainder of receptor cell apices: odor receptors (rest of cilia), PDE, Na^+, K^+-ATPase (rest of cilia), OMP, HSP 70 (small subpopulation)
Dendrite

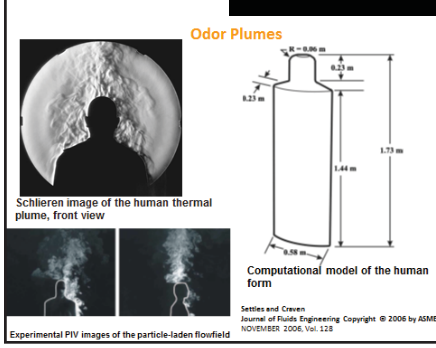

Audiograms of sniffing dog and human
500 pA
Dog
sniff
sniff
sniff
Human



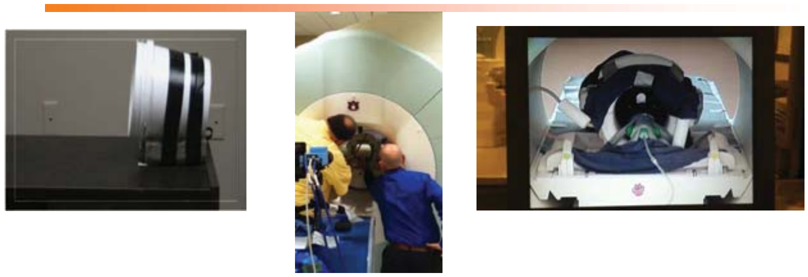

Wide Area Canine Surveillance (WAX)
Red X
– Autonomous instrumented dog deployed covertly and offensively for identifying bomb-making factories and explosive caches
– Means for moving significantly "left of boom."
– Leverages AU Intellectual Property for characterization of canine sniff patterns
Wireless Link PROVIDES: - emergency exfiltration communication capability
GPS and boundary assessment REPLACES: - need for direct visual contact POTENTIAL to provide: - intelligence mapping capability, mission area designation
Sensor Suite REPLACES: - need for physical presence to read dog's reactions. POTENTIAL to provide - improved reliability in detection tasks
Analysis REPLACES: - human on-location analytical tasks
Speaker REPLACES: - need for presence of human for reward/reinforcement
Explosive Sniffing event
Raw Microphone Data
– Successful prototype operational demonstration for Army REF
– DARPA has contracted with The John's Hopkins-Applied Physics Laboratory to collaborate with Defense and Auburn on further development to include study ssible neural correlates of olfactory recognition.
UPENN-mout_site_sound.wmv
1

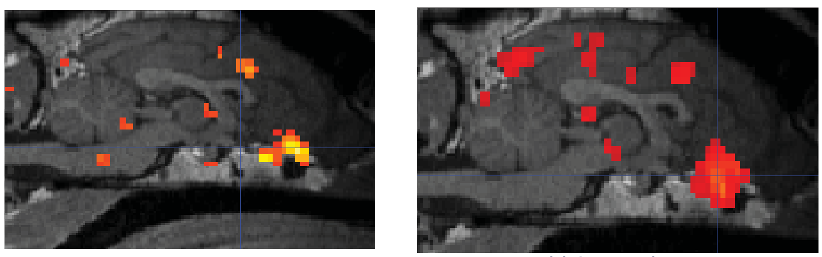


Vapor Detection



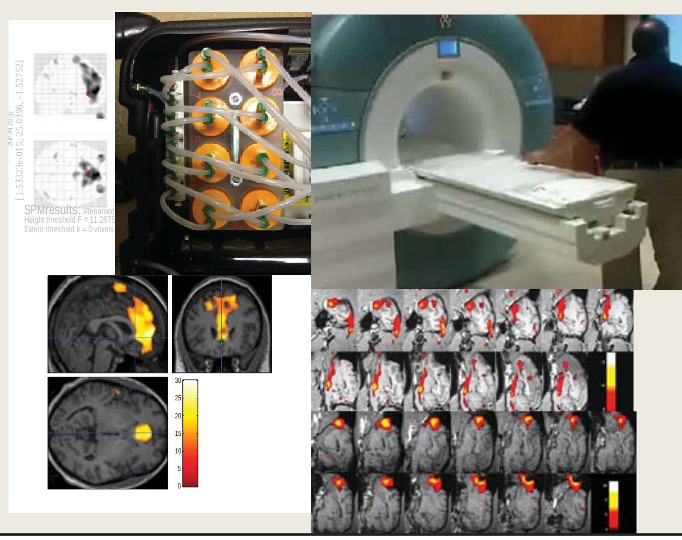
fMRI Imaging of Response to Odorants

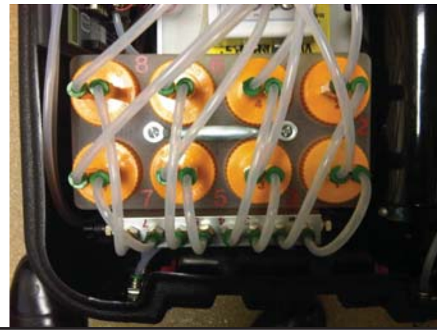




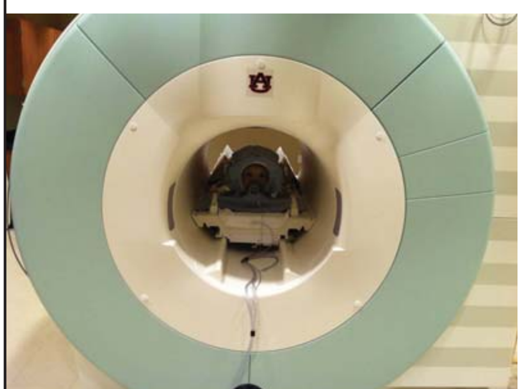
Low Concentration   High Concentration

Canine Olfactory fMRI





Before we can get to this……

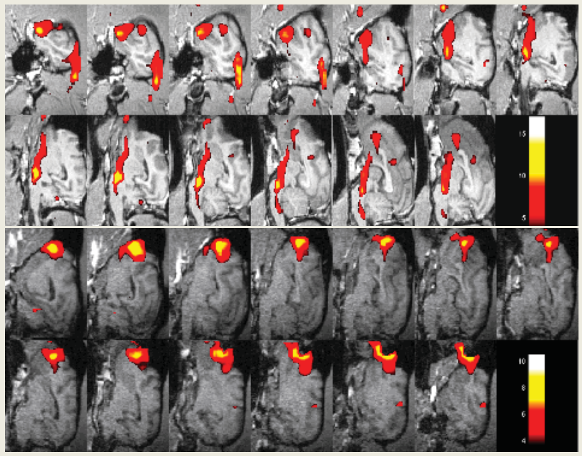


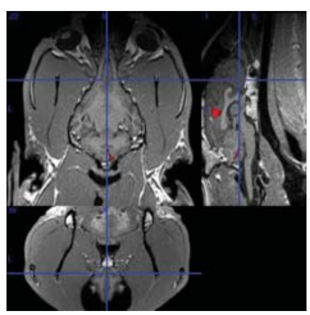
Eli awake in 3T

Eli Training

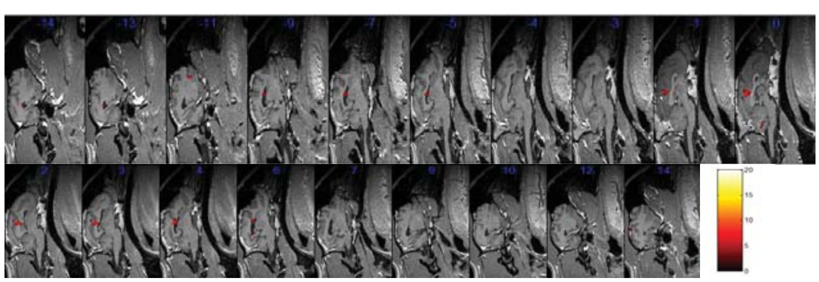
We now have dogs within knee hole for 3.5 minute sample time as long as 45 minutes

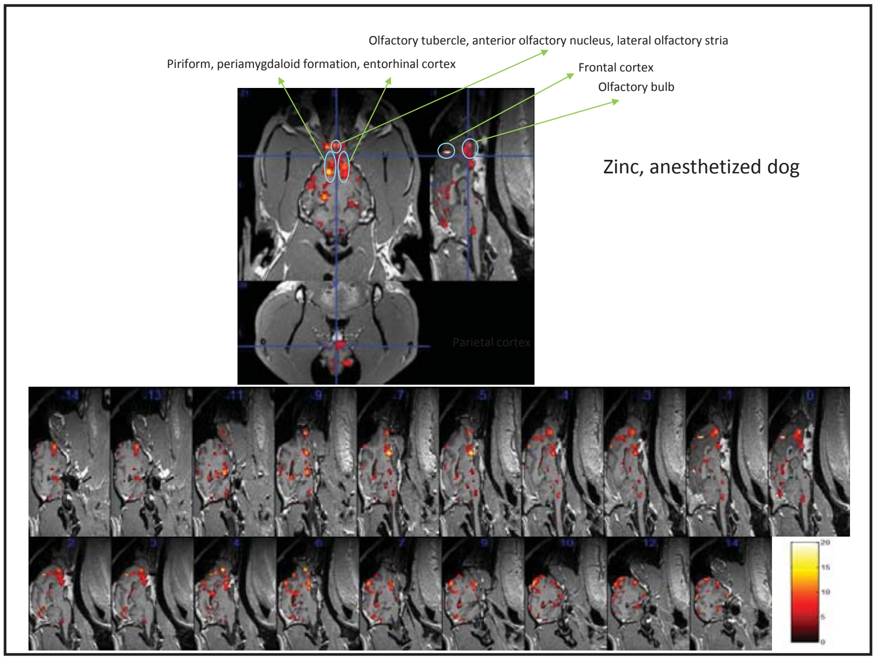
Anesthetized vs Awake

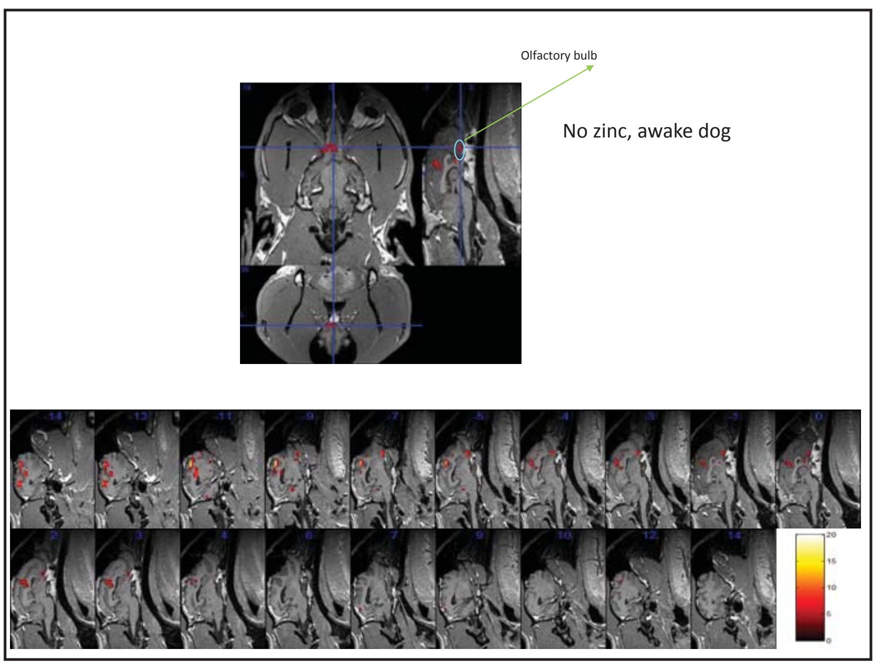


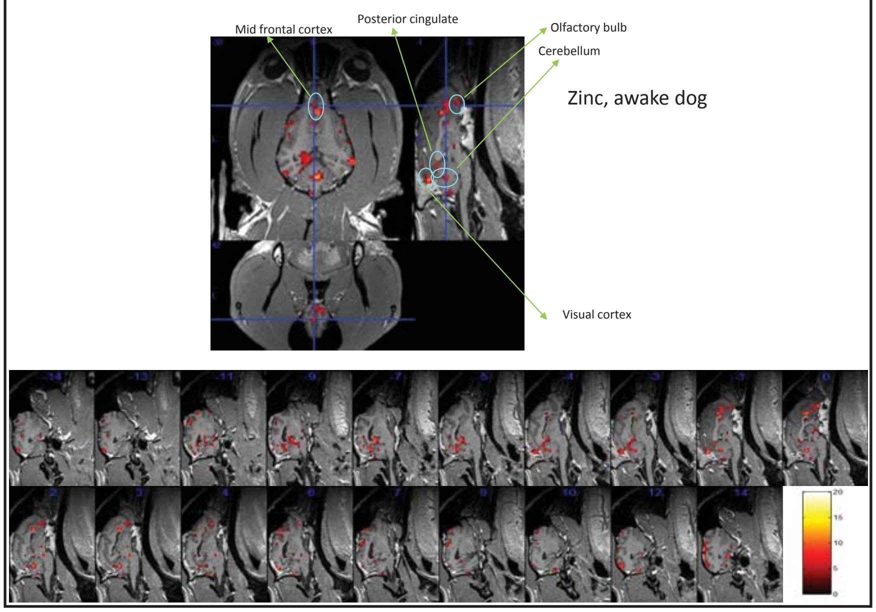


No zinc, anesthetized dog




Olfactory tubercle, anterior olfactory nucleus, lateral olfactory stria
Piriform, periamygdaloid formation, entorhinal cortex
Frontal cortex
Olfactory bulb
Zinc, anesthetized dog
Parietal cortex


Olfactory bulb
No zinc, awake dog



Prior Auburn Canine fMRI Work

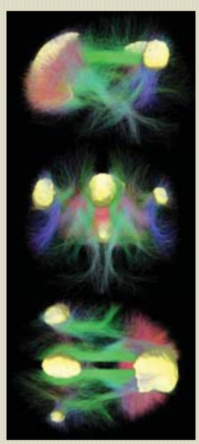
- Demonstrated difference in magnitude of neural activation in response to high vs. low concentration odorant
  - Procedural validity
- Demonstrated difference in magnitude and location of neural activation in awake vs. lightly anesthetized dogs
  - Awake dog activity focused and in higher cognitive function areas
  - Procedural validity

H. Jia, O. Pustovyy, P. Waggoner, R. Beyers, J. Schumacher, C. Wildey, J. Barret, E. Morrison, N. Salibi, T. Denney, V. Vodyanoy and G. Deshpande, "Functional MRI of the Olfactory System in Conscious Dogs.," *PLoS One,* vol. 9, no. 1, p. e86362, 2014.

Prior Auburn Canine fMRI Work

- Demonstrated increased magnitude of neural activation in response to odorant in presence of zinc nanoparticles.
  - Confirmed increased olfactory response in presence of zinc seen at level of receptors in electrophysiology study is seen upstream in higher brain area.
- Demonstrated local association but disassociation of the anterior and posterior regions of the *default mode network* (DMN) in resting state anesthetized and awake dogs
  - DMN implicated in self-referential processing, emotional and social processing.
  - In humans, functional connectivity in DMN important in working memory efficiency and higher level cognition
  - Dogs DMN localized connectivity similar to that of human child
  - DMN in dogs may have potential as predictor of behavioral performance and individual traits, such as empathetic response useful in emotional support dogs

H. Jia, O. Pustovyy, P. Waggoner, R. Beyers, J. Schumacher, C. Wildey, J. Barret, E. Morrison, N. Salibi, T. Denney, V. Vodyanoy and G. Deshpande, "Functional MRI of the Olfactory System in Conscious Dogs.," *PLoS One,* vol. 9, no. 1, p. e86362, 2014.



SUMMARY

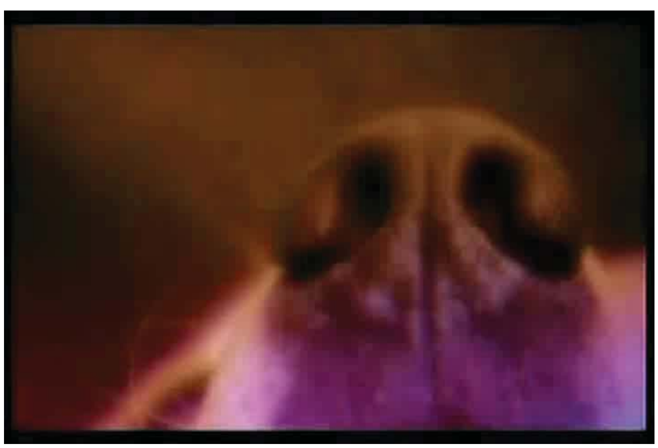
•Canine nasal cavity complex

•Canine Defensins are present in nasal cavity and may play a significant role in protection and immunity

•Olfactory signals are strongly enhanced by Zn nanoparticles, member of PNCs (small misfolded proteins)

•Zn metallic nanoclusters (not Zn ions) assist an electronic coupling between G-proteins and extracellular receptors. Effect is dose dependent and reversible.

•fMRI in Canine detectors is feasible and opens new avenues into canine research



Acknowledgements

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The Fetzer Institute — The Fetzer Institute

Aetos Tecnologies, Inc. — AETOS Technologies, Inc.

I am grateful to my colleagues and graduate students:

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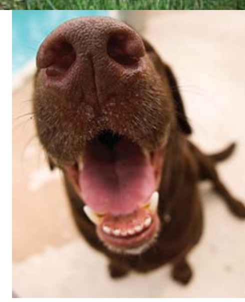
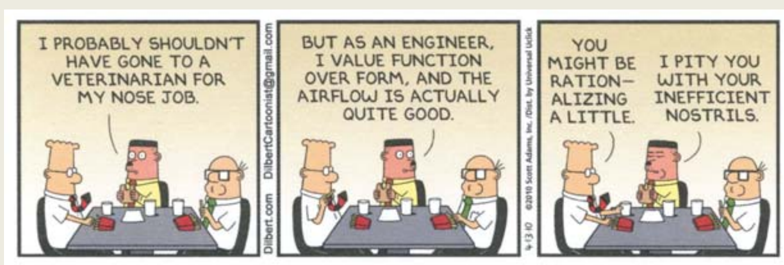
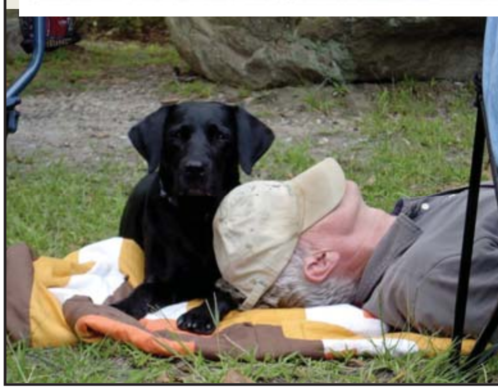
Oleg Pustovyy
Ludmila Globa
Victoria Light
Srikumar Sinnarajah
Deepa Srikumar
Lew Scharpf
Eleanor M. Josephson
Vitaly Vodyanoy

Paul Waggoner
Gary Settles
Tom Denny
Jishu Shi
Shelly Aono
Janet Steiss

Auburn University
Penn State University
Johns Hopkins University
Kansas State University

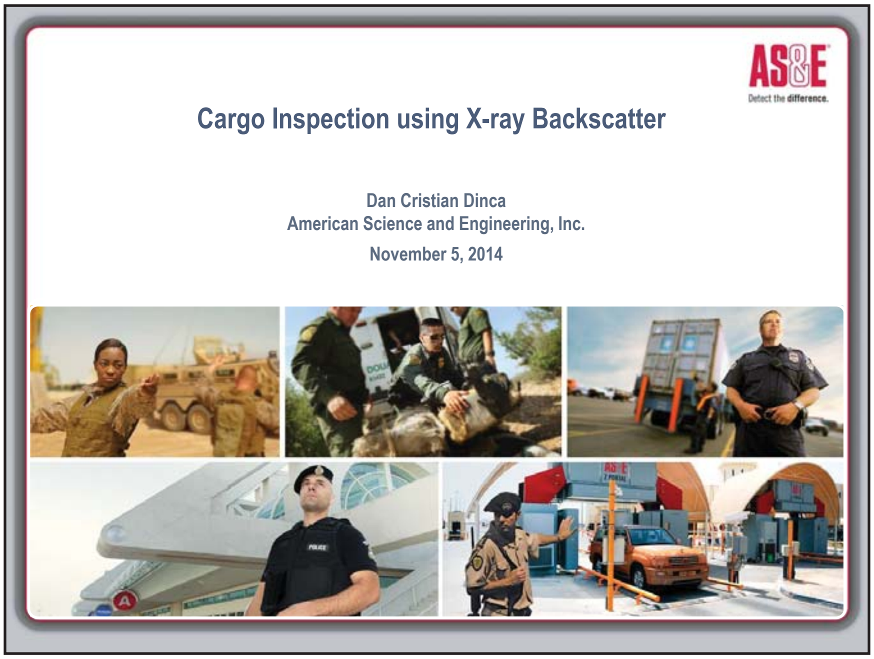


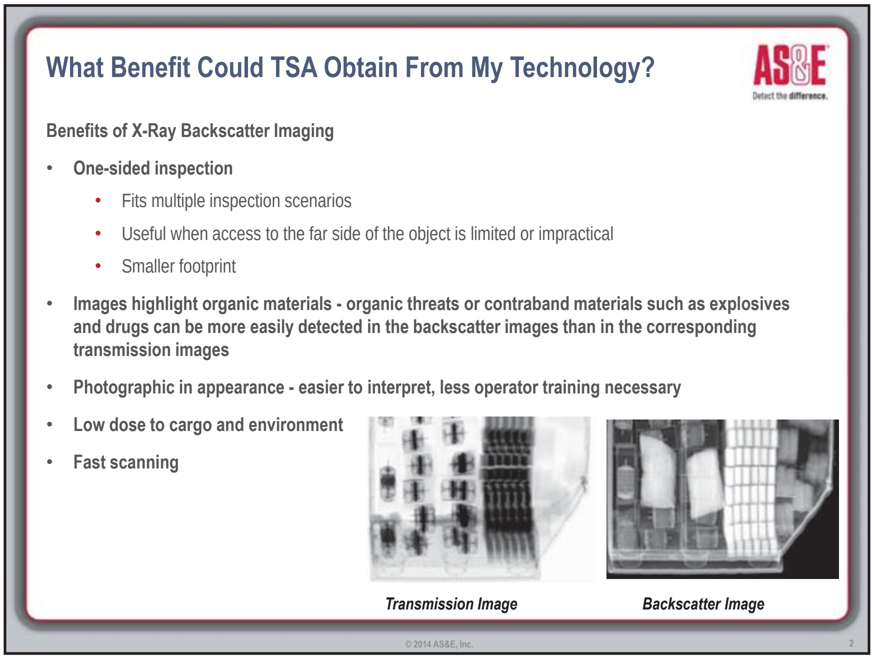


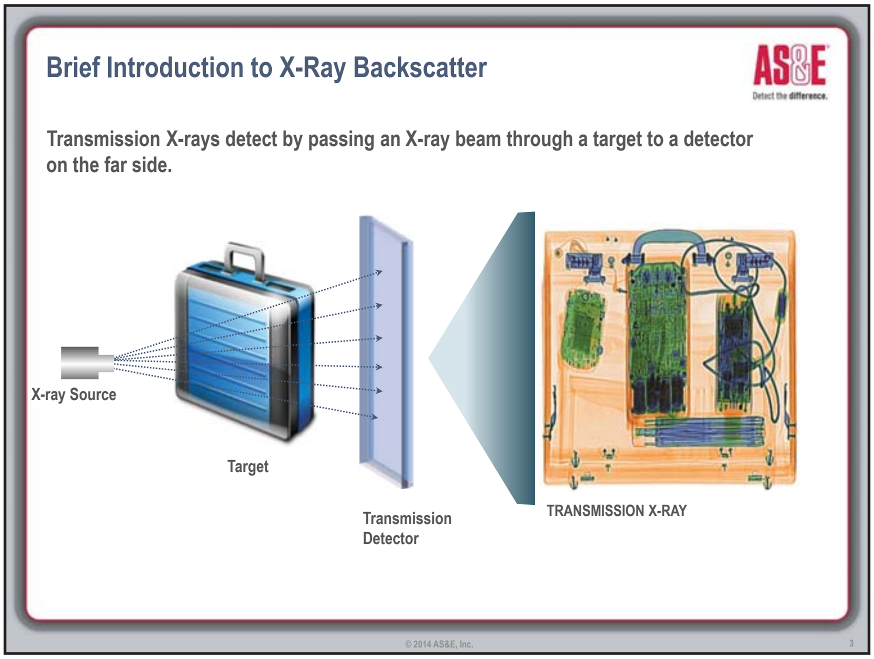


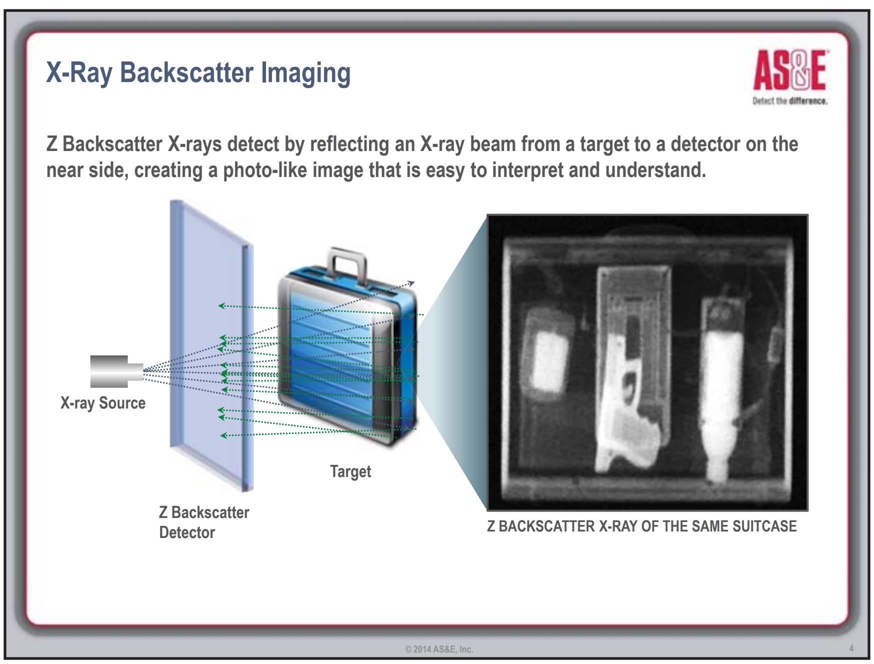
Questions

17.23 Dan Cristian Dinca: Cargo Inspection Using X-ray Backscatter



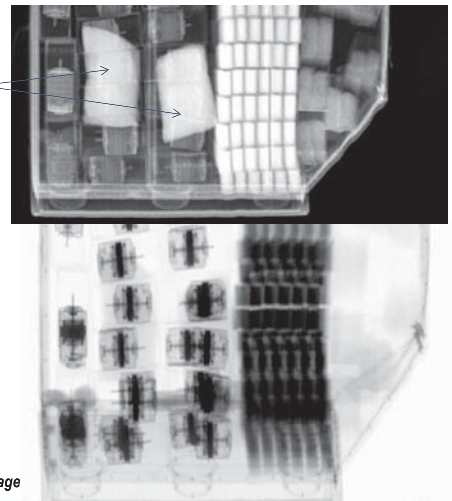



Brief Introduction to X-Ray Backscatter
AS&E
Detect the difference.
Transmission X-rays detect by passing an X-ray beam through a target to a detector on the far side.
X-ray Source
Target
Transmission Detector
TRANSMISSION X-RAY
© 2014 AS&E, Inc.


X-Ray Backscatter Imaging
AS&E
Detect the difference.
Z Backscatter X-rays detect by reflecting an X-ray beam from a target to a detector on the near side, creating a photo-like image that is easy to interpret and understand.
X-ray Source
Target
Z Backscatter Detector
Z BACKSCATTER X-RAY OF THE SAME SUITCASE
© 2014 AS&E, Inc.

Enhances Detection of Certain Objects in a Cluttered Environment

AS&E
Detect the difference.



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Adds Context to a Complex Cargo Container Image

AS&E
Detect the difference.

- By inspecting both the transmission and backscatter image the operator understands the context of the transmission image features

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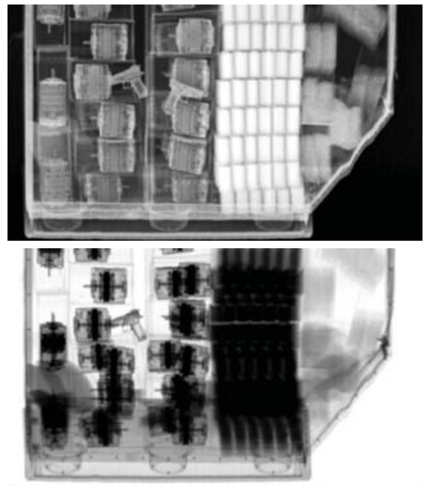
Not Limited to Organic Objects

- Ability to detect non-organic objects depends on the surrounding environment



Second gun hard to notice in the transmission image

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Parcel and Break Bulk Cargo Screening

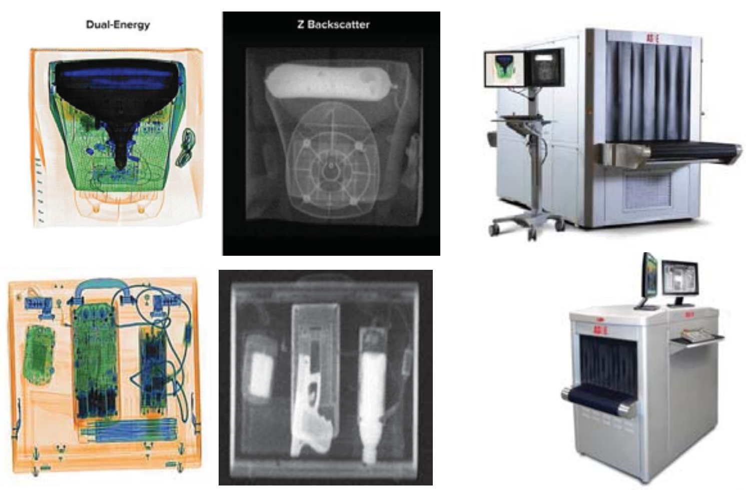

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Image Objects in Places Hard to Screen

AS&E
Detect the difference.

Fast, portable detection of organic objects (drugs, explosives, etc.) located in voids behind non-metallic surfaces

- Examination of walls, vehicle interiors, airplane interiors, pleasure boats, packages, furniture…

Narcotic simulant in a car seat

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See Through Non-metallic or Thin Metallic Objects and Produces Images of Potential Threats and Contraband

AS&E
Detect the difference.

Narcotic simulant in bumper

Narcotic simulant concealed in tire

Dose to operator less than 50 urem/h for 100% duty cycle

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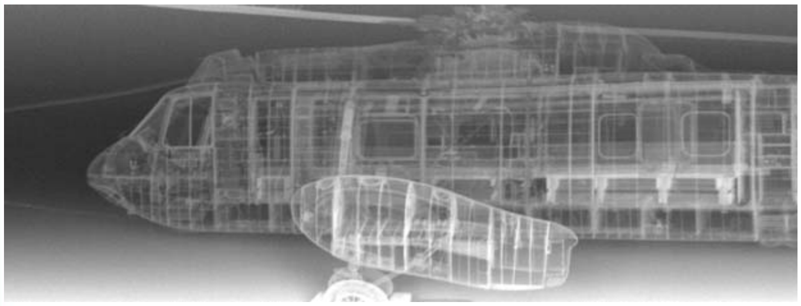
A Quick Way to Examine Large Objects

AS&E
Detect the difference.



One-sided imaging allows for simple inspections

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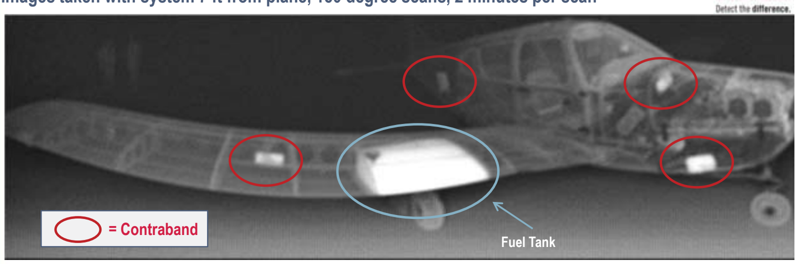
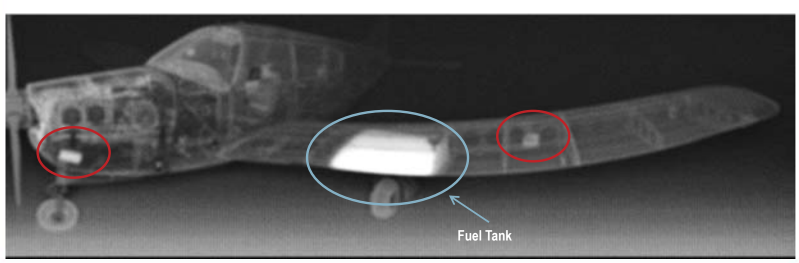
General Aviation Scanner: Small Plane with Contraband

Images taken with system 7 ft from plane, 150 degree scans, 2 minutes per scan

AS&E
Detect the difference.





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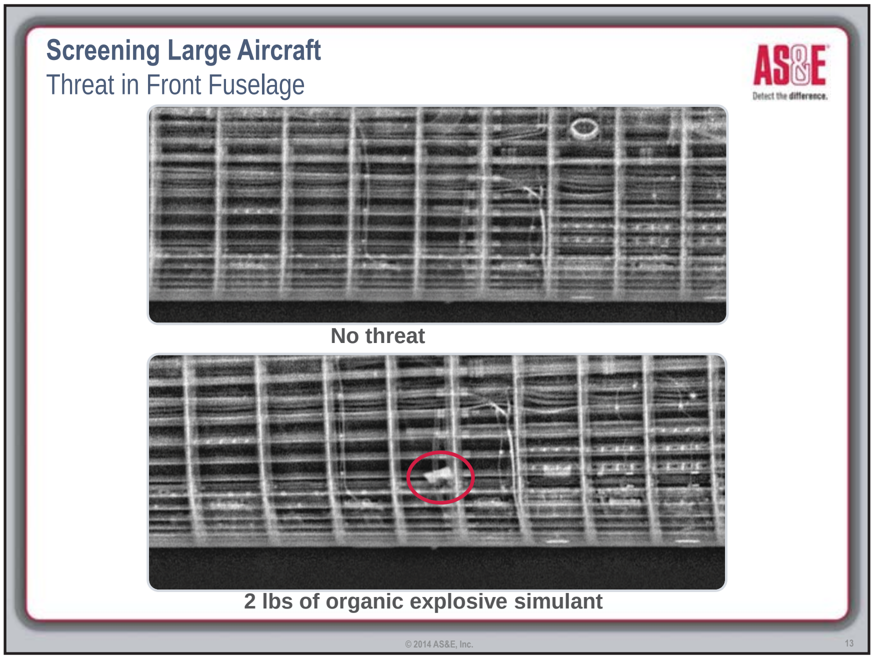
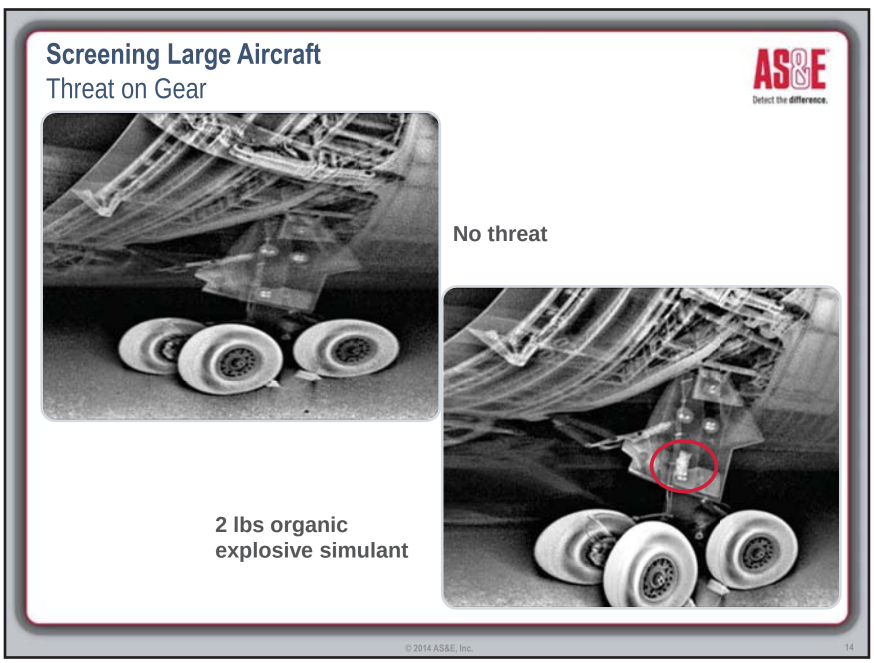
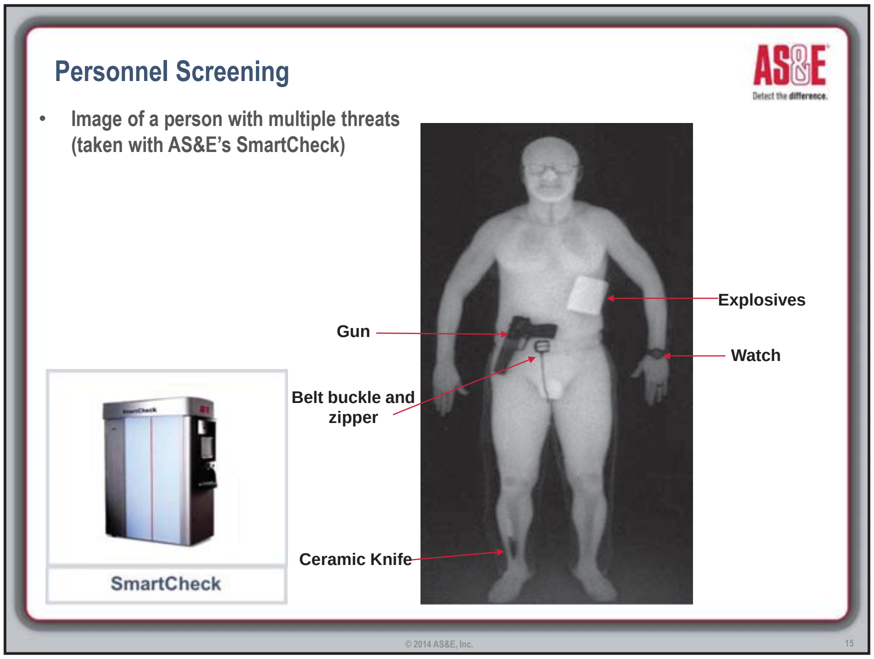
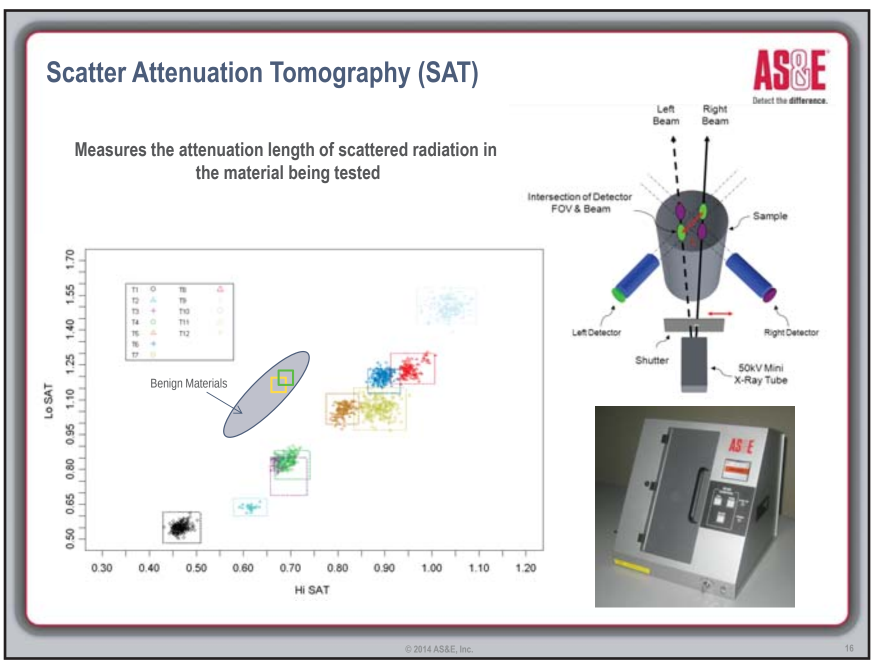

Screening Large Aircraft
Threat in Front Fuselage
AS&E
Detect the difference.
No threat
2 lbs of organic explosive simulant


Screening Large Aircraft
Threat on Gear
AS&E
Detect the difference.
No threat
2 lbs organic
explosive simulant


Personnel Screening
AS&E
Detect the difference.
Image of a person with multiple threats (taken with AS&E's SmartCheck)
Explosives
Gun
Watch
Belt buckle and zipper
Ceramic Knife
SmartCheck
© 2014 AS&E, Inc.
15


Scatter Attenuation Tomography (SAT)
AS&E
Detect the difference.
Measures the attenuation length of scattered radiation in the material being tested
Benign Materials
Lo SAT
Hi SAT
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
0.50
0.65
0.80
0.95
1.10
1.25
1.40
1.55
1.70
Left Beam
Right Beam
Intersection of Detector FOV & Beam
Sample
Left Detector
Right Detector
Shutter
50kV Mini X-Ray Tube
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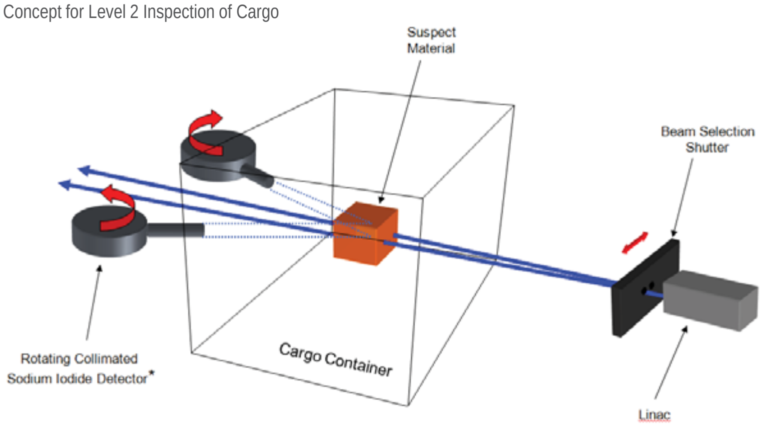
16

SAT Can Scale to Larger Cargo Sizes

Concept for Level 2 Inspection of Cargo



*Rotation Angle of detectors selects depth of object being interrogated

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17

Limitations of the Method

- **Backscatter X-ray limitations**
  - Difficult to penetrate optically dense cargo → limited penetration compared to transmission X-ray imaging
  - Highlights organic materials but cannot distinguish between explosives and other high density benign organics
  - Typically lower spatial resolution than transmission X-ray
- **Mitigation techniques**
  - Combine with other scan method (e.g. X-ray transmission)
  - Multiple views to increase cargo coverage
- **Optical density is a problem for transmission X-ray imaging too**
  - Palletized cargo and ULDs are optically dense → higher energy necessary → lower Zeff resolution

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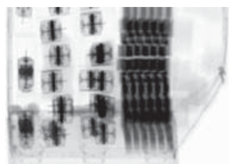
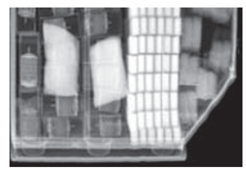
Conclusions

Benefits of X-Ray Backscatter Imaging

- **One-sided inspection**
  - Fits multiple inspection scenarios
  - Useful when access to the far side of the object is limited or impractical
  - Smaller footprint
- **Images highlight organic materials - organic threats or contraband materials such as explosives and drugs can be more easily detected in the backscatter images than in the corresponding transmission images**
- **Photographic in appearance - easier to interpret, less operator training necessary**
- **Low dose to cargo and environment**
- **Fast scanning**



Transmission Image



Backscatter Image

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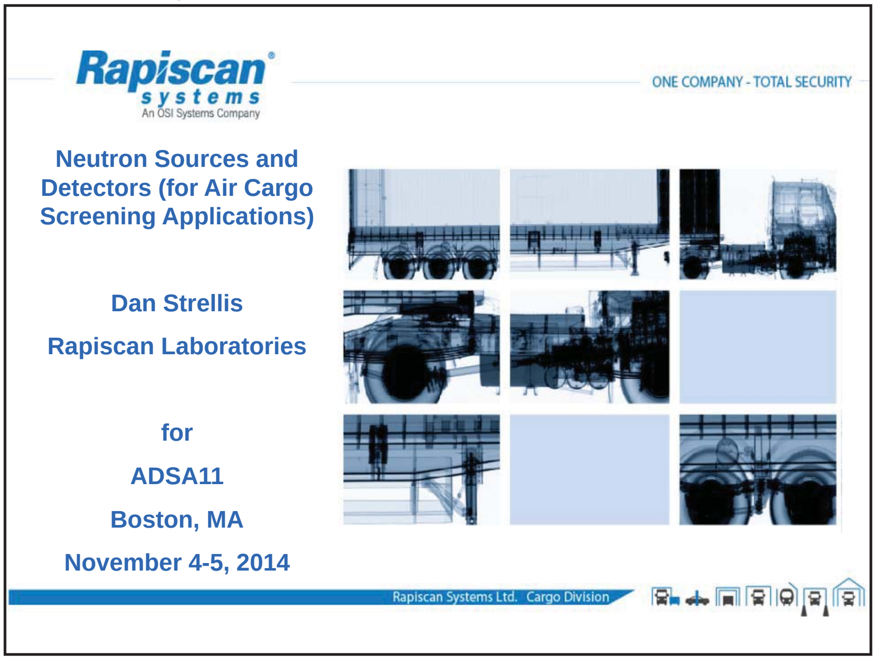
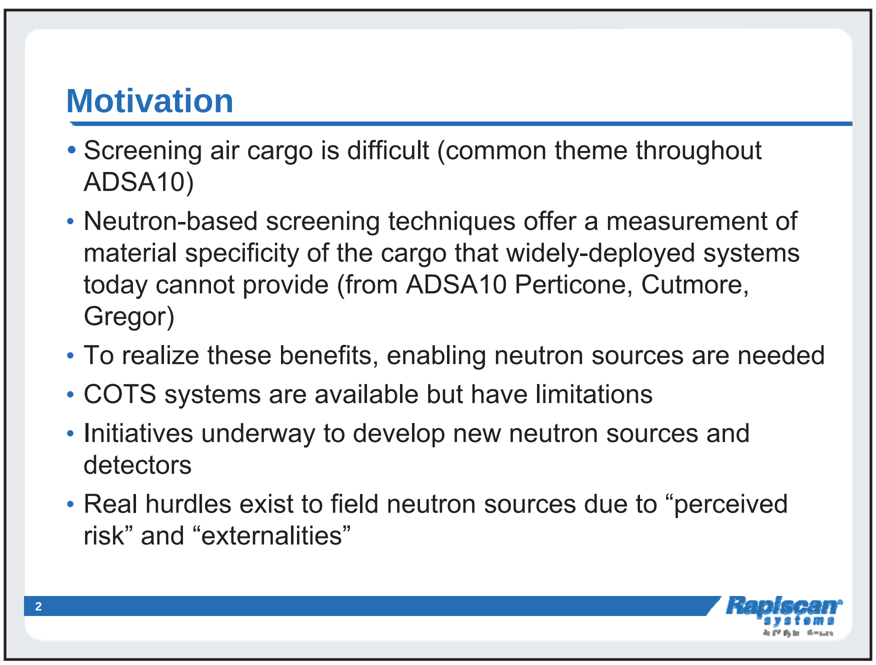
19

17.24 Dan Strellis: Neutron Sources and Detectors (for Air Cargo Screening Applications)





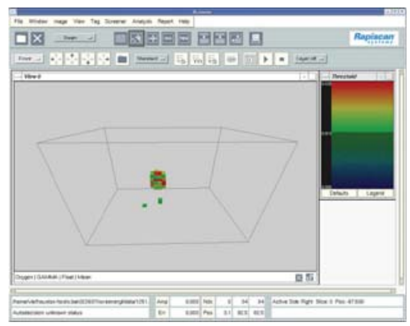
Applications

Fast Neutron Radiography (n in, n through)

- One part of CSIRO / NucTech's Dual Species scanning system (gamma

Neutron interrogation, measure secondary emissions (n in, γ out)

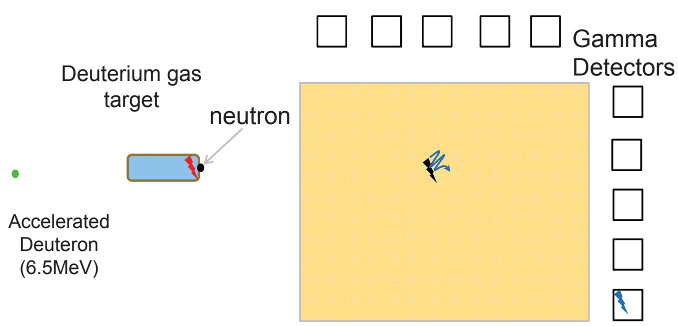
- Pulsed Fast Neutron Analysis



3

Pulsed Fast Neutron Analysis

- PFNA
- D + D → n (~8.5 MeV) + ^{3}He



4

Requirements

- For cargo scanning, neutron source is too large, too expensive but output is right – $10^{12\text{-}13}$ n/s

Pelletron Source $M, size of the Egan Research Center front lobby

- For portable systems, neutron source is too large, flux not high enough

5

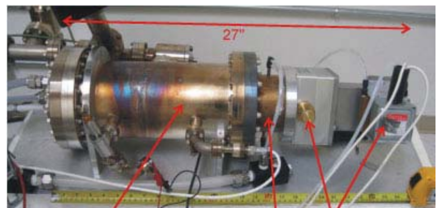
COTS

- Radioisotope – ^{252}Cf spontaneous fission neutron source
  - Steady state
  - 10^7-10^8 neutrons/s fission neutron E spectrum
- Electronic Neutron Generators
  - 1-3 $\times 10^8$ ($\times 10^6$) neutrons/s dT (dD)
  - 10-cm diameter, 91-cm long, 25 lbs
  - Vendors
    - Thermo Scientific (www.thermoscientific.com)
    - EADS Sodern (www.sodern.com)
  - 100x higher flux generators also offered for each vendor but much larger

6

COTS

- Electron Cyclotron Resonance (ECR)
  - Adelphi Technologies (www.adelphitech.com)
  - DD – 10^{9}-10^{10} neutrons/s
  - 25-cm diameter, 80-cm long, 500 lbs,



7

Newer Neutron Source Developments

- Starfire Industries – www.starfireindustries.com
  - 10^{7} neutrons/s DD, 8-cm diameter, 60-cm length, 43 lbs

- Phoenix Nuclear Lab – www.phoenixnuclearlabs.com
  - 3×10^{11} neutrons/s DD, 5×10^{13} DT
  - 8 cubic meter volume
  - 4500 lbs
  - Also working on compact generators

8

Ongoing Neutron Source R&D

DARPA Intense Compact Neutron Source (ICONS) Program (DARPA BAA 14-46)

- TA1: Development tool box sized intense neutron source for radiography
- TA2: Development of a human portable directional neutron source

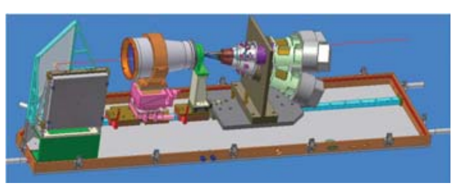
- Orders of magnitude improvement on SWaP
- Looking for innovative designs and construction methods to shrink a neutron accelerator from 10 meters or longer down to 1 meter or less, similar to the size of portable X-ray tubes today.
- Creating a high-yield, directional neutron source in a very compact package is a significant challenge
- Provide an imaging able to deliver very detailed, accurate internal imaging of objects in any setting

- Two 18-month phases

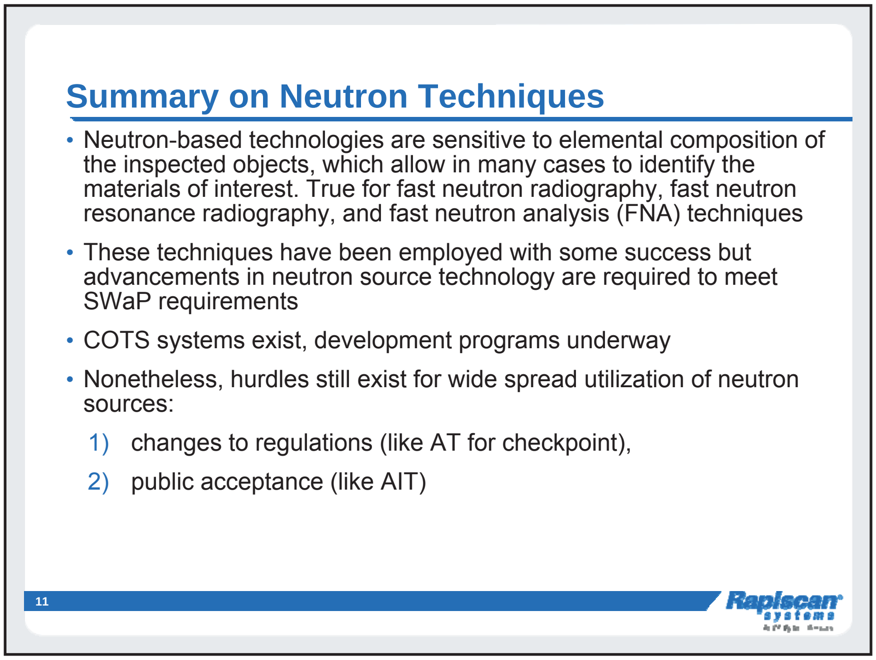
9

Neutron Detectors

- Application for air cargo limited to neutron radiography (n in, n through)
- Transmission Radiography
  - Thermal neutrons (limited by penetration depth needed for cargo), thus thermal neutron detector not relevant for this application
  - Fast neutrons (plastic scintillators – Cutmore)
- Fast Neutron Resonance Radiography (FNRR)
  - Vartsky (Soreq, Israel), Dangendorf (PTB, Germany)



10


Summary on Neutron Techniques
• Neutron-based technologies are sensitive to elemental composition of the inspected objects, which allow in many cases to identify the materials of interest. True for fast neutron radiography, fast neutron resonance radiography, and fast neutron analysis (FNA) techniques
• These techniques have been employed with some success but advancements in neutron source technology are required to meet SWaP requirements
• COTS systems exist, development programs underway
• Nonetheless, hurdles still exist for wide spread utilization of neutron sources:
1) changes to regulations (like AT for checkpoint),
2) public acceptance (like AIT)
11
Rapiscan systems

17.25 Cameron Geddes: Monochromatic Photon Source

Monochromatic photon source

Cameron G.R. Geddes,
Lawrence Berkeley National Laboratory

LBNL – BELLA Center within the Accelerator Technology and Applied Physics division
Sven Steinke, Jeroen van Tilborg, Nicholas H. Matlis, Sergey Rykovanov, Kei Nakamura, Carl B. Schroeder, Brian Shaw Csaba Toth, Min Chen, Eric H. Esarey, Wim P. Leemans

LBNL Divisions of Accelerator Technology and Applied Physics; Nuclear Science; Physics
Bernhard Ludewigt; Brian J. Quiter, Paul Barton, Yigong Zhang, Kai Vetter; Maurice Garcia-Sciveres

LLNL
Marie-Anne Descale, David Grote, Alex Friedman

INL
David Chichester, Matt Kinlaw, Scott Thomson

PNNL
Glen Waren

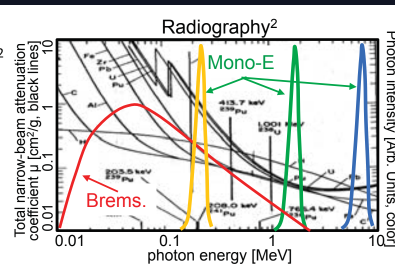
U.C. Bekeley
Stan Prussin

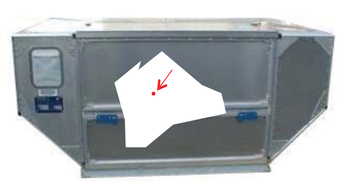
U. Michigan
Almantas Galvanauskas and students

ACCELERATOR TECHNOLOGY & APPLIED PHYSICS DIVISION ATAP | U.S. DEPARTMENT OF ENERGY | Office of Science | NNSA | Defense Nuclear Nonproliferation R&D

Quasi-monoenergetic photon sources can improve material detection/characterization and reduce dose

- Radiography & CT: image + identify Z
  - Luggage: 0.2-2 MeV, Container: 1-9 MeV[1,2]
  - Bandwidth (BW) ~20%, 10^5-10^8ph/shot
- Photoneutrons: identify element, ratios
  - Material dependent near 10 MeV[1,3]
  - Bandwidth ~10-20% avoids background
  - Photofission for nuclear material[4]
- Nuclear Resonance Fluorescence: isotope
  - Isotope specific[5] in range 1-7 MeV
  - Bandwidth ≤ few % FWHM isolates peak



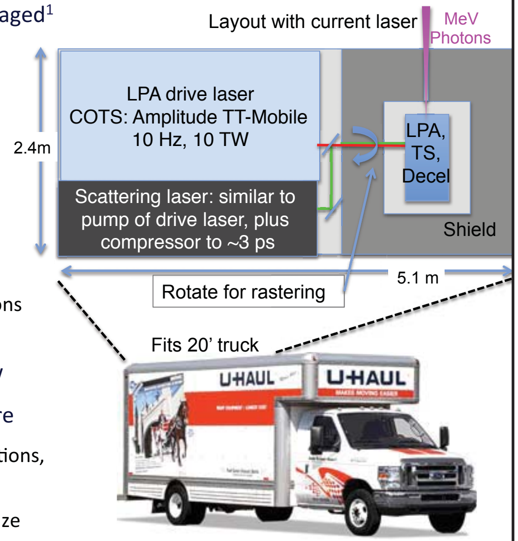


– Precise identification at container scale.
– Low dose + cm resolution at scan rate ~100cm/s

1: J. Clayton, Varian. Related: B.J. Quiter et al, J. Appl. Phys. **103**, 064910 (2008) 2: Nelson and Reiley LAUR-90-732 (1991). ANSI N42.46, DNDO call CFP13-100
3: R. B. Firestone,et al, Table of Isotopes Wiley, New York, 1996 4.T.P. Lou, LBNL. Related: ISIS test & sims by Campbell (PNNL), M. Johnson et al., AIP Proc. 1336 no 1 (2011)
5: B. Quiter, LBNL. Related: Hayakawa et al. NIM A 621 (2010);Hajima et al. NIMA (2009) Pruet, et al. J. Appl. Phys. 99 (2006).

Compact MeV photon source concept – Laser-plasma based Lasers trailerable now and reducing in size rapidly

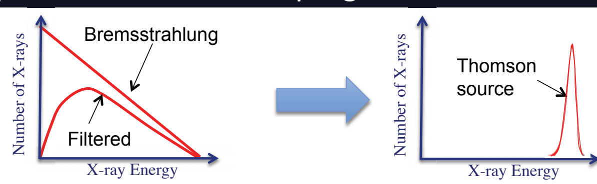
- COTS 10 TW, 10 Hz, trailer packaged[1]



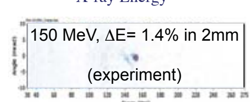
- 2 MeV concept fits 20' van
  - Deceleration, scatter critical
  - Rep rate too low for applications
- Develop source techniques now
- Even smaller source in the future
  - Efficient kHz lasers for applications, smaller in size[2]
  - Deceleration/CONOPS/optic size

1: Amplitude Technologies 2 ; http://science.energy.gov/hep/research/accelerator-rd-stewardship/workshop-reports/

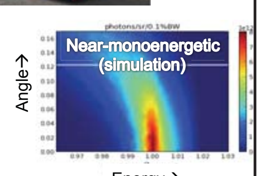
Summary: Laser-Plasma Accelerator (LPA) Thomson source & application validation in progress on current lasers



- LPAs produce photon suitable beams in ~cm
  - Tunable, 1% level energy spread, low emittance
  - 0.2 GeV from 10 TW – transportable, shrinking



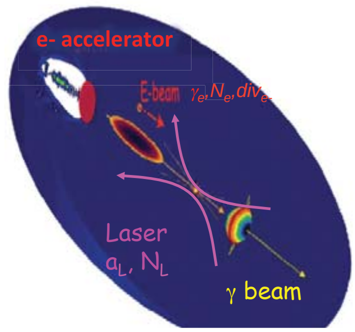
- 10% BW source being built: LPA + efficient scatter + deceleration control of radiation
- NP Application experiments in dedicated area
- Developing ≤ Percent bandwidth and high flux[1]

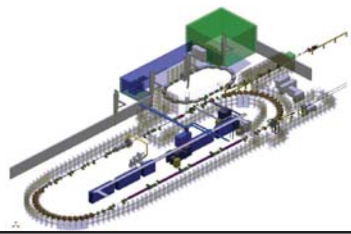


1 ; http://science.energy.gov/hep/research/accelerator-rd-stewardship/workshop-reports/

Quasi-Monoenergetic photon sources can be enabled by Thomson scattering + compact accelerators

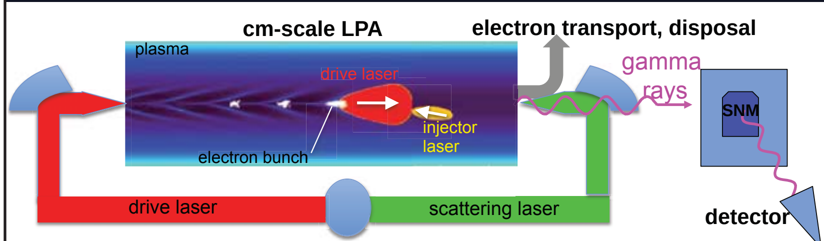
- Well established photon source:
  - 0.1-9 MeV ph. from electrons at 0.1-0.5 GeV
  - Quasi-monoenergetic, set by e-beam quality: → clear signal, low dose
  - Low divergence → high spatial resolution
  - No bremsstrahlung converter → low bkg.
- Current large facilities unsuitable
  - High energy: > 10 meter accelerator
  - High current or large scattering laser
  - Many meters of shielding





*P. Sprangle et al, J.Appl. Phys 1992,
W.P. Leemans et al., PRL 1996, R.W. Schoenlein et al., Science 1996;
Leemans TPS 2005; Geddes et al., CAARI 2008,
Albert et al PoP2012, Kawase et al, NIMA 2011.

Projects under NNSA-DNN R&D (NA-22) Integrate transportable MeV photon system elements

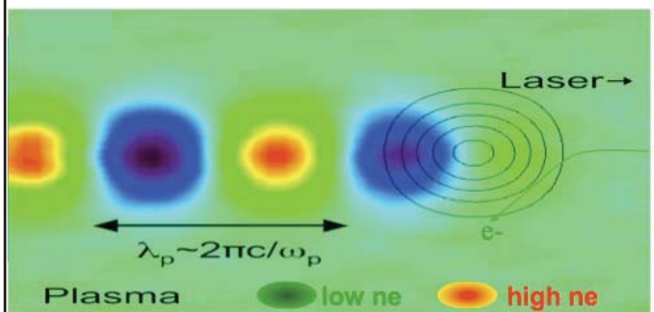


- Compact high quality electron source – Laser Plasma Accelerator (LPA)
- Photon yield with minimum electron current – scattering efficiency
- Compact, safe electron beam disposal using plasma
- Application experiments, study to demonstrate benefit

DNN Application: material discrimination in field for nuclear nonproliferation

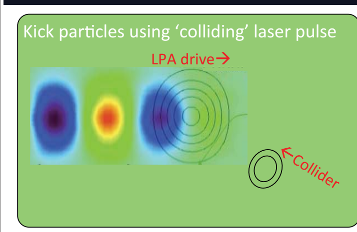
Explosives: in most cases easier- smaller size/density important, no isotopic need

Laser ponderomotive force + plasma oscillation create high gradient Laser-Plasma Accelerator structure

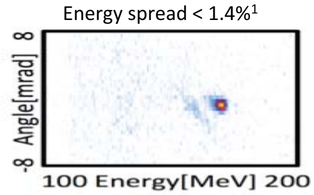


Concept: Tajima and Dawson, PRL 1979. Review articles: E. Esarey, Rev. Modern Physics 2009; Trans. Plasma Sci 1996.

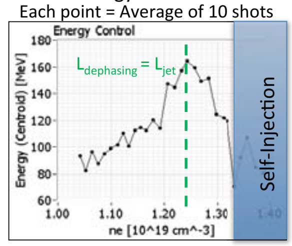
Colliding pulse controlled injection: LPA with ~1% energy spread Stable & tunable near 0.2 GeV – suitable for 0.2-2 MeV photons



Energy spread < 1.4%[1]



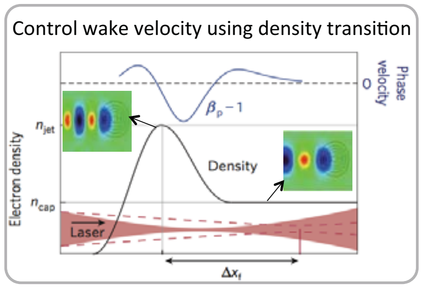
Energy is tunable
Each point = Average of 10 shots

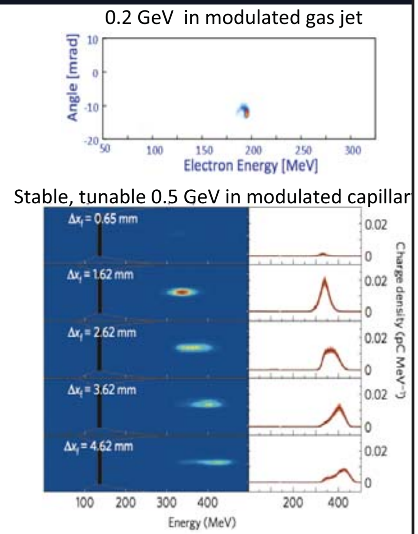


- Suitable for ~2% BW photon source (e.g. Nuclear Resonance Fluorescence)

Experiments: Geddes Proc. Adv. Acc. Concepts Workshop 2014; Theory: Esarey PRL 97; [1]Fubiani PRE06;
Related exp: Faure et al. Nature 2006, Kotaki et al PRL 2009, Toth et al, PAC 2007, Geddes PAC 2011.

Wake phase velocity modulation injection of ~5% ΔE
Stable & tunable near 0.5 GeV – suitable for 1-9 MeV photons

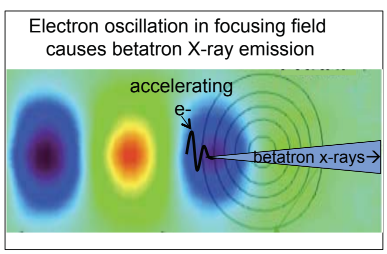


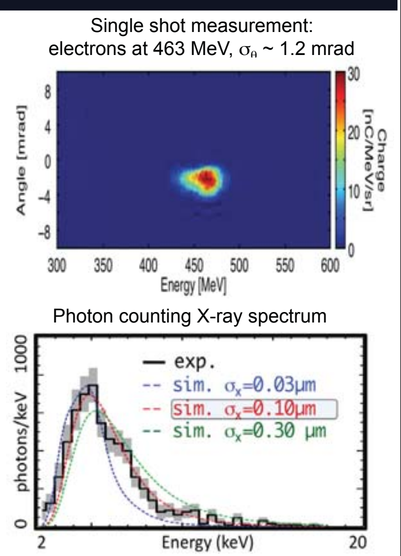


- Suitable for 10% BW photon source (e.g. radiography, photoneutron)

Gonsalves et al, 2011. Earlier experiments Geddes et al PRL 08, Hosokai PRE03; Theory: Bulanov PRL 98, Schroeder PRL11

High transverse beam quality inferred from X-ray spectra: Comparable to state of the art RF accelerators



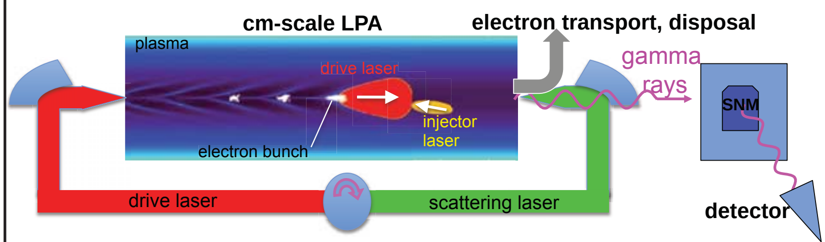


- 0.1 µm beam radius
- Low normalized emittance[1]

$$\epsilon_x \approx \gamma \sigma_x \sigma_\theta \approx 0.1 \text{ mm-mrad}$$

1; Plateau et al., PRL 2012, Thorn et al. RSI 2010 Related: Weingartner et al, PRSTAB 2012, Quad scan, measured similar emittance

NNSA-DNN R&D (NA-22) project at LBNL: Demonstrate transportable MeV photon system elements

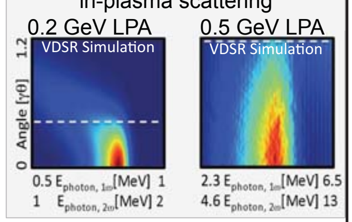


- Compact high quality electron source – Laser Plasma Accelerator (LPA)
- Photon yield with minimum electron current – scattering efficiency
- Compact, safe electron beam disposal using plasma
- Application experiments, study to demonstrate benefit

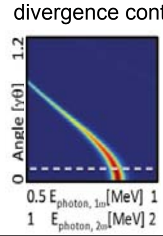
Thomson photon sources at ≤ 10% BW enabled by high quality LPA and scattering laser

- High quality e-beam enables narrow bandwidth
- Low emittance e- reduces $\Delta\theta$ contribution
  - Scattering in plasma for 10% BW
  - Divergence contribution dominant
- BW ~ 2% requires refocusing

10% bandwidth from direct in-plasma scattering



Percent-level bandwidth with divergence control

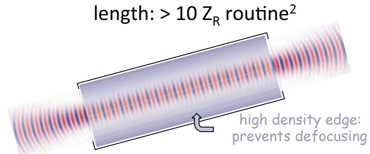


Rykovanov et al., J. Phys. B 2014, Chen et al., PR ST-AB 2013, Leemans et al. PRL 1996.
Related A.G.R. Thomas et al PRST-AB 2010 (U. Michigan); Ghebregziabher PRSTAB 2013 (UNL)
P. Chen, et al., a, NIMA 355 (1995) 107. (CAIN code)

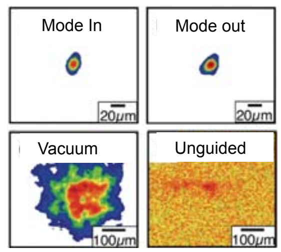
Plasma channel guided scattering can enable high yield with realistic scattering laser & e- current

- ≥1ph/e to minimize e- current implies long laser pulse (~10 ps >> LPA driver)
  - Vacuum: wasted energy because $Z_R \sim L_{laser}$
- Plasma guiding[1] allows $Z_R << L_{laser}$[2]
  - Reduce & fix $r_{laser} \rightarrow N_\gamma \propto E_{laser}$
  - ~10^8 ph/shot with E_{laser} ~LPA driver
- Laser pulse shaping to further reduce E_{laser}[3]
- 10^8 ph/shot with E_{laser} ~ LPA driver
  - separately controlled laser for scattering required for ps duration, chirp

Guiding increases focused propagation length: > 10 Z_R routine[2]

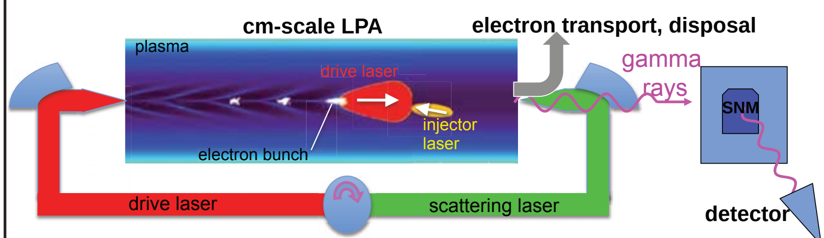


40J Unguided
3J Guided σ=5um^2 } 5ph/e- at a_0=0.15



1: many experiments, including Durfee PRL 1993, Butler PRL 2002, Geddes PRL 2005, Leemans Nat. Phys 2006.
2 ;Rykovanov, J. Phys. B 2014
3: Ghebregziabher et al., Phys. Rev.ST-AB16, 2013 , Rykovanov et al., in prep.

NNSA-DNN R&D (NA-22) project at LBNL: Demonstrate transportable MeV photon system elements



- Compact high quality electron source – Laser Plasma Accelerator (LPA)
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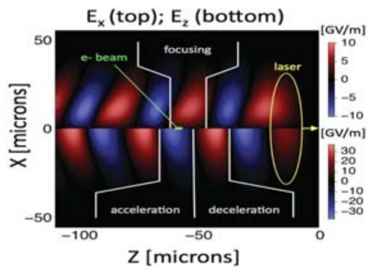
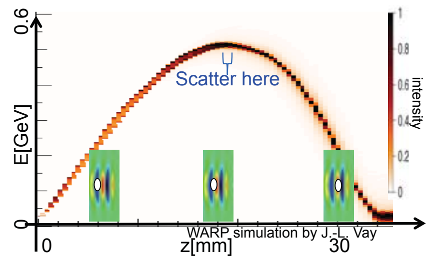
- Compact, safe electron beam disposal using plasma
- Application experiments to demonstrate benefit

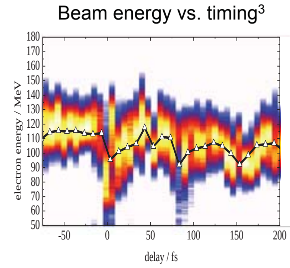
Plasma beam deceleration after scattering can reduce beam dump energy & radiation shielding





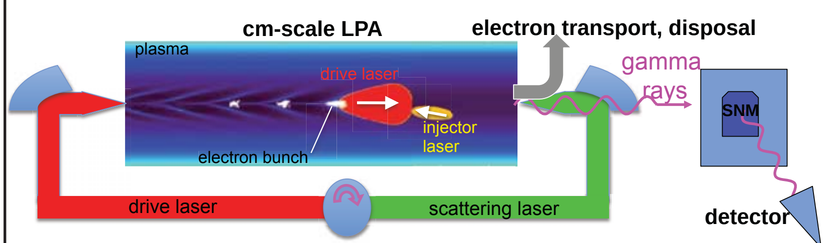
- Reduce electron energy after photon production
  - Reduce beam dump size (tons)
  - ≥ 85 % simulated[1,2]
- Initial experiments already indicate ~ 50%[3]

Beam energy vs. timing[3]



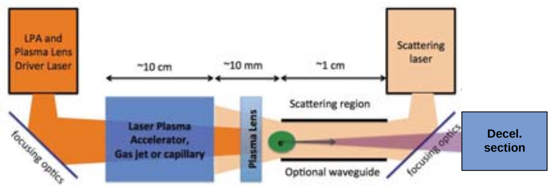
1; Vay et al., Proc. NPNSNP 2014; Rykovanov J. Phys. B 2014.. 2: A Bonatto proc. AAC 2014 3: Sven Steinke, proc. AAC 2014.

NNSA-DNN R&D (NA-22) project at LBNL: Demonstrate transportable MeV photon system elements



- Compact high quality electron source – Laser Plasma Accelerator (LPA)
- Photon yield with minimum electron current – scattering efficiency
- Compact, safe electron beam disposal using plasma
- Application experiments, study to demonstrate benefit

Source bandwidth ≤ 2% using multiple plasmas: Compact divergence control, scattering and deceleration



- Tailor plasma exit to expand beam radius ten-fold, preserving fs length
  - Nonadiabatic ramp over few mm[1]
  - Plasma lens after ~ 1mm drift expands 10x[2]

Laser driven plasma lens (blowout)

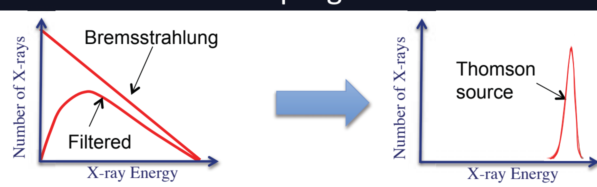
$$E_r = \frac{m_e c^2 k_p^2}{e} \cdot \frac{r}{2},$$

$$n_e \cdot l = 2.84 \cdot 10^{11}\,[\mathrm{cm}^{-1}] \cdot \frac{\gamma_e}{d}$$

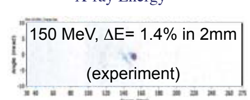
- Near-hollow channel or high order mode to reduce focusing allows guided scatter[3]
- kHz, efficient laser techniques[4] to enable high flux, fieldable source

1 Vay AAC 2014, 2; Rykovanov J Phys. B 2014. 3: Cormier, PRSTAB 14, 031303 (2011)., Schroeder Phys. Plasmas **20**, 080701 (2013);
4 ; http://science.energy.gov/hep/research/accelerator-rd-stewardship/workshop-reports/

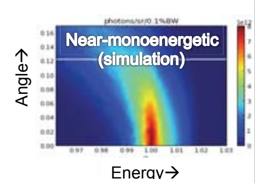
Summary: Laser-Plasma Accelerator Thomson source & application validation in progress on current lasers



- LPAs produce photon suitable beams in ~cm
  - 0.2 GeV from 10 TW – transportable, shrinking

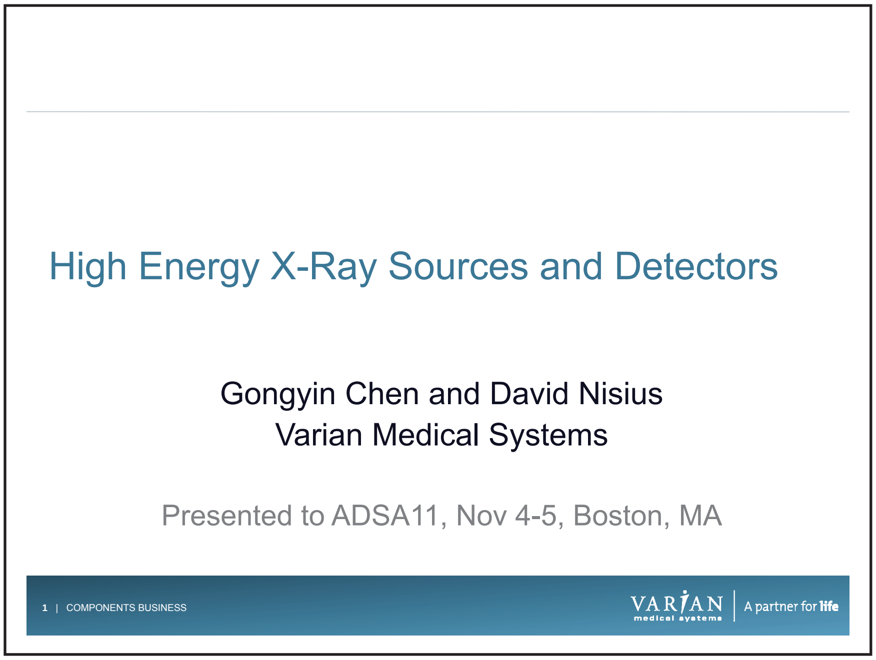


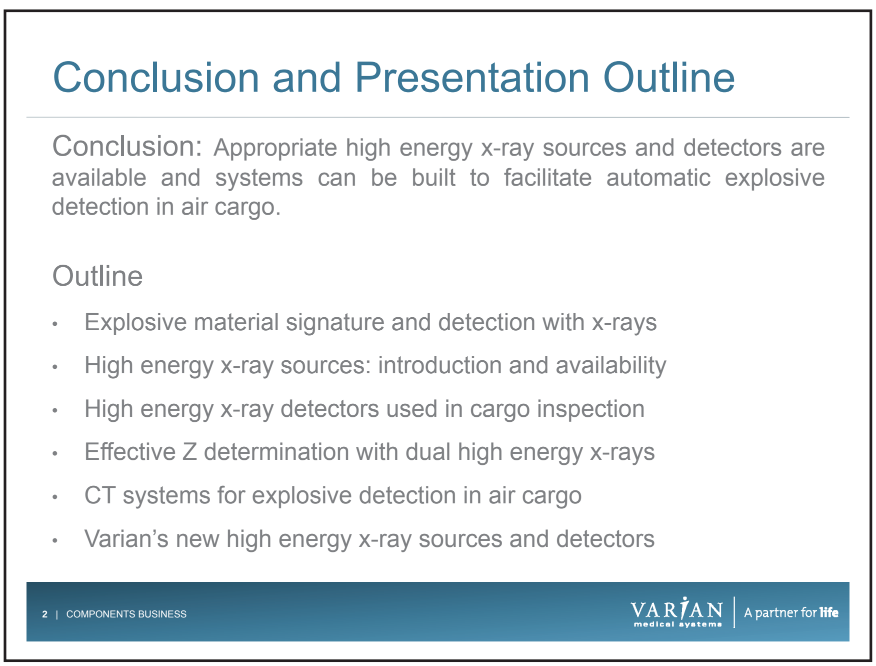
- 10% BW source being built: LPA + efficient scatter + deceleration control of radiation
  - Developing ≤ percent bandwidth, high flux[1]
- NP Application experiments in dedicated area
  - Opportunity to test explosives detection using monoenergetic photons for increased scan resolution, full container scans, reduced dose



1 ; http://science.energy.gov/hep/research/accelerator-rd-stewardship/workshop-reports/

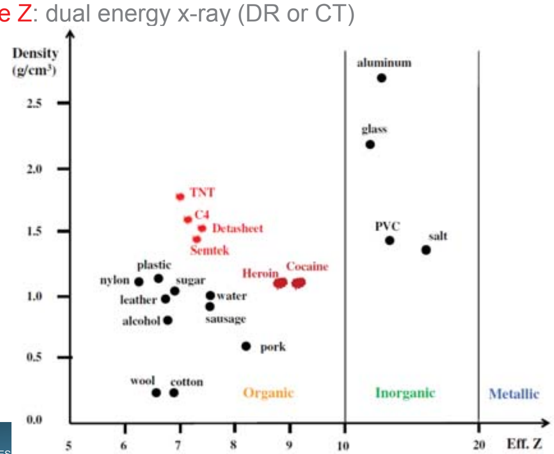
17.26 Gongyin Chen: High Energy X-Ray Sources and Detectors





Explosive Signatures and Measures

- Density: single energy x-ray CT
- Effective Z: dual energy x-ray (DR or CT)



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Dual Energy X-Ray Radiography for Checked Bags

- Single view or multi view projection images with typical X-ray energies are 75keV and 150keV (filtered)
- Measures Zeff (effective atomic number) to <0.1 (area average)
- Back scatter helps detecting sheet explosive
- Throughput can be over 1000 bags per hour (0.5m/s)
- Systems with 3~4mm pixel size have been very successful.
- False (positive) alarm is attributed to:
  - overlapping objects
  - Innocent material can have similar Zeff as some explosives

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Single Energy X-Ray CT for Checked Bags

- Planer or helical CT provides 3-D image (165 keV x-ray typically)
- Detection decision is based on density and total mass.
  - <2% voxel noise (up to 250mm water)
  - Measures density to ~1%; (~2% drift with 250mm water)
- Throughput is several hundred bags per hour
- Systems with >3mm voxel size have been very successful.
- False (positive) alarm is mainly attributed to:
  - Innocent material can have similar density as some explosives
  - At same image quality, false alarm rate grows linearly with bag volume
- Dual energy CT has been developed and certified

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Air Cargo: Challenges with Increased Size

- More penetrating (higher energy, weaker interacting) x-ray means reduced intrinsic measurement sensitivity;
- Material signature with higher energy x-rays is also much weaker;
- Scatter of higher energy x-ray in larger objects adds complication;
- Automatic detection at LD3 size is near impossible with x-ray radiography due to complex overlapping—CT might be necessary.

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RF Linac Based High Energy X-Ray Sources

- Commercial high energy (MV) x-ray sources are based on electron Bremsstrahlung.
- The electron accelerator is usually an RF Linac.
- Side coupled standing wave structure is the most common.

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Varian Linatron K-15A

- Beam energy: up to 15MV
- Dose rate: up to 15,000 rad/min at 1m
- By product: neutron
- RF structure: S-band/SW/side coupling
- RF source: 5.5MW klystron

- Typical use: inspecting large rockets

K-15 X-ray head

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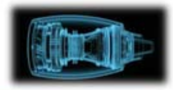
Varian M-Series Linatrons




- M9/Mi9: 6-9MV, up to 3,000 rad/min at 1m
- M6/Mi6: 3-6MV, up to 800rad/min at 1m
- M3: 1-4.5MV, up to 300rad/min at 1m
- RF structure: S-band/SW/side coupling
- RF source: 2.6MW magnetron

- M-series Linatrons are widely used in cargo inspection and NDT, with 1k+ units in service.
- Mi6, interlacing between 6MV and 4MV, is the standard source for cargo inspection.

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Varian CX1/NX1/PX1 Linatrons



- Beam energy: 1MV
- Dose rate: 3 rad/min at 1m
- RF structure: X-band/SW/center coupling
- RF source: 380kW magnetron

Typical uses:

- Law enforcement and special operations
- War zone security (Iraq and Afghanistan)

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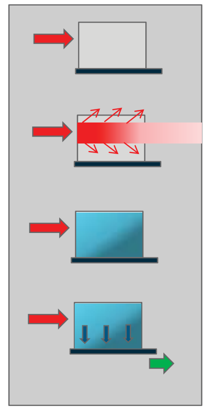
High Energy X-Ray Detectors in Cargo Inspection

- Detectors are usually CWO or CSI scintillators coupled to photo diodes.
- Photo diodes usually work in photovoltaic mode to minimize noise.
- Linear array is the most common in cargo inspection.
- Scintillation distribution changes through the beam path. Such change is x-ray energy dependent, providing a means for energy sensitive imaging detector (layered detectors).



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Detectors: Pixel, Module and Array

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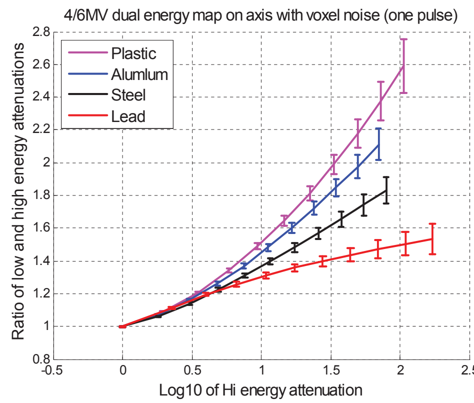
Measuring Effective Z with Dual-Energy X-Ray

- Various materials have different energy dependence in attenuation.
  - ➢Photoelectric effect and pair production cross sections are Z dependent;
  - ➢Compton scattering cross section is A/Z (electron density) dependent;
- Ratio of HiE and LoE attenuation contains material information (Zeff);



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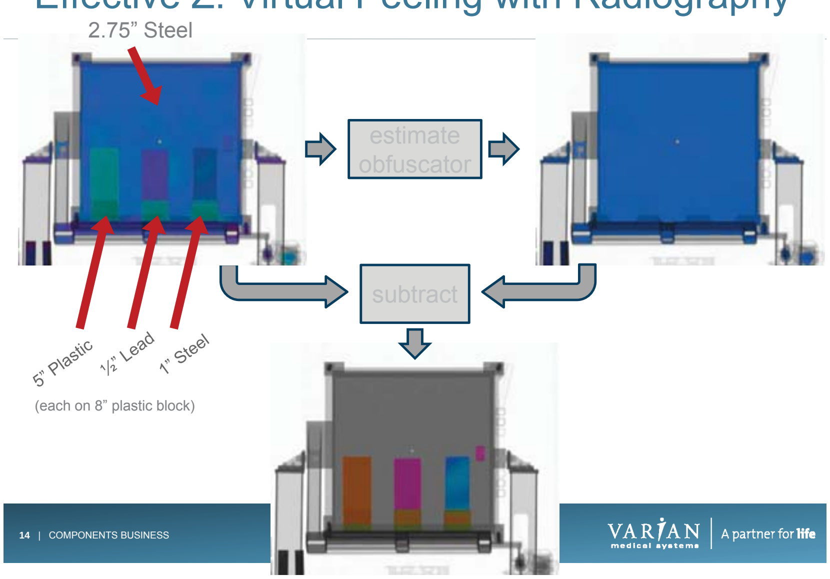
Effective Z: Virtual Peeling with Radiography



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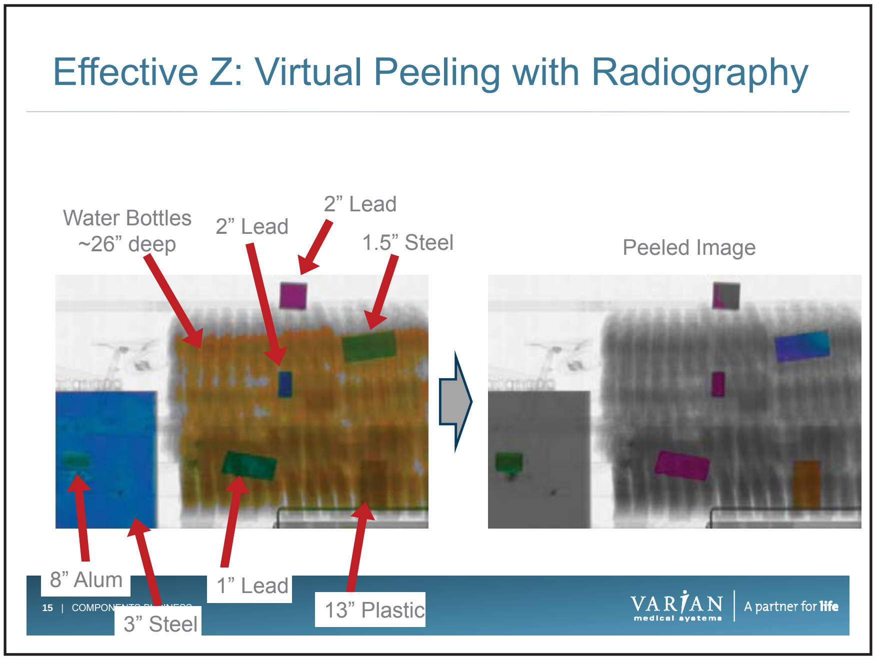
Effective Z: Virtual Peeling with Radiography
Water Bottles
~26" deep
2" Lead
2" Lead
1.5" Steel
Peeled Image
8" Alum
3" Steel
1" Lead
13" Plastic
15
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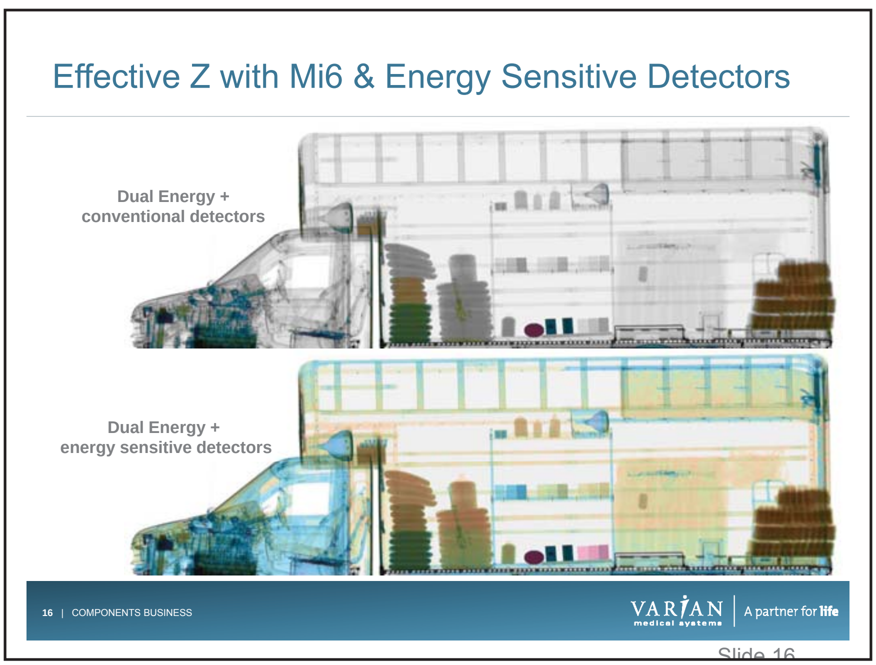
Effective Z with Mi6 & Energy Sensitive Detectors
Dual Energy +
conventional detectors
Dual Energy +
energy sensitive detectors
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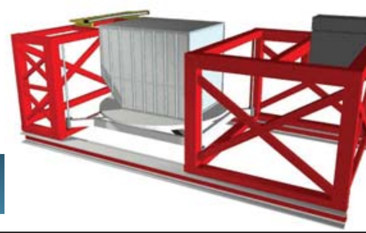
Tomography for Air Cargo

- Although layer peeling sounds encouraging, a fully loaded air cargo container is hopelessly complicated for algorithms fed with only radiographs.
- A 9MV (single energy) CT was built withTSA funding.
- The system has been used in automatic explosive detection algorithm development.
- Only density map is available.



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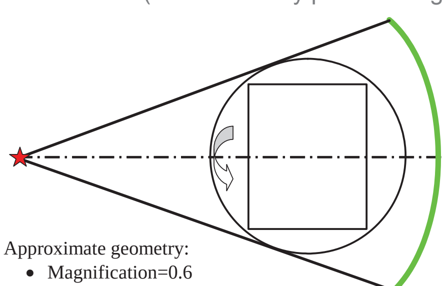
6/4MV Air Cargo CT Concept

- 6/4MV interlaced dual energy x-ray source
- 24 rows of detectors on helical pattern
- 3mm voxel size (900x900 array per rearranged slice)



Approximate geometry:

- Magnification=0.6
- SID=6m; SOD=3.6m
- Fan angle=43°
- FOV=2.7m
- Horizontal plane

18 | COMP

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6/4MV Air Cargo CT Performance Goals

- Throughput >20 LD3 containers per hour (<2 minute scan time)
- 3mm voxel size (2 voxel layers in sheet explosives)
- Voxel noise at 100g/cm^2 in primary (HiE) image: ~3%
- Voxel based Zeff accuracy (up to 100g/cm^2): ~2
- Volume averaged Zeff (up to 100g/cm^2): 0.2-0.3
- Volume averaged density accuracy (up to 100g/cm^2): 1%-1.5%
- Automated detection of <100% threat quantity in LD3 containers.

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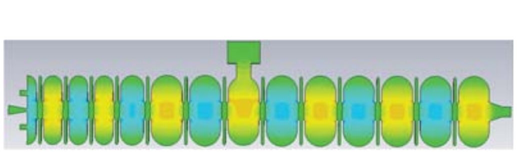
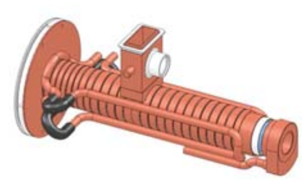
A New High Energy X-Ray Source

- CX1/PX1 at 1MV, 3rad/min works for air cargo radiography. CT with this source would be too slow.
- A new 1.6MV, 20rad/min source is being developed and will be available in 2015.
- One target use is air cargo CT (pallet size).





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New a-Si X-Ray Detectors for Cargo

- Detectors based on Varian's amorphous silicon technology are being developed.
- Detector is also segmented in depth direction and this adds spectral information.

21 | COMPONENTS BUSINESS
Page 21

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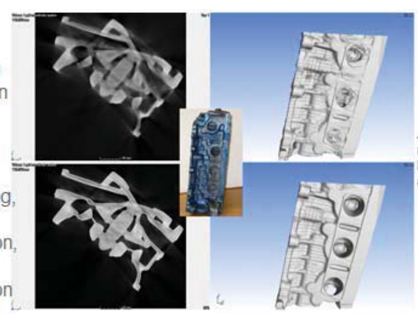
HE (MV) Flat Panel Detector and correction algorithm

Only ring correction

Beam Hardening, Scatter Correction, Lag Correction



Attenuation ranges between 50 and ~1000

MV flat panel detector and correction algorithm, used with 1.6MV x-ray source, will be used in air cargo security.

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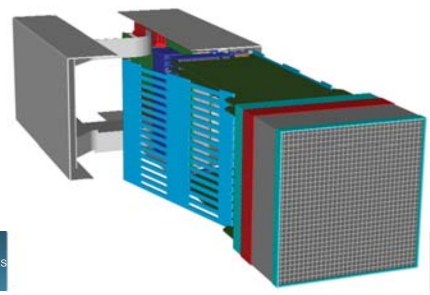
Flash Radiography Detectors

- Array is optimized for 20MV x-ray.
- Typical x-ray source has >5A electron beam current.
- Array works at 20,000,000 frames per second.
- Primary use is in weapon design (hydraulic test).



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Summary

- Appropriate high energy x-ray sources and detectors are available and systems can be built to facilitate automatic explosive detection in air cargo.
- Dual-energy x-ray CT feeds both density map and effective Z map to automatic explosive detection algorithm.
- New x-ray sources and detectors are in development.

24 | COMPONENTS BUSINESS

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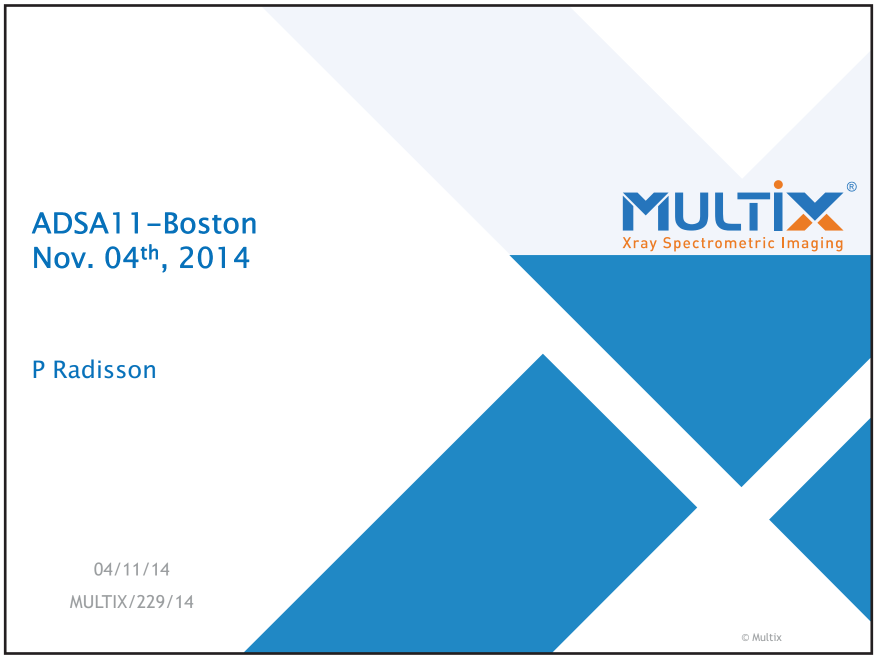
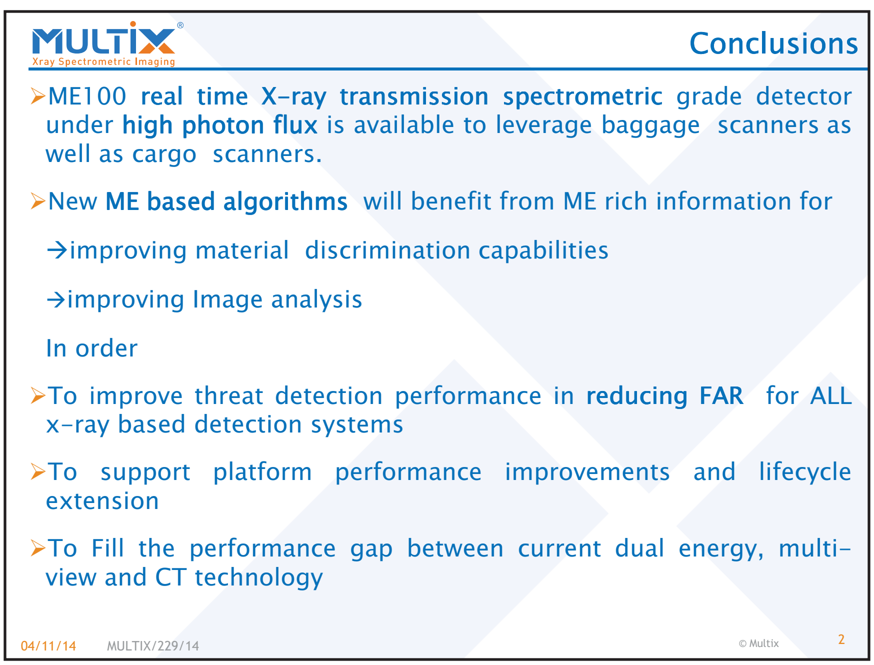
17.27 Patrick Radisson: Automated Treat Recognition and Alarm Resolution





MULTIX Xray Spectrometric Imaging

Executive summary

- Description: **French start-up** company incorporated in 2010. Spin off from Thales and venture capital backed.
- Business: **High resolution multi-energy X-ray detector** acquisition system developer for new builds or retrofit to existing x-ray systems dedicated for automated **explosives identification/discrimination.**
- Market: X-ray scanner manufacturers (conventional, CT and XRD), new build or retrofit to meeting existing and future regulations.
- Technology: Mature building blocks, major partnership with CEA/LETI French public Lab, patent portfolio.
- Maturity: Team engaged in the project since 2007. COTS product (ME100). CT and scatter development started in 2013.

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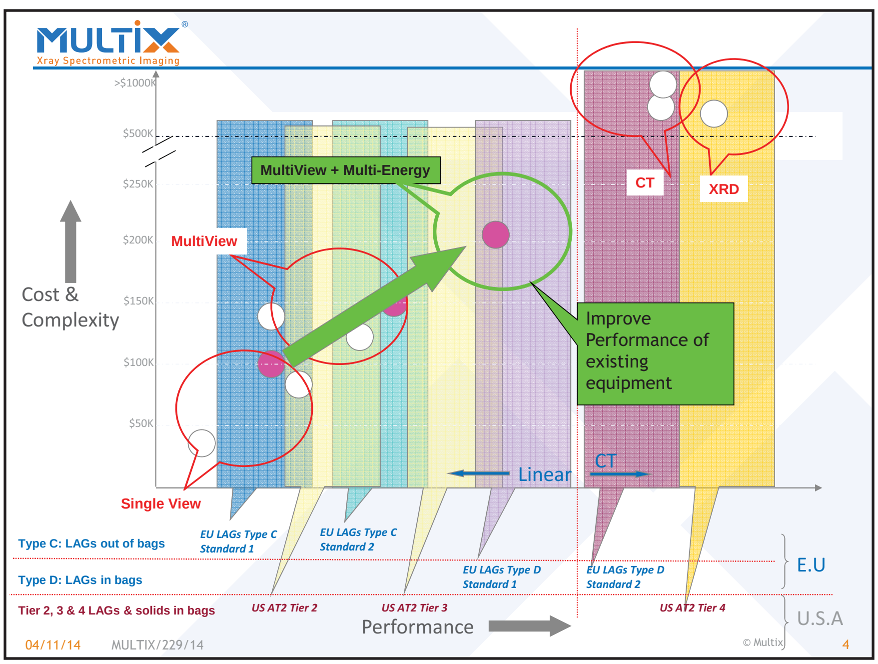

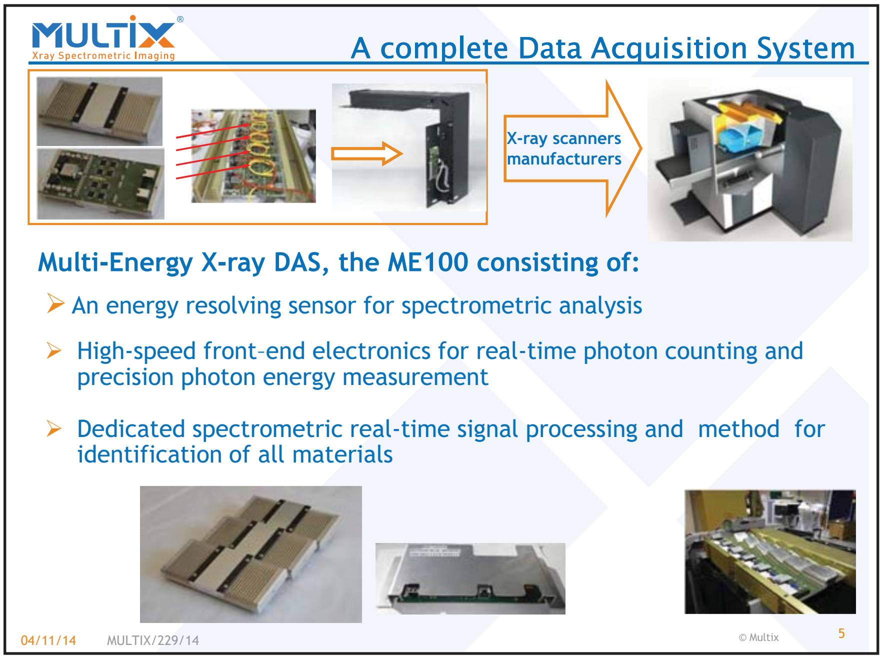
MULTIX
Xray Spectrometric Imaging
A complete Data Acquisition System
X-ray scanners manufacturers
Multi-Energy X-ray DAS, the ME100 consisting of:
An energy resolving sensor for spectrometric analysis
High-speed front-end electronics for real-time photon counting and precision photon energy measurement
Dedicated spectrometric real-time signal processing and method for identification of all materials
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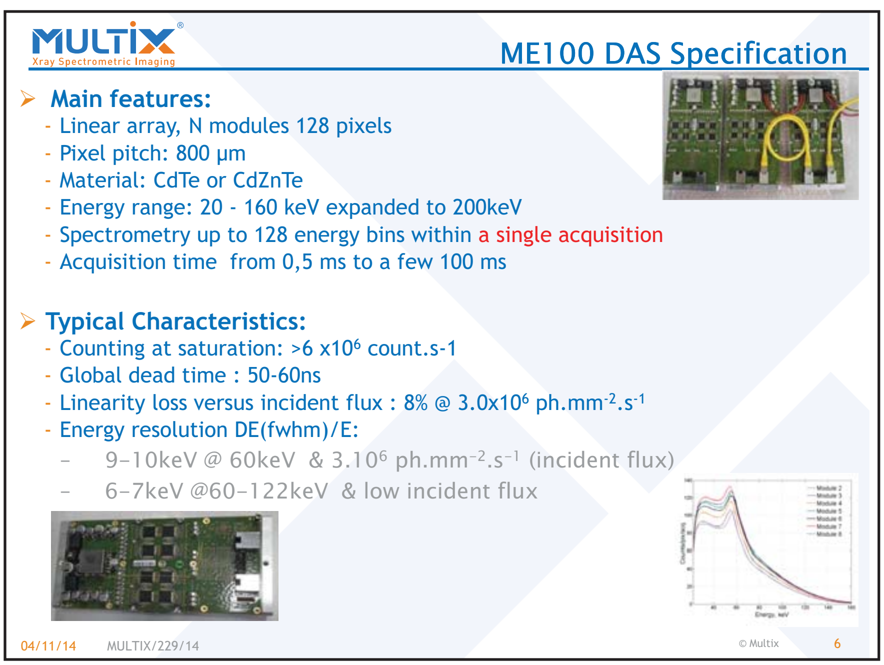
MULTIX
Xray Spectrometric Imaging
ME100 DAS Specification
Main features:
- Linear array, N modules 128 pixels
- Pixel pitch: 800 µm
- Material: CdTe or CdZnTe
- Energy range: 20 - 160 keV expanded to 200keV
- Spectrometry up to 128 energy bins within a single acquisition
- Acquisition time from 0,5 ms to a few 100 ms
Typical Characteristics:
- Counting at saturation: >6 x10⁶ count.s-1
- Global dead time : 50-60ns
- Linearity loss versus incident flux : 8% @ 3.0x10⁶ ph.mm⁻².s⁻¹
- Energy resolution DE(fwhm)/E:
– 9-10keV @ 60keV & 3.10⁶ ph.mm⁻².s⁻¹ (incident flux)
– 6-7keV @60-122keV & low incident flux
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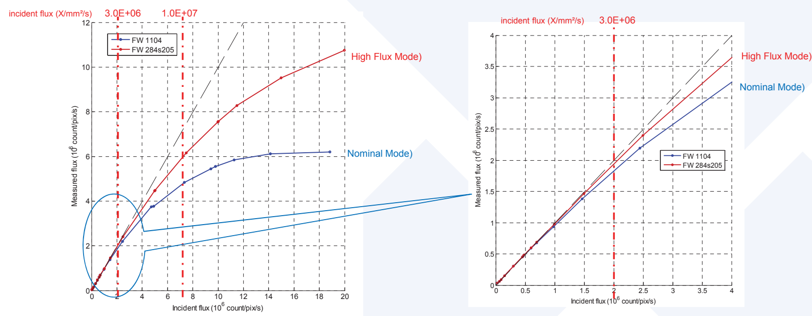
MULTIX Xray Spectrometric Imaging

Count rate linearity–performance adjustment

- **New High flux capability**
  - Counting at saturation: > 11×10^6 $count.s^{-1}$
  - Global dead time : 20-25 ns
  - Linearity loss :
    - <3% @ 3.0×10^6 $ph.mm^{-2}.s^{-1}$ and <8% @ 6.0×10^6 $ph.mm^{-2}.s^{-1}$



Recent improvement in Linearity performance
→ New High Flux mode with linearity range X2

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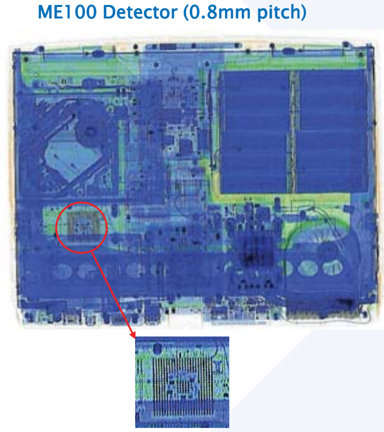
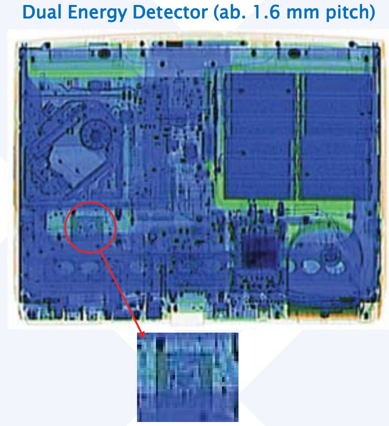
MULTIX Xray Spectrometric Imaging

Image Quality Improvement

ME100 Detector (0.8mm pitch)



Dual Energy Detector (ab. 1.6 mm pitch)



Improved Spatial Resolution with ME Detectors: small pixel–No lag_No crosstalk

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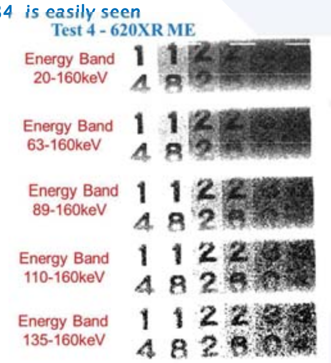
MULTIX Xray Spectrometric Imaging

Image Quality Improvement

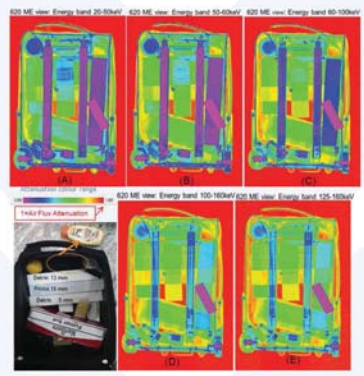
ME further improvement

1_ penetration with HE band selection

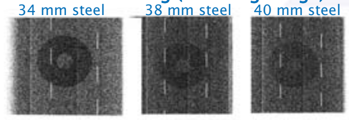
→ 34 *is easily seen*



2_ image segmentation



Steel + lead Ring (counting image)



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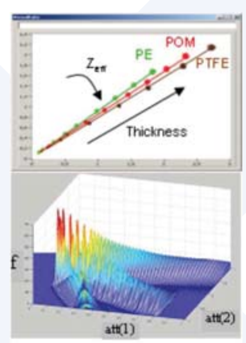
MULTIX Xray Spectrometric Imaging

Material identification method

- Multi-energy information :
  - →Dual energy method can't be used
- Development of a specific method :
  - N-dimension space(attenuations)
  - Calibration with noise learning,
  - Multi-Gaussian approximation
  - Method using probability densities
- Output :
  - Material likelihood
  - Equivalent organic thickness
  - Density
  - **Zeff**

… A tool to be integrated into equipment



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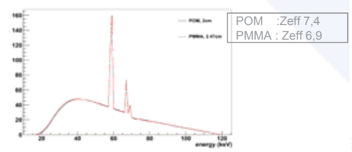
MULTIX Xray Spectrometric Imaging

Material Separability Results

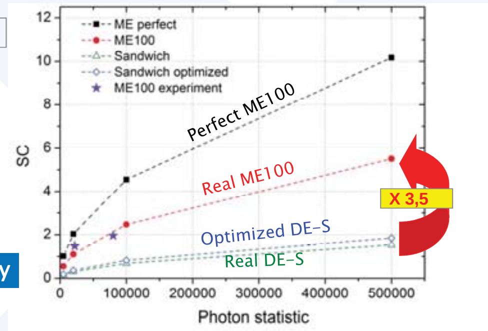
- Evaluation of Separability Criterion with photons statistics(1)



$$SC^2 = \sum_{i=1}^{k} \frac{(att_i^1 - att_i^2)^2}{(\sigma_i^1)^2 + (\sigma_i^2)^2}$$

SC ⇔ Z separability

$$Separation = \frac{|Z_1 - Z_2|}{\sqrt{\sigma^2(Z_1) + \sigma^2(Z_2)}}$$



Considering two materials with close X-ray absorption properties:

- Multi-energy detector separability is 3.5 times higher than Dual Energy detector
- ME100 performance can be improved further and thus enhance the ME/DE-S difference

(1) JINST .Gorecki, et al, Comparing performances of a CdTe X-ray spectroscopic detector and an X-ray dual-energy sandwich detector (2013) Journal of Instrumentation, 8 (11), P11011,

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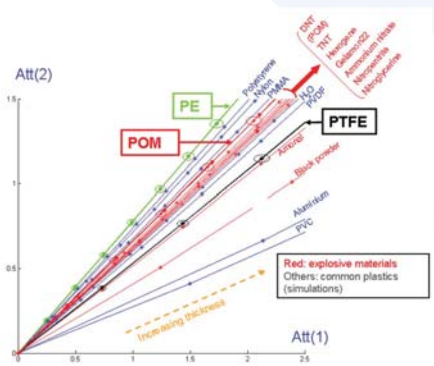
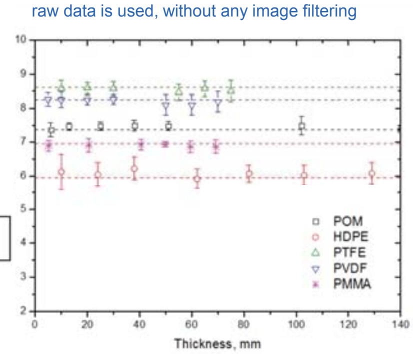
MULTIX Xray Spectrometric Imaging

Material identification: Zeff evaluation

Conditions
Real scanned data
Binning 2 x2 : pixel 0,8 x 0,8 → 1,6 x 1,6
RoI for σ: 20 x 20 pixels
raw data is used, without any image filtering





Identification method : →good accuracy and precision on a large thickness range
The Method is still in progress

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MULTIX Xray Spectrometric Imaging

Liquid discrimination in plastic bottle

- Standard “check-point” bag screening conditions (160kV, 22 cm/s,…)
- Single view -data collection
- Type C CONOPS – divested liquid randomly located in tray
- Liquids in commercial plastic container, various shapes , scanned N times
  - 24 Benign liquids ranging from: water , detergent, toilet milk, alcohol, coke ,diet coke…

18 - Alcohol 70
20 - toilet milk for baby
28 - Hair removal cream Nair
42 - concentrated milk
23 - demake up milk
41 - mustard
47 - mushroom soup
48 - ketchup
54 - still water
62 - hair fixating gel
64 - liquid soap
65 - liquid soap
66 - wash mouth
69 - mayonnaise
7 - detergent
6 - Shower Gel marque bien vu-10

  - Threats: NM-Nitromethan, H2O2 sim, NG-sim
- ROC curves on <u>**Zeff only**</u>

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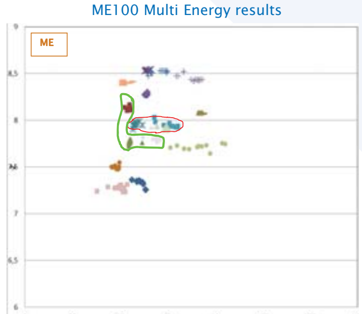
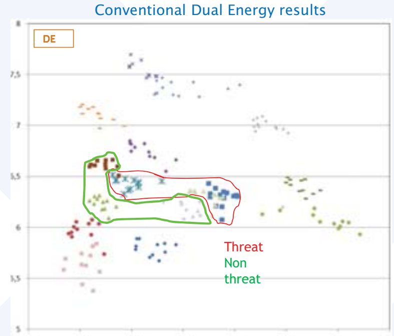
MULTIX Xray Spectrometric Imaging

Data collection 1: 3 Threat vs 3 benign, in plastic

ME100 Multi Energy results



Conventional Dual Energy results



Pictures not to scale

- Threat = water, detergent, concentrated milk
- Safe = toilet milk for baby, shower gel, mouth wash

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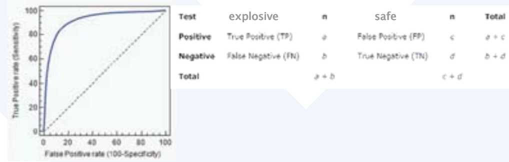
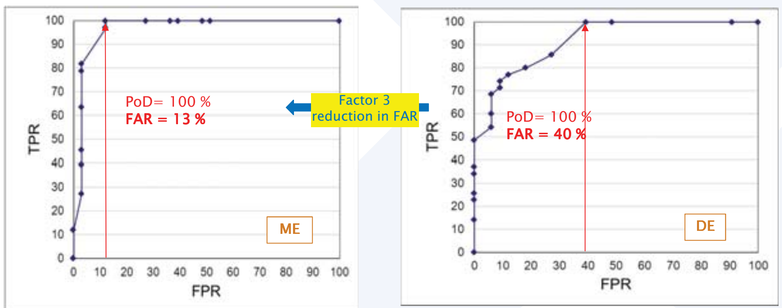
MULTIX Xray Spectrometric Imaging

ROC : 3 threats and 3 safe items

➢Preliminary results

- N scans =33 (ME) and 35 (DE)
- ROC on Zeff only
- True positive: Probability of detection
- False positive: False Alarm rate





→Factor 3 reduction in FAR (Zeff discrimination)

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MULTIX Xray Spectrometric Imaging

ROC curve 3 threat vs. rest of benign

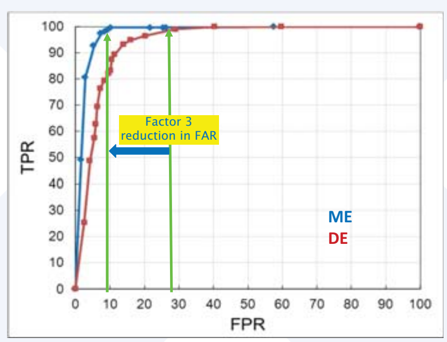
➢ Objects

- 24 benign items in plastic containers, ab. 11 scans each
  => DE (238) ME (243)
- 3 threats, ab. 100 scans each : NM-real, HP-sim, NG-sim
  => DE (310) ME (305)

TPR of 99%

- ME=> FAR 9.6 %
- DE=> FAR 28.9 %

- **NM**: real nitromethan (500ml),
- **OP**: Hydrogen peroxide 70%, simulant (500ml),
- **NG**: nitroglycerin, simulant (500ml)



→Factor 3 reduction in FAR (Zeff discrimination)

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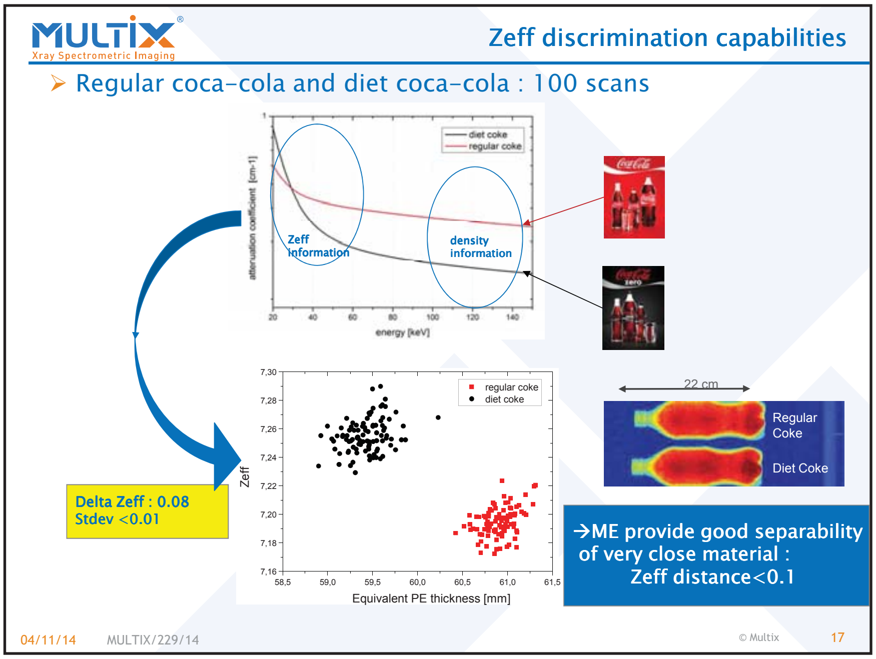
MULTIX
Xray Spectrometric Imaging
Zeff discrimination capabilities
Regular coca-cola and diet coca-cola : 100 scans
diet coke
regular coke
attenuation coefficient [cm-1]
Zeff information
density information
energy [keV]
regular coke
diet coke
Zeff
Equivalent PE thickness [mm]
Delta Zeff : 0.08
Stdev <0.01
22 cm
Regular Coke
Diet Coke
→ME provide good separability of very close material :
Zeff distance<0.1
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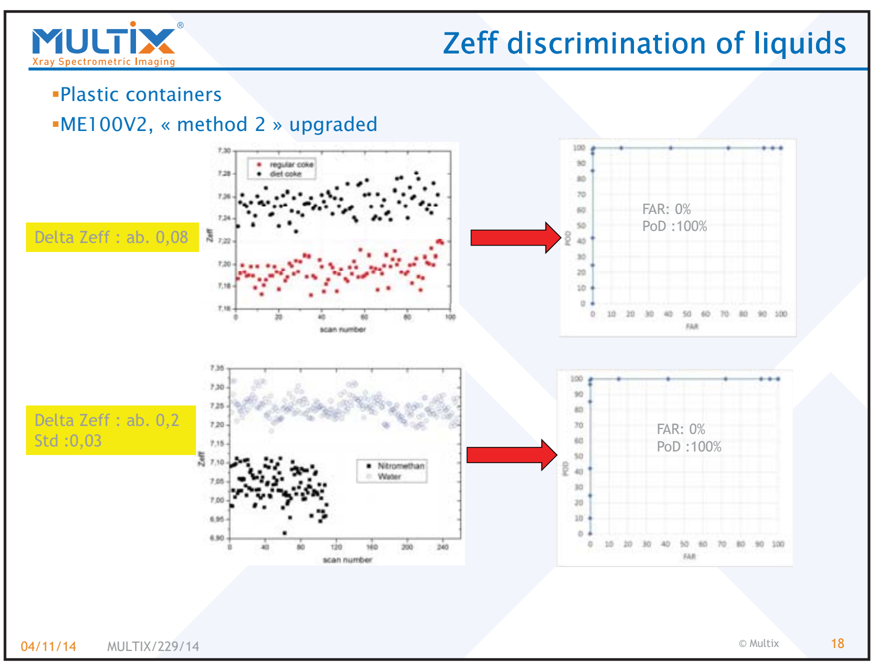
MULTIX
Xray Spectrometric Imaging
Zeff discrimination of liquids
Plastic containers
ME100V2, « method 2 » upgraded
Delta Zeff : ab. 0,08
regular coke
diet coke
scan number
FAR: 0%
PoD :100%
Delta Zeff : ab. 0,2
Std :0,03
Nitromethan
Water
scan number
FAR: 0%
PoD :100%
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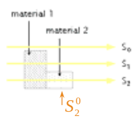
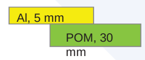
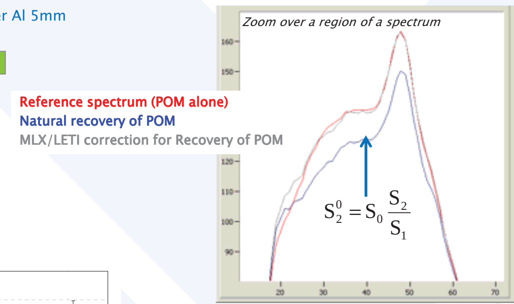
MULTIX Xray Spectrometric Imaging

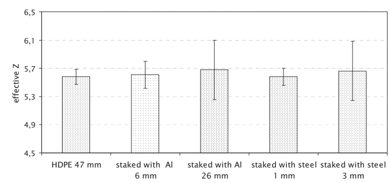
ME based Spectrum Recovery Process (SRP)



> POM 30mm after Al 5mm







> Zeff (mean & st. dev.) for HDPE (47mm) recovered after:
- Al 6 mm,
- Al 26 mm,
- steel 1 mm
- steel 3 mm.

Dedicated ME based methods (SRP) →good recovery (accuracy and precision) of the hidden material spectrum (patent pending)

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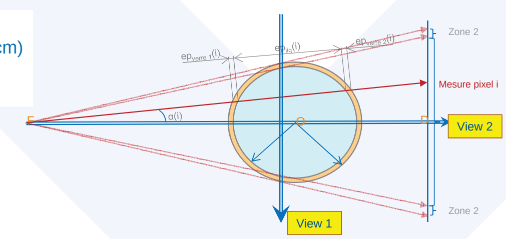
MULTIX Xray Spectrometric Imaging

Zeff -SRP benefit

ME Zeff processing with SRP on ROI
(10pixels x 100 acquisitions –ab. 1cmx 5cm)
Standard bagage screening conditions



Liquid	Reference Plastic container		Glass container + SRP	
	Zeff	σ_Z	Zeff	σ_Z
Water	7.20	0.02	7.20	0.03
Water +15% sugar	7.07	0.01	7.08	0.03
Water +30% sugar	7.05	0.02	6.90	0.02

ME processing allow a good recovery of Zeff assuming thickness a priori (Dual view configuration)
Further information processing in progress

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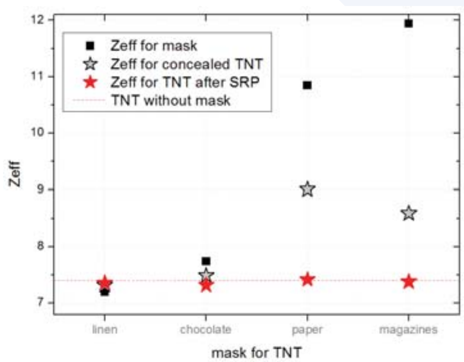
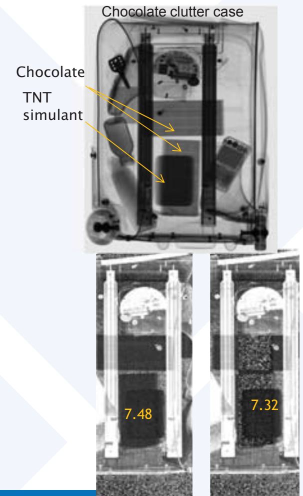
Zeff -SRP benefit in low clutter bag

- TNT recovery from various simple masking objects : chocolate (35 mm), paper (50 mm), magazines (13 mm) and bed linen (22 mm)

Preliminary





=> SRP processing allows recovering TNT Zeff within 0.1 precision
=> Further information processing in progress

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MULTIX Xray Spectrometric Imaging

Cargo retrofit with ME100–Eurosky Project

- Multi Energy detector integration in cargo scanner under EU-FP7 funded Project Eurosky (2013-2016)
- ME100V2 upgraded for higher kV range
- Rapiscan 632DV -1,5mx1,6m tunnel- 200keV X-rays

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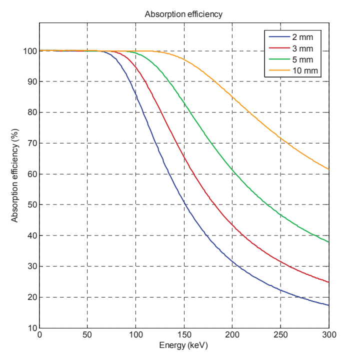
ME100 & cargo

- ME100 electronics architecture allows an easy adaptation to 200 kV
- ME100 provide still a good absorption at 200keV. Increasing to 4-5mm will recover additional signal and improve penetration characteristics.



632DV

Current ME100 Thickness

	50 keV	150 keV	200 keV	300 keV
2 mm	100 %	51 %	32 %	17 %
3 mm	100 %	66 %	43 %	25 %
5 mm	100 %	83 %	61 %	38 %
10 mm	100 %	97 %	85 %	61 %

CdTe sensor X-ray absorption vs kV

- Cost-benefit analysis to be performed

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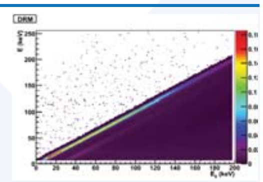
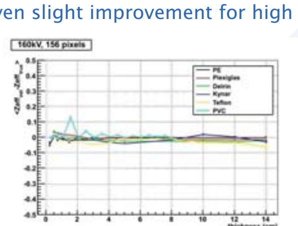
Discrimination performances with increased kV

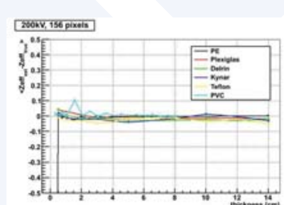
By simulation :

- Detector Response Matrix (DRM) until 200 keV considering all physical phenomena in CdTe crystal + electronic chain
- Simulation of the whole data acquisition chain:
  X-ray source 2 10^6X/px/s
  integration 2.2ms, pixel 0.8x0.8mm²
  photon pile-up (dead time ~ 70ns)
  material calibration and data processing
- Conclusions:
  - Separability (CS) is maintained
  - No significant change in the performance, even slight improvement for high Z material



SC on ROI ab. 1cm² (400 pixels)	Case 1 (Bagage)	Case 2 (Cargo)
kV	150-160	200
CS (POM/PMMA) 20mmPOM	10	9
CS (PVC/Alu) 10mm PVC	18	18





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ME100 & cargo

Current conclusions :

- No major design change in the DAS chain are requested
- Discrimination capabilities are expected to be maintained under 200kV operation
- Cost-benefit analysis of the sensor optimization is to be considered
- Data flow management –performance tradeoff is also to be considered

Next steps

- Finalization of detector simulations
- Data collection in a 632DV populated with ME100V2 detectors
- Confirmation of IQ and discrimination capabilities and trade-offs
- Optimization of the discrimination algorithms

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MULTIX Xray Spectrometric Imaging

Conclusions

- ME100 **real time X-ray transmission spectrometric** grade detector under **high photon flux** is available to leverage baggage scanners as well as cargo scanners.
- New **ME based algorithms** will benefit from ME rich information for

  →improving material discrimination capabilities

  →improving Image analysis

  In order

- To improve threat detection performance in **reducing FAR** for ALL x-ray based detection systems
- To support platform performance improvements and lifecycle extension
- To Fill the performance gap between current dual energy, multi-view and CT technology

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Xray Spectrometric Imaging
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92200 Neuilly sur Seine - France
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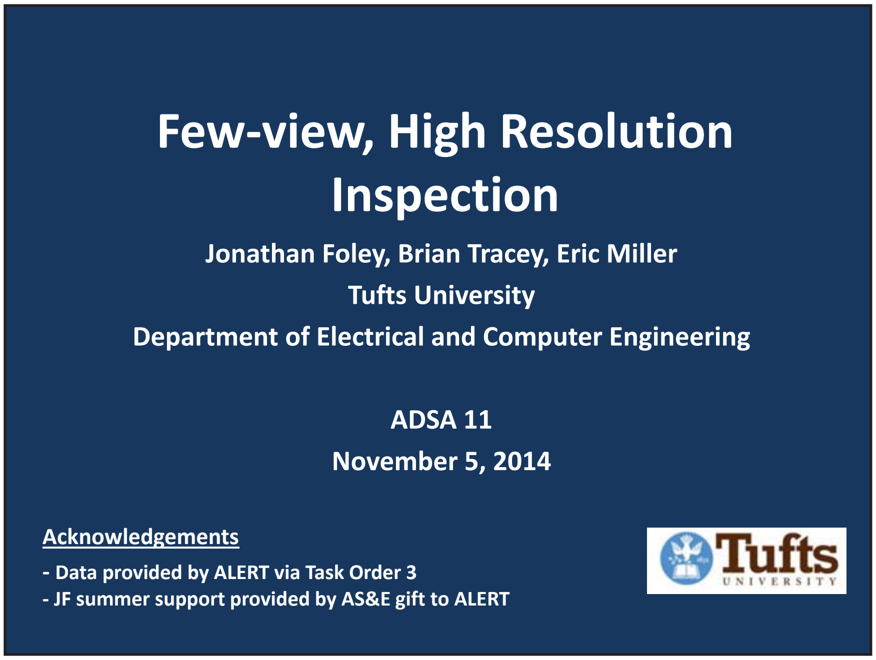
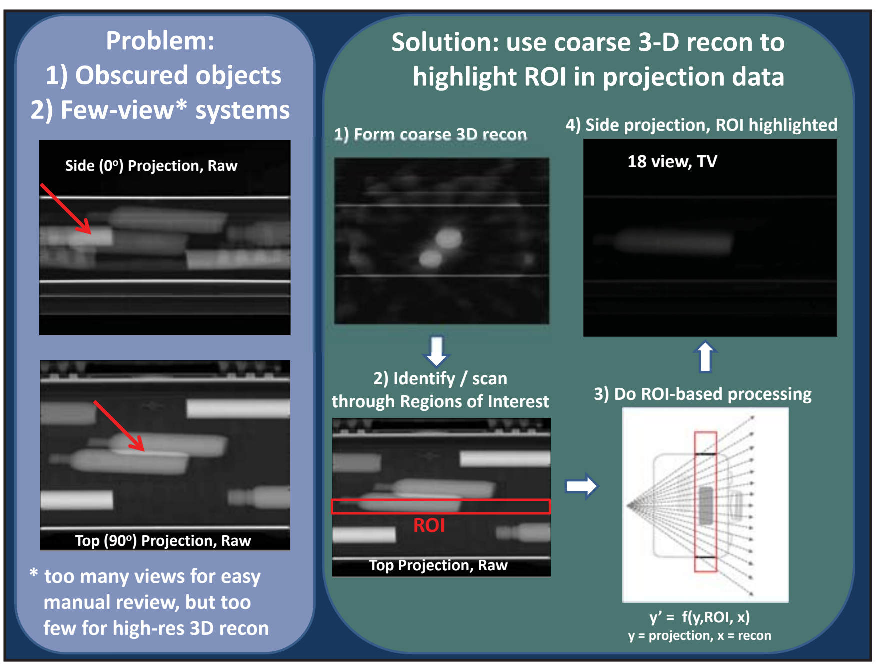
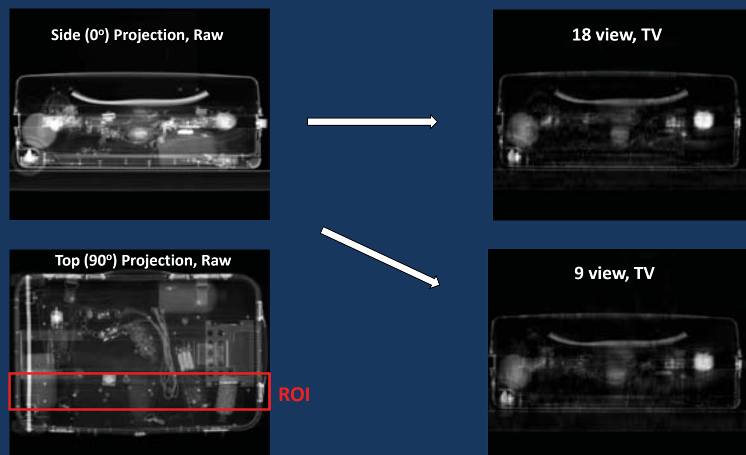
38430 Moirans - France

17.28 Jonathan Foley, Brian Tracey, Eric Miller: Few-view, High Resolution Inspection





Medium Clutter Dataset



Ongoing work:

- Investigate different recon methods and strategies for ROI based processing
- Understand how results depend on system geometry (# views, spacing)

Questions?

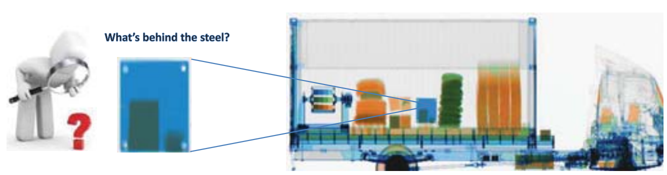
17.29 Yuxiang Xing: Multilayer Material Discrimination Methods with Dual-energy X-ray

Multilayer Material Discrimination Methods with Dual-energy X-ray

Yuxiang Xing, Li Zhang, Guangming Xu, Jianping Gu
Tsinghua University, Beijing, China
5 Nov 2014

The 11th workshop on advanced development for security applications

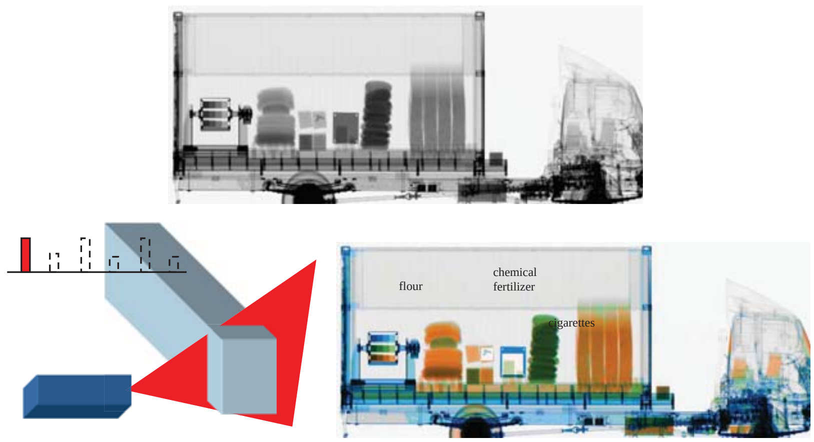
The problem



- A solution for the problem of overlapping materials on ray-pathes in X-ray imaging.

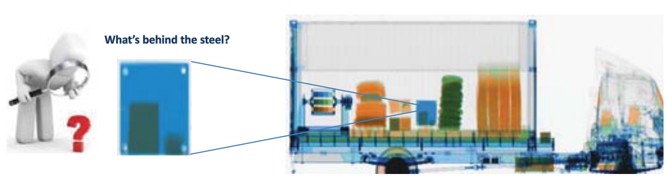
2

Large Container Scanner



3

The Problem



- Dual-energy X-ray systems can obtain the effective atomic number of the distributed objects in the beam direction, visualizing a colored image.
- How about multilayer conditions? Contrabands, explosives are usually multilayered with other goods.
- Multilayer material discrimination problem shall be studied.

4

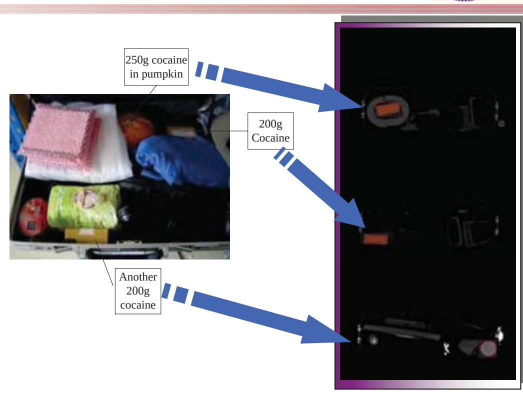
Dual Energy CT (MeV)

Dominate effects: Pair production & Compton

--A reconstruction method for dual high-energy CT with MeV X-Rays, IEEE TNS, VOL. 58, NO. 2, 2011.

5

Dual Energy CT (KeV)

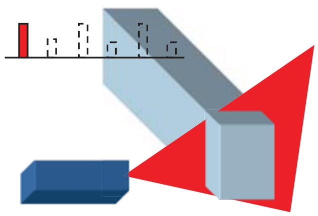


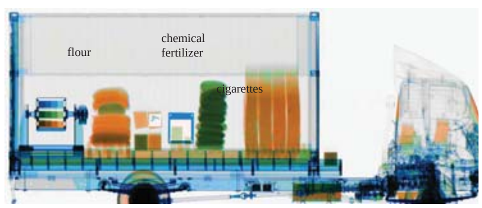
Dominate effects: Photo-electric & Compton

- *A practical reconstruction method for dual energy computed tomography, J. X-ray Sci & Tech. 16(2), 2008.*
- *Dual energy CT reconstruction method with incomplete data, IEEE NSS-MIC record, 2013, N25-2*

6

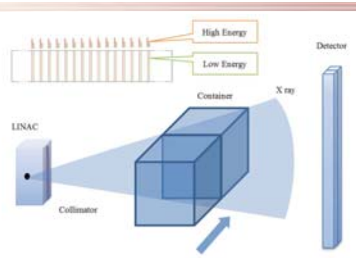
Large Container Scanner

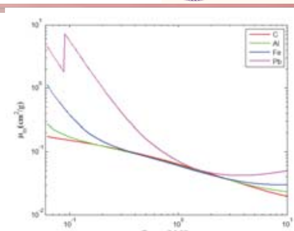




7

Dual-energy X-ray Radiography

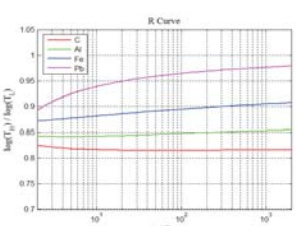




transparency $T = I/I_0 = \exp(-\mu_m t_m)$

$$\begin{cases} T(E_H, t_m, Z) = \dfrac{I_H}{I_{0H}} = \dfrac{\int_0^{E_H} p(E_H)\exp(-\mu_m t_m)\,\varepsilon\, E_H dE_H}{\int_0^{E_H} p(E_H)\varepsilon\, E_H dE_H} \\ T(E_L, t_m, Z) = \dfrac{I_L}{I_{0L}} = \dfrac{\int_0^{E_L} p(E_L)\exp(-\mu_m t_m)\,\varepsilon\, E_L dE_L}{\int_0^{E_L} p(E_L)\varepsilon\, E_L dE_L} \end{cases}$$

$$\mathrm{R}(E_H, E_L, t_m, Z) = \frac{\ln(T(E_H, t_m, Z))}{\ln(T(E_L, t_m, Z))} = \frac{\overline{\mu_m}(E_H, t_m, Z)}{\overline{\mu_m}(E_L, t_m, Z)}$$



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Dual-energy X-ray Radiography

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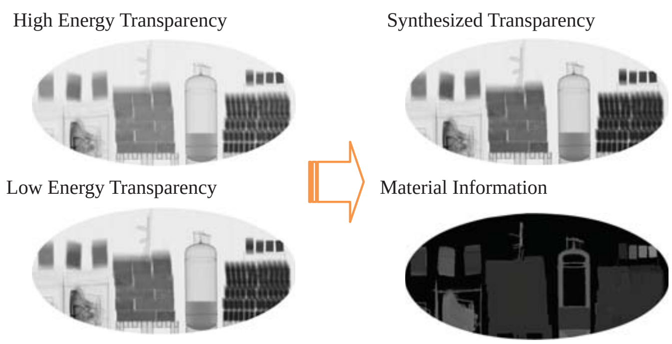

9

Dual-energy X-ray Radiography

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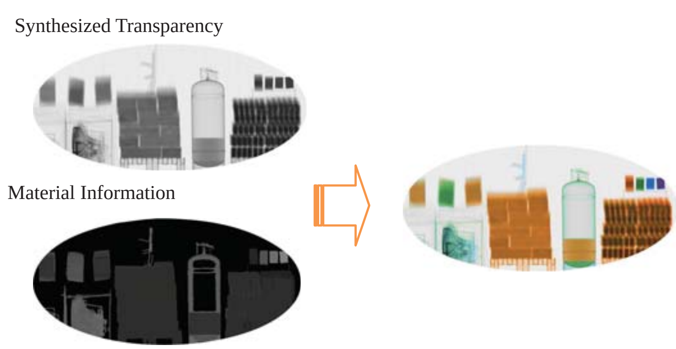

- Colorization of the dual-energy X-ray image implies the material information of the objects been imaged.

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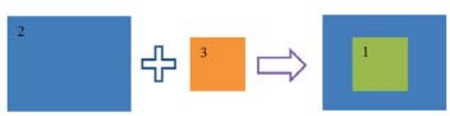
Dual-energy X-ray Radiography

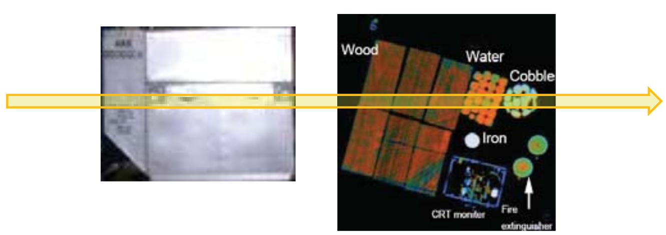
Materials	Equivalent atomic number range	Typical Material	Color
Organic	$1 \le Z \le 10$	Graphite	
Compound	$10 < Z < 18$	Aluminum	
Inorganic	$18 \le Z < 57$	Iron	
Heavy metal	$Z \ge 57$	Lead	

- Colorization of the dual-energy X-ray image implies the material information of the objects been imaged.

11

Multilayer Material Discrimination





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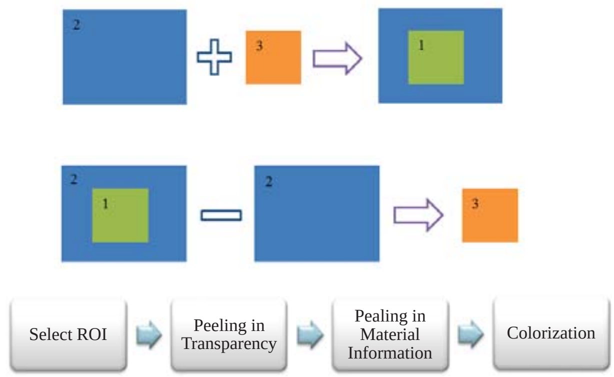
Multilayer Material Discrimination



- The procedure of multilayer material discrimination, within an area of uniform distribution.

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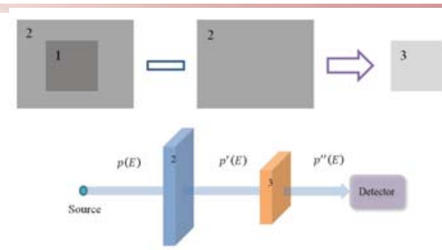
Peeling in Transparency



- The overall transparency from one ray path is equivalent to the cascade of transparencies from multi-layer materials.
- Number of layers can be determined by automatic local segmentation, or can be manually selected.

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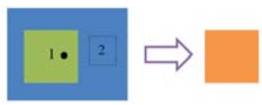
Peeling in Material Information

- **Slope Curve Method**
- **Beam Hardening Correction Method**



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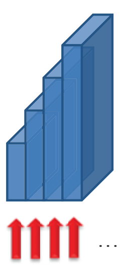
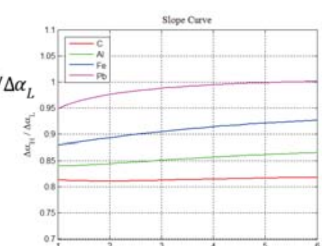
Peeling in Material Information

Slope Curve Method



$k = \Delta\alpha_H / \Delta\alpha_L$



$\alpha_L = -\log(T_L)$

- The classification curve (R curve, etc.) can reflect the beam hardening effects.
- We obtain the slope curve by measuring the step-wedges of known thickness made of standard materials and calculating the slope value.

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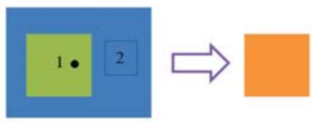
Peeling in Material Information

Slope Curve Method



- Slop is from baseline of the material in base-layer
- Weighted combination of transparency

Obtain the slope curve by training

Process Area of base-layer → Transparency Peeling Calculation → Calculate the slope value k → Obtain Z info by α_{Index} → Colorization

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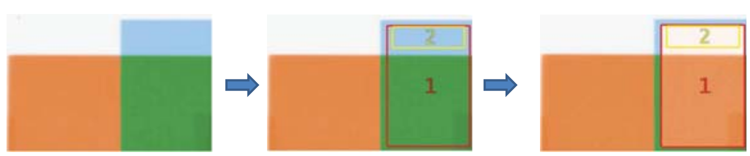
Peeling in Material Information

Slope Curve Method



- The experiment by placing the steel plate behind the graphite plate shows nice result using slope curve method.
- The look up index α_{Index} is calculated by using a weight factor, which is usually 0.2~0.4 by experience.

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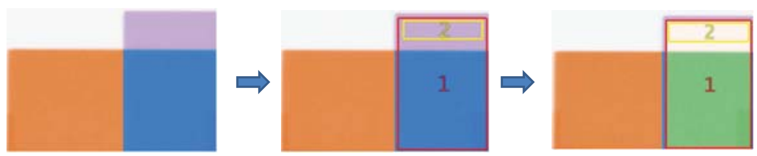
Peeling in Material Information

Slope Curve Method



Partially peeled

- Experiment by placing the lead plate behind the graphite plate, the peeling result turns green.

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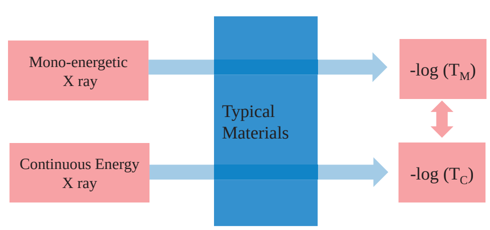
Peeling in Material Information

Beam Hardening Correction Method



The Beam Hardening Table (BHT)

- With the continuous energy spectrum X-ray and chosen mono-energetic X-ray associated by mapping their transparencies, the beam hardening effect will be corrected.

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Peeling in Material Information

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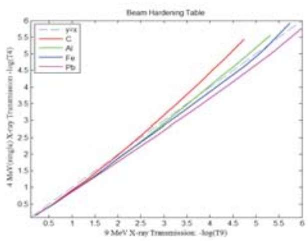
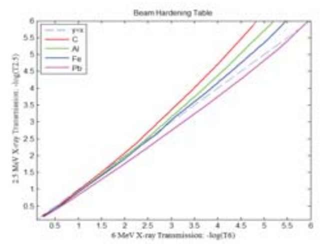
Beam Hardening Correction Method





- Each material has its own beam hardening table, use certain table according to the dual-energy material discrimination results.
- Select a corresponding mono-energy X-ray for the mapping. Here we use mono-energetic 4/2.5MeV system to map the continuous energy 9/6MeV system.
- The R value after beam hardening correction will be independent from mass thickness.

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Peeling in Material Information

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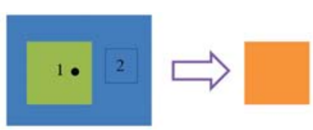
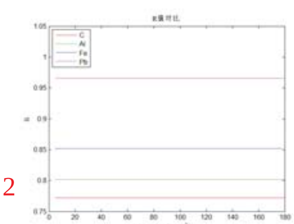
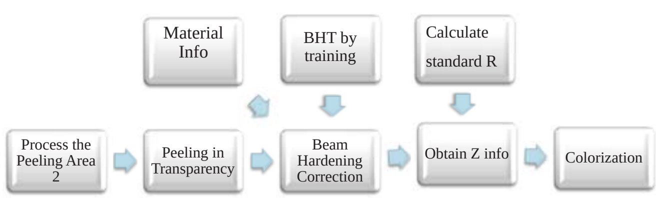
Beam Hardening Correction Method





- Slop index from baseline of material 2



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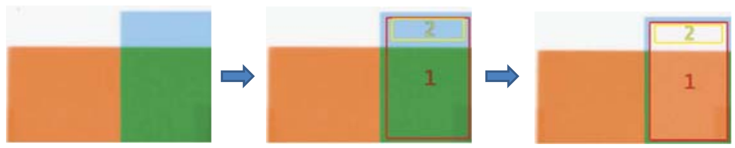
Peeling in Material Information

Beam Hardening Correction Method



- The experiment by placing the steel plate behind the graphite plate shows nice result using beam hardening correction method.

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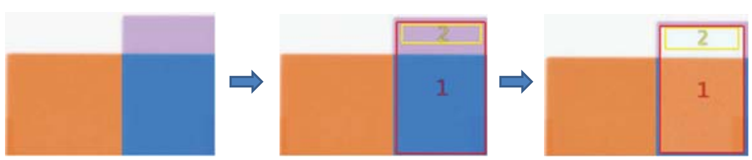
Peeling in Material Information

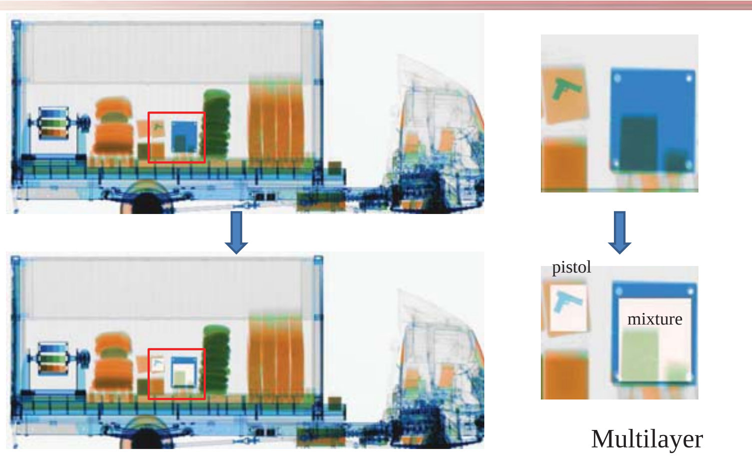
Beam Hardening Correction Method



- The experiment by placing the lead plate behind the graphite plate also shows nice result using beam hardening correction method.

24

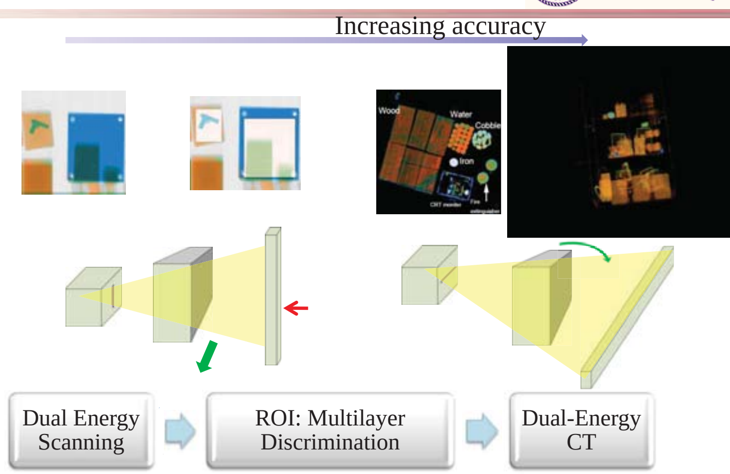
Multilayer Material Discrimination



Multilayer processing in ROI

25

A Comprehensive Solution



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Discussion

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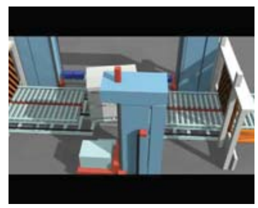
- Dual-energy information provides us material discrimination capability.
- Radiographic images are of limited accuracy in the inspections. Overlapping of multiple objects are common situations. Multilayer material "peeling" can check materials layer by layer within a region of interest.
- A comprehensive solution for performance optimization would be dual energy Radiography (Speed) + conditional CT (accuracy).



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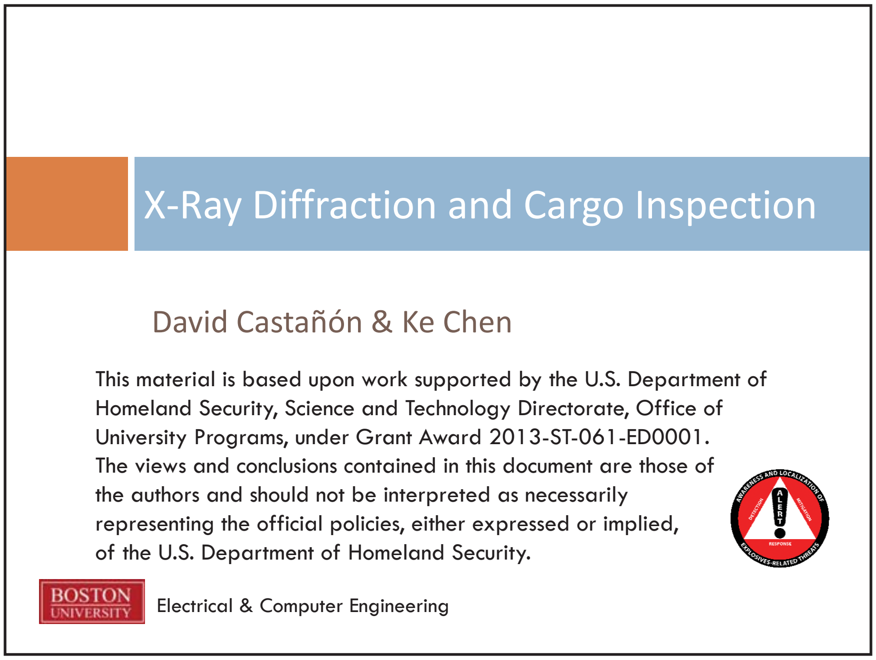
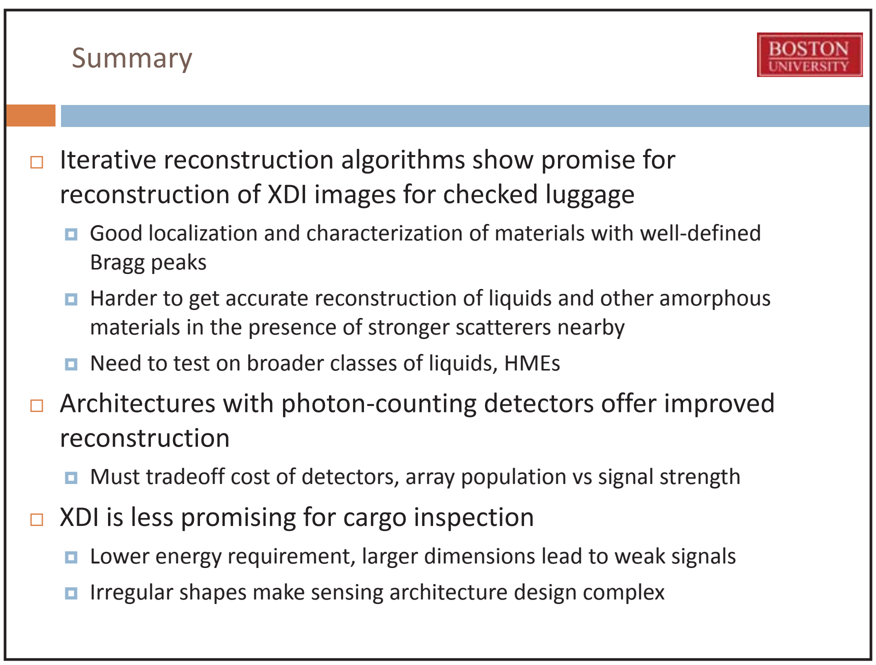
Thank you !

- This work is supported by NUCTECH. com
- All data are provided by NUCTECH.com

17.30 David Castañón and Ke Chen: X-Ray Diffraction and Cargo Inspection

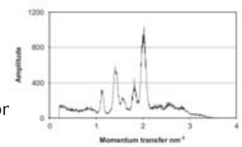




Motivation

Background:

- Material identification based on conventional X-ray computed tomography (CT) images can be ambiguous
- X-ray diffraction imaging (XDI) systems identify materials based on coherent-scatter form factor – New signature that depends on molecular structure



Coherent-scatter form factor of TNT (Harding '09, Morpho)

XDI currently proposed for luggage inspection

- Existing XDI commercial product
- Much recent research: Brady's group (Duke), BU, others

Crawford asks: Can these ideas be used in cargo?

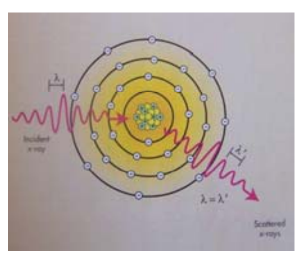
- ?????

Focus of Talk: Discuss XDI, recent progress, and extrapolate on applicability to cargo inspection

Morpho XRD 3500 ™

Coherent Scattering

- Change in direction of incident photons interacting with the electron layers, but no change in energy (momentum transfer)
- Lower energy photons (15-60 KeV)
  - 12% of photons <30 keV
  - 5% of photons >70 keV
  - Forward scatter, small angles
- Also known as Thompson, or elastic, or Rayleigh Scattering
- Ignored as noise in usual X-ray imaging (transmission)



X-ray Diffraction Imaging

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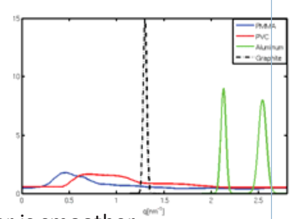
- Construct the *coherent-scatter form factor* |F(q,***x***)|^2 at all positions x in volume of interest: 4-dimensional function!
  - Expressed as distribution of transferred momentum q that causes the deviation of photon of wavelength λ by angle θ

$$q = \frac{1}{\lambda}\sin(\frac{\theta}{2})$$

  - For crystalline materials, Bragg peaks reveal molecular composition for material discrimination in terms of preferred scattering angles
  - For amorphous materials, or liquids, form factor is smoother

Form factors



- **Measuring coherent form factor:**
  - Given photon energy wavelength ¸, measure angular deflection μ
  - Given angular deflection μ, measure wavelength ¸

X-ray Diffraction Principles

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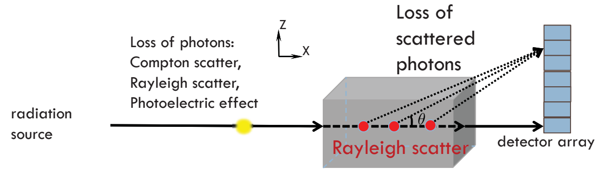

Observations:

- Fraction of photons that are scattered coherently is small – fraction decreases with increasing photon energy
- Fraction of photons that are lost to photoelectric effect also decreases with increasing photon energy
- ➔ Low energy Rayleigh scatter will be highly attenuated
- ➔ High energy Rayleigh scatter is less likely

Weak signals! Limit on effective energy band

Typical X-ray Diffraction Architecture

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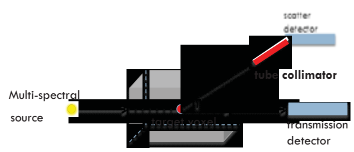
- Localize excitation, localize detection
  - Similar to two-photon imaging and other similar localized imaging problems
  - Block secondary scatter whenever possible
  - Many scattered photons fail to reach detector
  - Requires photon-counting detectors



Schematic drawing of XDI system

X-Ray Diffraction: Tomographic Architectures for Stronger Signals

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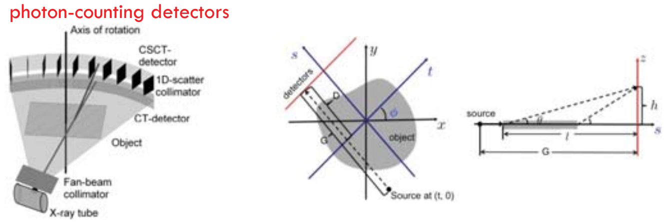
Limited-angle tomography: sheet collimators, vertical scatter mostly

Rotating detectors and tomography algorithms- use either intensity or photon-counting detectors

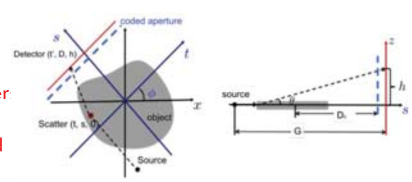


Coded aperture imaging: vertical and horizontal scatter

Captures more photons, complex inver
problem

non-rotating source/detectors, limited source locations

either intensity or photon-counting detectors



XDI Tomography Models

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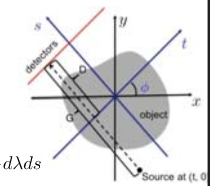
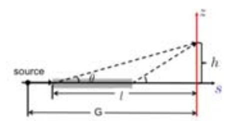
Model depends on architecture :

- Example below for intensity detectors, sheet collimators separating vertical lines of detectors



$$I_\phi(t,h) = \int_0^G \int_{\lambda_m in}^{\lambda_m ax} I_\lambda(t,0)\mathcal{A}_\lambda(t,0,s,0)\mathcal{B}_\lambda(t,s,G,h)\frac{|F(t,s,q)|^2}{[(G-s)^2+h^2]^{3/2}} d\lambda ds$$

$$q = \frac{\sin(0.5\tan^{-1}(\frac{h}{G-s}))}{\lambda} \approx \frac{h}{2\lambda(G-s)}$$



$I_\lambda(t,0)$: incident x-ray intensity at λ;
$\mathcal{A}_\lambda(t,0,s,0)$:attenuation for λ along incoming ray from 0 to s;
$\mathcal{B}_\lambda(s,0,G,h)$:attenuation along the scattered ray from $(s,0)$ to (G,h).
$|F(t,s,q)|^2$:coherent-scatter form factor at location (t,s)

- For photon counting detectors, model changes:

$$I_\phi(t,h,\lambda_0) = \int_0^G \int_{\lambda_0}^{\lambda_0+\Delta} I_\lambda(t,0)\mathcal{A}_\lambda(t,0,s,0)\mathcal{B}_\lambda(t,s,G,h)\frac{|F(t,s,q)|^2}{[(G-s)^2+h^2]^{3/2}} d\lambda ds$$

Reconstruction Algorithms for Tomographic Architectures

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- Iterative reconstruction important
  - Limited view angles in coded aperture imaging
  - Minimize streaking artifacts (worse in form factors than intensity only!)

- Algorithm (IREP):
  - Iterative reconstruction, slice by slice (each slice is 3-D)
  - Look for spatial coherence in form factor reconstructions among
  - Simultaneous segmentation/image formation avoiding smoothing across edges (Ambrosio-Tortorelli)

$$\min_{(\mathbf{x},\mathbf{s})} ||\mathbf{y} - C\mathbf{x}||^2_{W(\mathbf{y})} + \alpha_1^2 \sum_{m=1}^{M} ||\mathbf{D}\mathbf{x_m}||^2_{\mathbf{W_s}} + \varphi_S(\mathbf{s},\gamma)$$

$$W_s = \text{Diag}\left[(1-[\mathbf{s}]_i)^2\right], \quad \varphi_S(\mathbf{s},\gamma) = \gamma^2\|\mathcal{D}\mathbf{s}\|^2 + \frac{1}{\gamma^2}\|\mathbf{s}\|^2$$

  - Solve using biquadratic iterative optimization
  - Other algorithms investigated (overcomplete basis representations, …) with similar results.

Beam hardening and attenuation correction

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- **Multi-energy attenuation reconstruction needed**?

$$I_\phi(t,h,\lambda_0) = \int_0^G \int_{\lambda_0}^{\lambda_0+\Delta} I_\lambda(t,0)\mathcal{A}_\lambda(t,0,s,0)\mathcal{B}_\lambda(t,s,G,h)\frac{|F(t,s,q)|^2}{[(G-s)^2+h^2]^{3/2}}d\lambda ds$$

  - Frequency-dependent absorption on incoming path and scattered path
- If measure scatter at small angles and: assume attenuation along transmission path is same as attenuation along scatter path and: photon-counting detectors …
  - Normalize scatter signal by transmitted signal

$$J_\phi(t,h,\lambda_0) = \frac{I_\phi(t,h,\lambda_0)}{I_\phi(t,0,\lambda_0)} \approx \int_0^G \int_{\lambda_0}^{\lambda_0+\Delta} \frac{|F(t,s,q)|^2}{[(G-s)^2+h^2]^{3/2}}d\lambda ds$$

Does this work?

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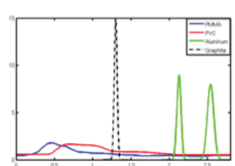
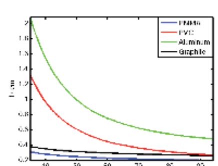
- Compare reconstructions using ratio approximation vs reconstructions using accurate attenuation models
  - Object of size 8*4cm, composed of 4 elements (PMMA, PVC, Aluminum, Graphite)
  - Phantom: tall rectangular solid, 40 cm tall
  - Focus on clutter, interference, attenuation
    - Different attenuation of scatter

Plan view of object in Illumination plane



Form factors for elements



Linear attenuation coefficients for elements

Illumination Variations

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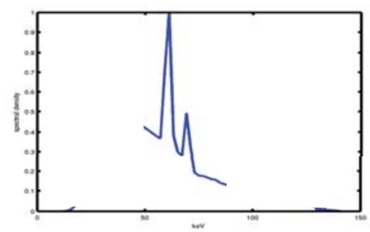
- Polychromatic source from 50 keV to 80 keV with basic spectra
- Simulated Monte Carlo photon sources:
  - GEANT 4 with modified Rayleigh scatter, Compton & Photoelectric
  - Analytical model with Poisson noise
  - Sampled spectrum, 30 energy bins



Beam Hardening Correction with Circular Architecture, Column Detectors

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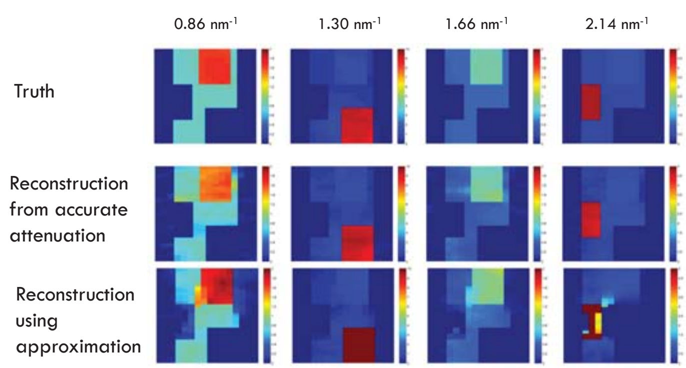
- 4 KeV resolution photon counting detectors, 12 views



Works ok…

Beam Hardening Compensation is is Harder with Intensity Detectors

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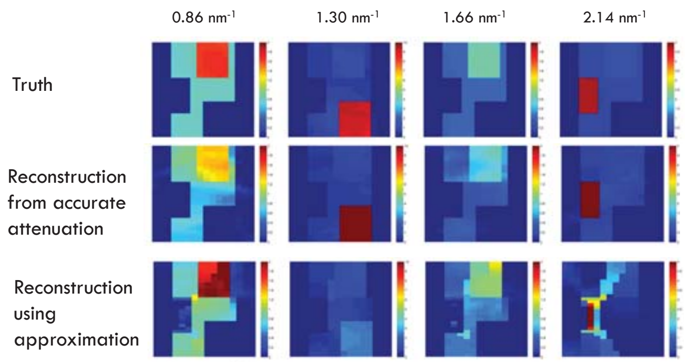
- Intensity detectors, 12 views



Lose structure, size even in aluminum block

Approximation for coded apertures? No…

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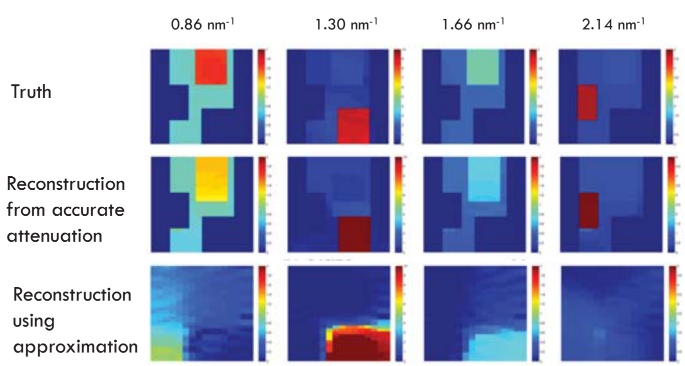
- 3 views: (-60, 0, 60 degrees)
- Must have attenuation map for correction



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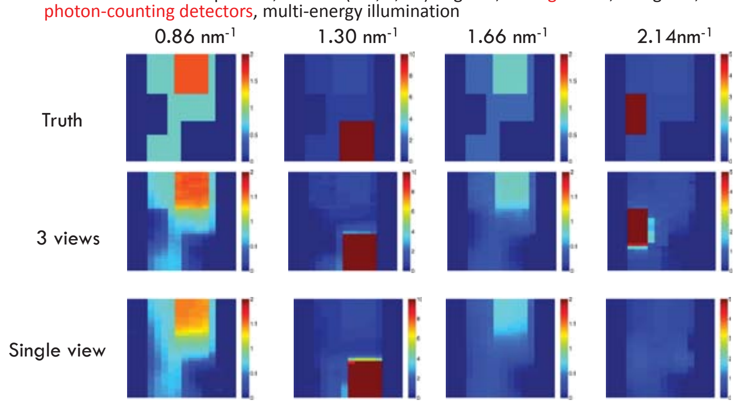
Other Reconstruction Behavior

- Phantom: **Tall rectangular solid**
- Architecture: Coded aperture, 3 views (-60, 0, 60) degrees, vs single view, 0 degrees, with photon-counting detectors, multi-energy illumination



Strong absorption from a single view can reduce scatter signal (no aluminum…)

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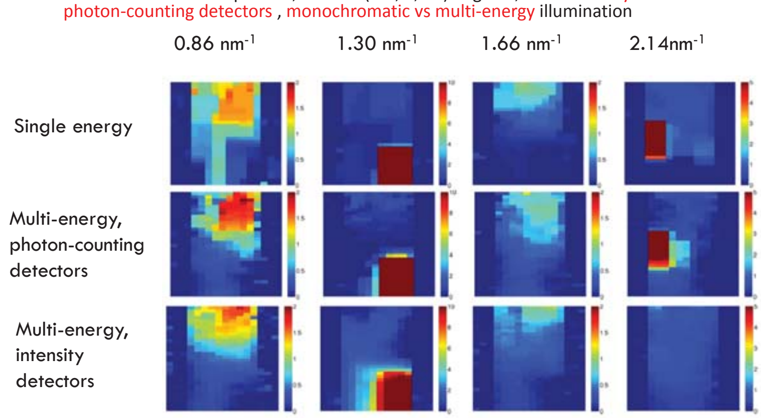
Photon-counting detectors help

- Phantom: **Tall rectangular solid**
- Architecture: Coded aperture, 3 views (-60, 0, 60) degrees, with intensity detectors and photon-counting detectors , monochromatic vs multi-energy illumination



What about XRD Cargo?

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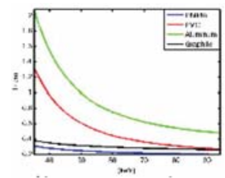

- Energy Levels
  - Need to work at lower energy to get sufficient coherent scatter → LACs of 0.2-0.8
  - Difficult to get coherent scatter for minimum dimension over 15 inches – longer exposure times
- Irregular shapes make tomographic architectures hard
  - Hard to arrange coherent scatter detectors for rotating architecture
  - May have very different length paths for radiation
- Larger minimum dimension → larger arrays needed
  - Photon counting detectors desired
  - Greater expense to populate array
- Increased metal content → increased streaking, attenuation
  - Advanced algorithms required

Summary

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- Iterative reconstruction algorithms show promise for reconstruction of XDI images for checked luggage
  - Good localization and characterization of materials with well-defined Bragg peaks
  - Harder to get accurate reconstruction of liquids and other amorphous materials in the presence of stronger scatterers nearby
  - Need to test on broader classes of liquids, HMEs
- Architectures with photon-counting detectors offer improved reconstruction
  - Must tradeoff cost of detectors, array population vs signal strength
- XDI is less promising for cargo inspection
  - Lower energy requirement, larger dimensions lead to weak signals
  - Irregular shapes make sensing architecture design complex

17.31 David Castañón, Clem Karl, Zach Sun: Coded Aperture X-ray Fluorescence for Cargo Inspection

Coded Aperture X-Ray Fluorescence for Cargo Inspection

David Castañón, Clem Karl and Zach Sun

Boston University
Department of Electrical and Computer Engineering

This material is based upon work supported by the U.S. Department of Homeland Security, Science and Technology Directorate, Office of University Programs, under Grant Award 2013-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.

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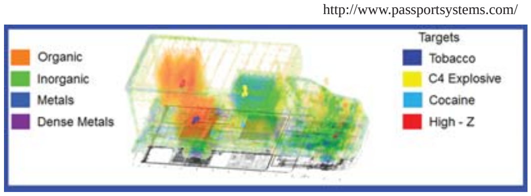
Conclusions

- Nuclear Resonance Fluorescence provides information on material properties
- Obtaining localization through collimated sensing reduces counts and makes acquisition time slow, limiting use to selective areas
- Using a coded aperture can increase SNR and lower acquisition time, but …
- Much more to analyze – secondary radiation, multispectral excitation, inverse problems, classification, system concepts & cost, …

http://www.passportsystems.com/



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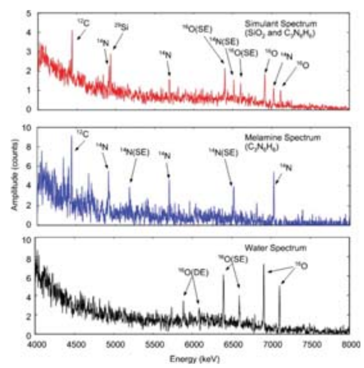
Nuclear Resonance Fluorescence

- Nucleus absorbs and reemits high-energy photons (> 1MeV)
- Reemission profile vs energy is characteristic of material
- Can obtain information on elemental composition



Bertozzi, et al, 2007

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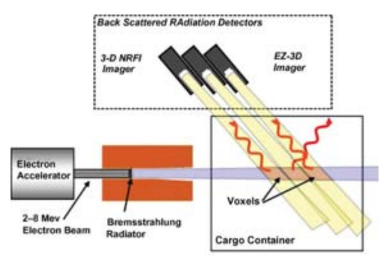
Imaging with NRF (Passport Systems)

- Use pencil beam scanning coupled with collimation to localize emission
- NRF Imager inspects localized areas of interest
- Collimation reduces signal preventing NRF from being used on a larger scale



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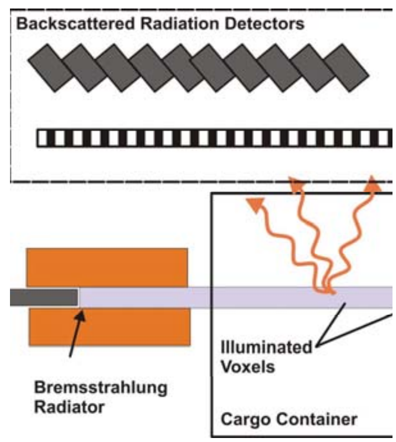
Concept: Use Coded Aperture vs Collimation

- Coded mask can increase effective aperture size, photon efficiency
- Improve measured SNR to reduce acquisition time



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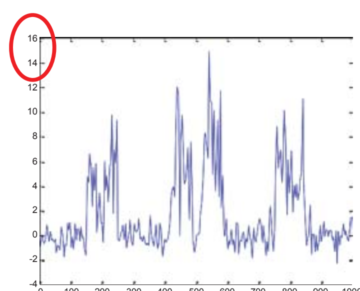
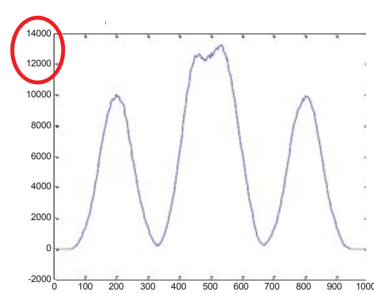
Higher SNR of Coded Aperture System



Measured Collimated Signal Profile



Measured Coded Signal Profile

- Single energy, 1-D profile – Improved SNR by 1 order of magnitude

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Signal Inversion Approach

$$\|y - Cx\|^2 + \alpha\|Dx\|^2$$

Measured Profile — Mask Operator — Latent Signature — Spatial Prior

- Assume:
  - Emission independent at each energy
  - No photon interaction between emission and detection
  - Coding mask effect is linear, identical for each energy
  - Independent linear inversion problem at each energy

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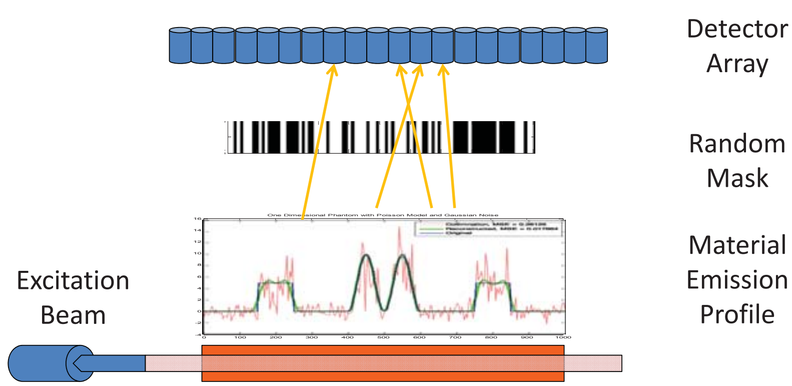
1-D Simulation Geometry



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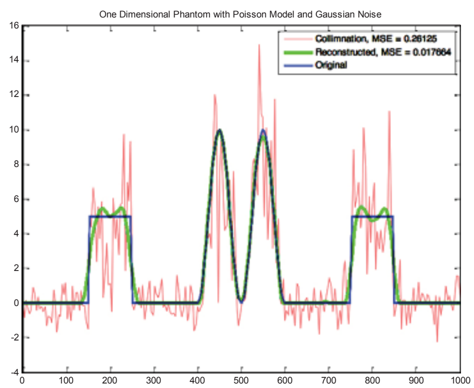
1-D Simulation Recovered Profiles



Data: 1000 units wide
Mask: 100 units
Sensor array: 1000 units, 3.9 unit res.
Distance Mask to Data: 300 units
Distance Sensor to Mask: 300 units

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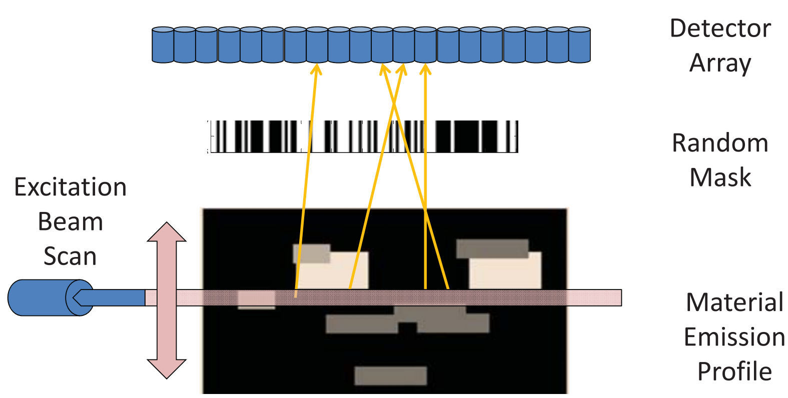
2-D Simulation Geometry



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Two-Dimensional Reconstructions

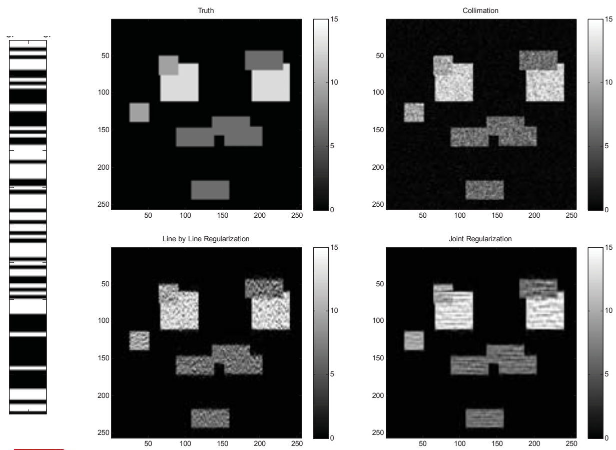

Image: 1000 x 1000
Sensor: 1000
Mask: 100
Mask to Image: 300
Sensor to Mask: 300

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Two Dimensional Simulation

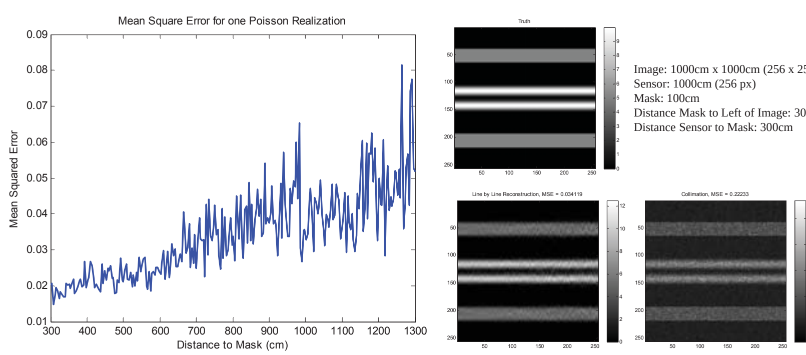

Image: 1000cm x 1000cm (256 x 256)
Sensor: 1000cm (256 px)
Mask: 100cm
Distance Mask to Left of Image: 300cm
Distance Sensor to Mask: 300cm

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Coded Aperture X-Ray
Fluorescence Cargo Inspection

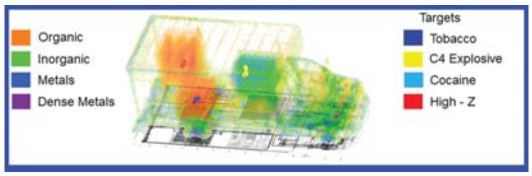
12

12/9/2014

Conclusions

- Nuclear Resonance Fluorescence provides information on material properties
- Obtaining localization through collimated sensing reduces counts and makes acquisition time slow, limiting use to selective areas
- Using a coded aperture can increase SNR and lower acquisition time, but …
- Much more to analyze – secondary radiation, multispectral excitation, inverse problems, classification, system concepts & cost, …

http://www.passportsystems.com/



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17.32 Tim White: Perspectives on Cargo Inspection: What was heard? What was not heard? What's next?

Perspectives on Cargo Inspection

What was heard?
What was not heard?
What's next?

Tim White, Harry Martz
ADSA-11, Nov 4, 2014

LLNL-PRES-664383 Topics used to guide discussion at the conclusion of the workshop PNNL-SA-106924

What Did We Hear

DfT, TSA (the regulators)

- Air cargo screening is a weak link / soft underbelly
  - Or a significant challenge in need of a solution?
- Regulations drive solutions
  - Selection of "most appropriate means possible"
  - Non-technical approaches often chosen
  - Lowest costs technologies most often deployed
    - Regulations may drive cost; e.g., UK requirement that trace swabs are performed on the inside of the package (time cost, liability cost)
- Commodity-driven approaches
  - e.g., EMD, RF detection, ETD, AT, EDS
  - There may be technologies that are appropriate to specific commodities and may not be appropriate elsewhere (e.g., EMD for fresh berries)

LLNL-PRES-664383 Topics used to guide discussion at the conclusion of the workshop PNNL-SA-106924

What Did We Hear

(some comments)

DfT, TSA (the regulators)

- Note about "most appropriate means" from Allan Collier:
  - There are pretty strict guidelines about what cannot be used in what situation. There is a process in which a screener's proposed solution is evaluated (so you cannot just buy the cheapest tool and run with it, as the presenter may have implied)
  - TSA has an air-cargo-inspection toolbox
    - Are the tools being used in the right way?
    - Can the tools be improved and at what cost?
    - Are they sufficient for future threats?

LLNL-PRES-664383 Topics used to guide discussion at the conclusion of the workshop PNNL-SA-106924

What Did We Hear

Freight Forwarders (end users, stakeholders)

- "Volunteering" to help
- Screening needs to fit business model
  - Life-cycle costs need to be considered, not just initial purchase costs
  - (and DHS / TSA have recognized this as well, even if it has not been communicated clearly)
- Does this allow new opportunities?
  - Inspection paradigms that offer other business opportunities, i.e.
    - RFID tags that allow tracking and chain-of-custody verification)
    - Inspection technique that finds other items that the shipper cannot ship, e.g., aerosol cans (increase the value proposition for the shipper)

LLNL-PRES-664383 Topics used to guide discussion at the conclusion of the workshop PNNL-SA-106924

What Did We Hear

Geeks (vendors, academics, labs)

- Cool technical “solutions”
  - Parts per quadrillion limits
  - Exotic x-ray sources
  - New detectors
  - Clever algorithms – tomosynthesis, peeling of layers in radiography
  - Fake (and real) dog noses
- Risk analysis and game theory say we have it all wrong

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Additional Audience Comments on “What We Heard”

- Pre-check has been touted as a big success for TSA
  - This opinion seems to be driven by less-disgruntled passengers
  - But has it been demonstrated that risk is reduced?
    - And by corollary, would a similar game in air-cargo reduce risk?
- Comment regarding the market and the future of CT at the checkpoint
- A Risk-Based screening scenario may allow the infrastructure to remain in place, but it is only “turned on” occasionally (randomly?)
- Since air-cargo screening is not done in one place, the discussion needs to consider the entire process, not just a single technology
  - This is different that the approach to EDS algorithms, e.g.

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What We Did Not Hear

- Measures of Pd, PFA throughput
  - In the old days (ADSA-01), this was the problem to solve
- Technologies for commodity-specific screening approaches
  - Metal detectors (EMD), NQR, RF, & technique fusion
- How do we get the signal in & out of the box?
  - X-ray energy, penetration, contrast, …, ?
  - Is there any vapor/particulate available?
    - We may have heard about as much of this as possible at the clearance level of the meeting

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What Can Be Done

- Is there a viable “traditional” technical solution?
  - Can this be solved with AT, EDS, EDT?
  - Yes? → what should DHS invest in?
    - How to over come the high cost?
  - No? → shall we (ADSA) abandon all hope?
- Possible path forward: similar to ADSA-01, develop surrogate problem set for this community to chew on?

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What Can Be Done?

- Are there alternate solutions?
  - Vents and heaters in LD-3 (or other) containers to aid in sniffing?
  - Can the business model be flipped over
    - Tags and seals (RFID) offer customer feedback (and provide security)
- There are (were) 170 bright people in the room, whadaya got?

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What Can Be Done!

- Is there a benefit to forcing a marriage between the risk, game-theory, and instrument geeks?
  - How does this play into instrument thresholds, Pd?
  - TSA has risk analysis tools that have been applied to screening regimes that they control, could they be applied at certified shipping locations?
- How can the rest of the information (manifest info, history, …) be used?
- Do we really want high Pd?
  - Re-investigate the argument that low Pd is OK if Pfa goes to zero
- Can we measure the value of deterrence?
  - If deterrence is the objective, does the preferred

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What Can Be Done!

technology change?

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18. Appendix: Douglas Bauer: Answers to Questions Provided for Consideration for ADSA11 Workshop Talk

1. With respect to risk:

a. Whose risk should be considered?

There are three kinds of "risk." They differ on the basis of *who* bears the risk and *how* the risk is determined. The first kind of risk is *explicit* risk. This is risk developed through some methodological process that identifies different kinds of risks and then seeks to quantify them. The second is *implicit* risk. This is the implied risk which is the resultant of budget allocations and political decisions by government. So, if air cargo is receiving less attention in budgets and priorities and discussions the implicit risk can reasonably be determined to be low. The third kind of risk is *perceived* risk. This is the subjective risk which different people and institutions may judge a particular risk, e.g. the risk that air cargo might explode, to be. It is a risk typically without methodological basis. It may or may not be altered by conversation with others.

For our more immediate purposes, there are two different categories of risks to be considered: *internalized* risks and *externalized* risks. Internalized risks are reflected in prices charged for scanners. Traditional vendors have such internalized "risks" associated with every new technology. These include risks of performance falling short of design expectations, cost overruns, and even market risks associated with TSA buying technologies on a schedule other than the one forecast. These kinds of internalized risks ultimately should be incorporated in the prices charged for completed scanners by competing vendors. The price must cover specific costs and a competitive rate of return to owners. But the risks are susceptible to recovery via the prices selected.

Externalized risks, on the other hand, are risks borne by the public. A governmental authority, e.g. TSA or local transit authority, must assess these externalized risks to the general public through a comprehensive risk assessment for each transportation venue where government has a responsibility to protect the public. Externalized risks include the risk that an event causing severe damage to people or property occurs as a result of any of a number of factors: the risk any kind of cargo in any kind of configuration may contain an explosive; risk that a machine might not work properly or fail to detect a threat which causes such injury; risk that a layered defense fails to catch the defect in an earlier detection component; risk of a security officer missing a threat; risk of a gap in system-of-system security awareness, etc.

It is the determination of *externalized* risks which should guide governmental operations research and technical system R&D investment.

b. For government, the relevant *stakeholder* is the traveler.

c. *Perceived* risk is relevant to government only to the extent that, as a practical matter, it must be reflected in the *political* dimension of procurement decision-making. So, when the TSA administrator states that he wants a risk-basis for security system investment, that expectation should drive serious, quantitative risk assessment and procurement based upon its insight. However, we recognize it is a political world. Therefore, for example, he may have to bend to that will and keep small knives off airplanes because the political pressure not to do so is irresistible. But such actions should be variants on methodological risk assessment – not the sole criterion on what to invest.

<u>2. With respect to "buying down":</u>

a. <u>Who will pay for this buy down?</u> The traveling public should pay for the buy down of internal risk reduction. It should be reflected in the price of tickets or in the taxes paid to public authorities to "buy down" risks identified through comprehensive risk assessments.

b. <u>Do stakeholders need to be forced to buy down risk?</u> A functioning political system should gain acceptance of taxes sufficient and equitably distributed to pay for "buying down" risks. Any incident which causes serious harm to people or infrastructure is a public "cost" which should be rationally "bought down" by incremental risk reduction through prudent public investment based upon comprehensive in situ risk analysis. Internal "costs" for accomplishing this result should be reflected in the prices charged by supplying vendors.

c. <u>How does *a priori* risk affect willingness to "buy down" risk and how much willing to spend for how much reduction? (sic)</u>

A priori risk, meaning perceived risk, may affect the <u>political</u> receptivity to resource allocations to support enhanced air cargo protection. Such risks may affect how far along the incremental rate of risk return as a function of investment dollar public authorities are willing to travel. However, they shouldn't affect the shape of the curve, itself. The curve, itself, should be the resultant of comprehensive, quantitative risk assessment – methodologically and objectively undertaken.

There are precedents for such comprehensive, methodologically-based rate of return vs. investment curves. One is in the F*AA aviation safety program* with Boeing in which returns on safety enhancement are plotted against safety dollar investments. Strict methodological approaches determine the curve. How far along the curve the government is willing to invest is determined by budgets and affected by perceived safety risks.

The second example is electric utility *integrated resource planning (IRP)*. Utilities develop a curve of incremental demand (megawatts) vs. dollar investment. Megawatt increments can either be provided by new supplies (gas, coal, nuclear, renewables) or by improved efficiency ("negawatts" in Amory Lovins'[1] famous lexicon). Under IRP, incremental new "supply" investments are ordered in accordance with declining incremental return. Public Service Commissions determine how far along the incremental rate of return curve to meet future demand at any time a utility is authorized to invest.

I believe the government should engage in developing similar rate of return curves for incremental investments in security systems through a comprehensive transparent risk assessment methodology. The cures would be different for different modes/venues of transportation.

3. Other questions:

a. Is improved security a competitive advantage?

Only to the extent that the cost of "buying down" an increment of risk is differentiable from one mode of transportation to another would security investment arguably affect competitive advantage of one transportation mode over another. Otherwise, the costs of incremental risk investment reflect an internalization of reduction of externalized risks which the public otherwise would bear.

From a *vendor's* competitive position *vis a vis* competing vendors: improved security could be a competitive advantage over competitors if that advantage provides the opportunity for increased market share. Capturing of such an advantage requires the governmental procure-

1. Founder and research director of Rocky Mountain Institute.

ment criteria to favor vendors with improved security over their competitors – not just criteria which place all vendors on an equal position if they "pass" certification/qualification.

b. What is the impact of the TSA (government) not doing the screening of air cargo itself?

TSA, like any government agency, emphasizes those modes and venues of transportation for which it has specific legislative responsibility. Thus, it is in response to such responsibility that TSA has emphasized checked baggage and check point. TSA has interest in all modes of transportation and all venues, including air cargo, but its emphasis lies in legislative mandates. TSA could undertake its screening either by employees or contract personnel. Contract personnel could be held to the same standards of professional accountability as employees.

As a practical matter, in a climate of tight and reducing budgets. It is likely that air cargo will not receive the same emphasis as checked baggage or check point. Thus, it is not surprising to me that research – which itself has taken a back seat to "low hanging fruit" – in all research investments of late that *within* research, air cargo research has received lower priority than checked baggage or check point R&D. Adding to this challenge, many checkpoint scanners are nearing obsolescence and require replacement. That requirement places further strain on air cargo investments.

c. Is there a benefit of having technology more expense (sic) than trace on the QPL? (Or, will stakeholders always choose the least expensive technology?)

Private sector incentives are to maximize profits. An important way to accomplish this is to reduce costs. The ACEDPP which I managed while in government and which will be discussed further by Terri Rose and Todd Combs revealed that labor costs dominate all other cost factors. Thus, even if a new technology, itself, were more expensive than trace, it might be preferred if labor costs could be reduced thereby.

TSA has an important opportunity, not yet taken, to adopt a total life cycle or ownership cost perspective in making its procurements. Such a policy would better account for the tradeoffs between labor and technology and support overall efficiency improvements in the way security is accomplished.

d. What will happen if there is an event due to explosives in air cargo?

I would suspect that Congress might provide TSA with more direct authority to regulate security in air cargo. There might be an increase in budgets for R&D to support better technologies to meet whatever the gap was that led to the event due to explosives in air cargo. There could be more random checks of air cargo and increased surveillance of cargo facilities, depending upon the facts of the event. There would be active public discussion of whether cargo should be carried in passenger-carrying aircraft. However, at the end of the political *strum und drang* I suspect that economics would rule and air cargo would continue to be carried on passenger-carrying aircraft.

e. (Paraphrase) Industry must be concerned with its competitive standing. Costs of enhanced security, especially if they fall differentially on different vendors, might work to competitive disadvantage. Is there an impetus for "collective action" on the part of industry to "force themselves" to all buy down risk?

I return to the example of the regulated industries for informative parallels. After the Northeast blackout of 1965, the federal government proposed holding back a penny per kilowatt hour of wholesale tariffs to support a government-conceived and managed R&D program in electric utility reliability. That was a wakeup call to industry and all elements of the electric industry (public, private, municipal) joined to form the Electric Power Institute (EPRI).[2] EPRI established a comprehensive R&D program which for years as provided top class innovations to improve electric service in all its dimensions, including reliability. The program was funded through its members and reasonable costs were passed through to ratepayers who were and are the beneficiaries of the improved service and reliability.

The institutions for aviation security, its R&D, its authorities, and its regulation, are as complex if not more complex than those for the electric industry. However, the government (DHS and TSA) has sufficient authorities to establish the performance criteria for increments of new security technology and the research basis to support the development of such new acquisition criteria and capabilities. The federal government could engage more vigorously with states and cities to pool resources for increments in security enhancements in train and mass transit security enhancements wherein the federal government has less statutory authority than for aviation security (checked bag-

2 Several years later the gas industry established a parallel organization, the Gas Research Institute. Additionally, state commissions established a parallel organization, the National Regulatory Research Institute, to provide similar collective R&D services for public service commissions.

gage, checkpoint).

The government needs to be actively involved in the research enterprise as it is in the regulated gas and electric industries. It cannot stand by with a passive approach of only inviting industry from time to time to provide the best it has. Only through engaged research can the government set reasonable security performance expectations. Only through such engaged research can it appreciate both what is possible and what it will cost to relevant stakeholders who bear internalized costs and the general public who bears the externalized costs/risks.

The following relevant excerpts are from the HSARPA and TSA R*esearch and Development Test & Evaluation Strategic Plan*, signed by Adam Cox and John Sanders on 11/1/13 and 10/30/13, respectively – almost exactly a year ago. A question for us is where does this process stand today??

Transportation Security Administration

Homeland Security

Science and Technology

Department of Homeland Security

HOMELAND SECURITY ADVANCED RESEARCH PROJECTS AGENCY &

TRANSPORTATION SECURITY ADMINISTRATION

Research and Development Test & Evaluation Strategic Plan

October 30, 2013

Priority Area 6.8: Improve Freight Tamper Prevention and Detection Capabilities

Focus Area 6.8.1: Improve freight tamper prevention and detection capabilities

Surface and Air Cargo Integrated Project

Teams

Within the Surface and Air Cargo programs, formal collaboration is managed through the DHS HSARPA and TSA Integrated Project Teams (IPT) meetings. Led by the TSA OSC Intermodal Division Director, representatives from TSA OSC, DHS HSARPA (Explosives, Chem/Bio, Resilient Systems), TSA Office of Security Policy and Industry Engagement, and Office of Health Affairs discuss statuses and provide feedback on ongoing TSA/HSARPA technology initiatives on a project-level basis.

Technology Strategy Roadmaps

To encourage consistent dialogue and proactive involvement with HSARPA, TSA passenger aviation programs will produce and maintain technology roadmaps that outline desired capabilities, high-level development milestones and dependencies for major technology products and incremental capability enhancements. Strategy roadmaps indicate key mission capability needs and the TSA efforts to accelerate the development of advanced solutions. For TSA Intermodal programs, these items are developed through the RDWG and monthly IPT meetings.

RDT&E Program Plans

In order to help ensure alignment of RDT&E activities to TSA's strategic goals, using the aforementioned TSA Technology Strategic Roadmaps for guidance, HSARPA produces and maintains technology development roadmaps and program plans for transportation security. Technology development roadmaps and program plans encompass chemical, biological, radiological, nuclear, explosives (CBRNE), behavioral science, and cyber security programs. These roadmaps and plans provide TSA with a timeline of HSARPA's RDT&E program deliverables. Maintaining a transparent RDT&E program allows HSARPA to strike the proper balance between R&D lead time and research impact. HSARPA also works with TSA on RDT&E program planning and provides timely program reviews so that TSA can maintain the appropriate level of insight into R&D program status.

ALERT

AWARENESS AND LOCALIZATION
OF EXPLOSIVES-RELATED THREATS

Awareness and Localization of Explosives-Related Threats

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