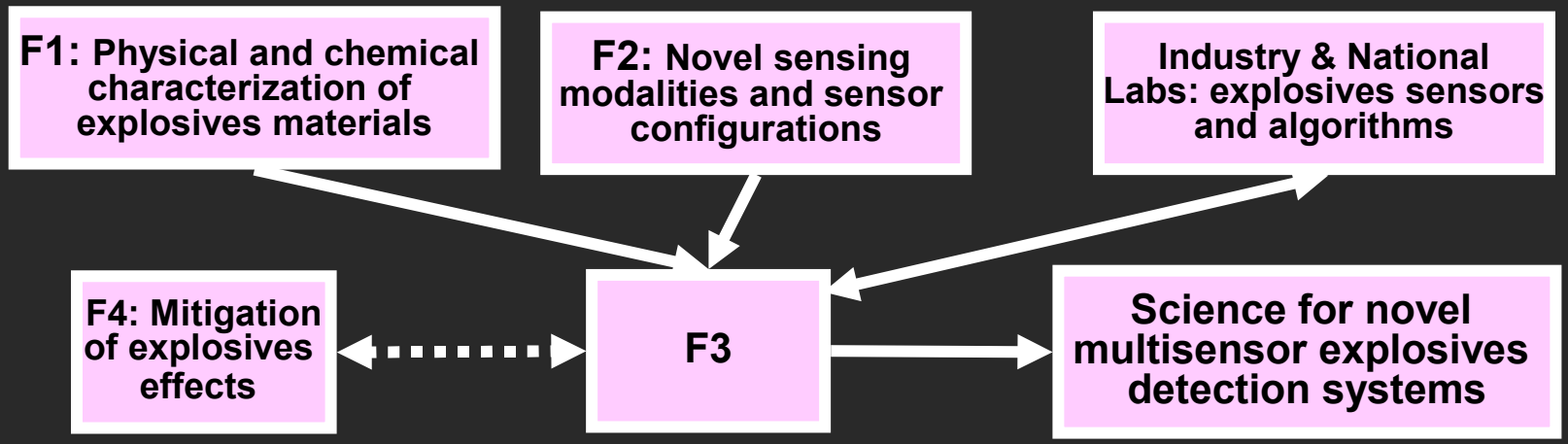
Thrust F3 Multisensor Systems for Threat Detection & Identification

- Design and implementation of novel explosive detection and identification systems
  - Multisensor systems
  - Unconventional approaches involving alternative signatures
- Major themes
  - Information fusion from heterogeneous sources
  - Sensor distribution and sensing control
  - Novel algorithms for extracting enhanced signature information and improved explosives detection and classification
  - Human factors both in system design and alternative signatures



Portal and Standoff Systems

- Portal systems
  - Suite of sensors in controlled environments
  - Key requirements: detection accuracy, throughput, clutter rejection, integration with human operators
- Standoff systems
  - Spatially distributed, heterogeneous networks of sensors, perhaps mobile
  - Moving targets, lots of clutter → lots of data
  - Key requirements: area coverage, early detection, accurate warning

The Academic Research Team

D. Castañón (BU)	Optimization, information fusion, stochastic control, estimation, sensor networks, machine learning
W. C. Karl (BU)	Statistical signal and image processing, detection, estimation, inverse problems and tomography
V. Saligrama (BU)	Sensor networks, information theory, compressed sensing, information fusion
O. Camps (NU)	Computer vision (tracking, object recognition), machine learning, image processing
M. Sznaier (NU)	Robust identification and model validation, tracking, information-based complexity, optimization
G. Tadmor (NU)	Dynamical systems, large scale systems modeling, model reduction, robust control
R. Radke (RPI)	Distributed computer vision, video networks, modeling 3D environments, machine learning
B. Yazici (RPI)	Statistical signal processing, inverse problems in imaging, biomedical optics, radar, tomography.
E. Miller (Tufts)	inverse problems, tomographic processing, inverse scattering, statistical estimation and detection theory
M. Vélez-Reyes (UPRM)	Remote sensing, hyperspectral imaging, machine learning, component unmixing

Year 1 Projects

- **Two groups of projects: Portal and Standoff**
- **Projects: Applications-motivated basic research**
  - Connections to existing sensor concepts to provide representative domain components
  - Focus on fundamental basic research questions of design, processing and control to enhance system effectiveness
  - Exploit ties to industry, national labs and other DHS resources for assistance in concept evaluation
- **Key cross-cutting themes**
  - Principled foundations for information fusion in multisensor, multimodal systems
  - Enhanced automation for increased throughput
  - Improved detection/classification performance: reduced false alarms, improved accuracy
  - Active, adaptive management of information acquisition and processing
  - Emerging theories for systems design and architectural tradeoffs

Next Generation Image Formation for Portal Systems

Miller (Tufts), Karl, Castañón (BU)

- Motivation and purpose:
  - Reduction of false positive alarms in explosive detection systems
- Focus:
  - Advanced physics-based and geometric image formation and object detection methods
  - Feature-enhancement/artifact suppression
  - Incorporation of prior knowledge on explosive characterization
  - Enhanced quantitation and localization
- Year 1 outcomes
  - Feature guided image formation from dual energy scanner data
  - Collaboration with Analogic
- Long range impact
  - Robust, enhanced formation methods
  - Large scale portal applications with limited view data sets

Multi-modal Imaging for Portal-based Screening

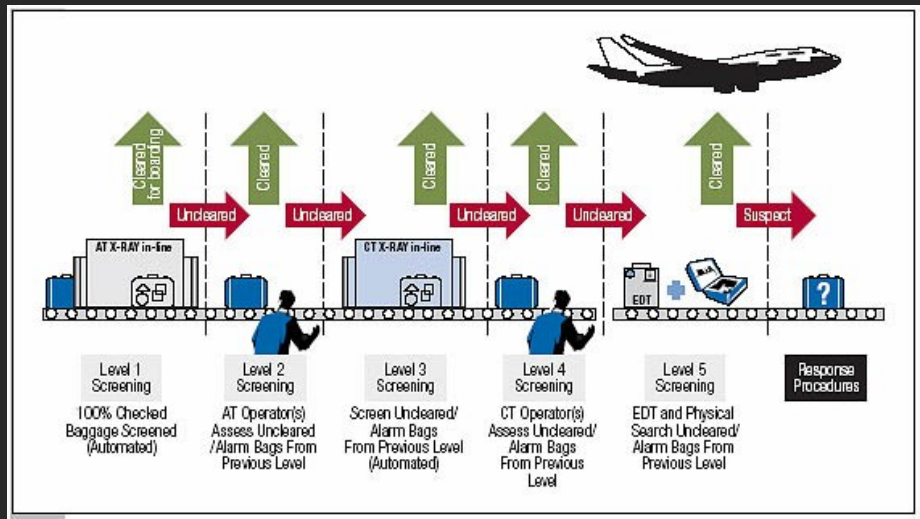
Yazici (RPI), Miller (Tufts), Karl, Castañón (BU)

- Motivation and purpose:
  - Increased specificity and sensitivity
  - Reduction of false alarms
  - Increased throughput
- Focus:
  - Fusion of multiple modalities
    - Dual energy X-ray, X-ray Backscatter
    - THz data sources
    - Bulk and trace sensors . . .
  - Exploit shared physical structure, super-resolution imaging
- Year 1 Outcomes
  - Fusion of X-ray and Thz data
  - Collaboration with Analogic, AS&E
- Long range impact
  - Principled methods for multi-modal fusion for explosive detection

Sensor Management for High Throughput Screening

Castañón, Karl (BU), Miller (Tufts), Yazici (RPI)

- Motivation and purpose:
  - Increase throughput while maintaining high probability of detection
- Focus:
  - Optimal sensor and algorithm management
  - Sequential design of experiments integrated into detection/classification
  - Increased throughput to remove airport/port bottlenecks
  - System-level stochastic optimization
- Year 1 Outcomes
  - Theory and algorithms for sequential multistage classifiers
- Long range impact
  - High throughput screening management algorithms with good sensitivity/specificity



Compressive sensing for portal screening

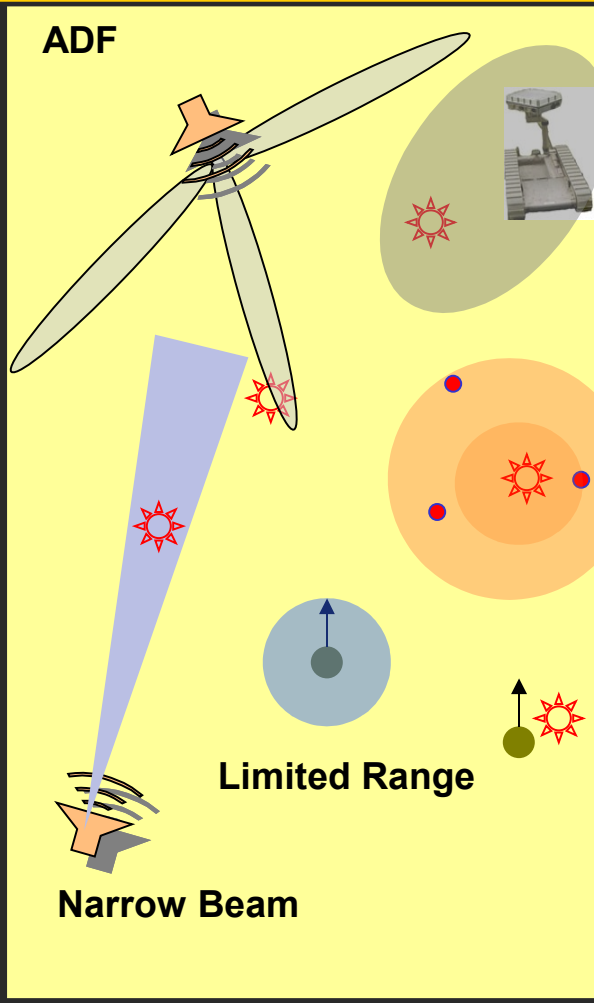
Yazici (RPI), Miller (Tufts), Karl, Castañón (BU)

- Motivation and purpose:
  - Increased throughput while maintaining specificity and sensitivity
- Focus:
  - Application of compressive sensing to determine needed set of optimal projections for spiral CT
  - Goal is faster inspection with reduced measurements
  - Classification from compressed sensing measurements
- Innovative Aspects –
  - Extension of on the emerging technology of compressive sensing to classification from tomographic data
  - Integration of sensing/feature extraction/classification
- Year 1 Outcomes – A method of recognition directly from "compressed" measurements as opposed to reconstructed image
- Long range Impact – New, more efficient and less expensive portal-based screening systems

Multi-modal Sensor-Networks

Saligrama, Castañón, Karl (BU)

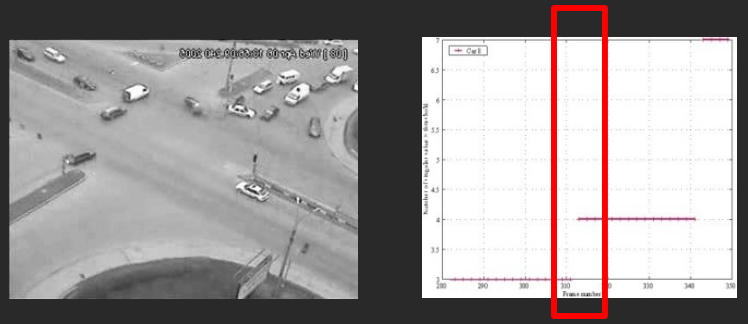
- **Motivation and Purpose**
  - Pervasive wide-area explosive threat detection
- **Innovative Aspects**
  - Foundations for optimal sensor network design
    - Understanding of “sensing capacity” of a system
  - Theoretical structure for performance limits
  - Development of framework for multi-modal fusion of distributed/mobile sensors
  - Development of a theory for active, adaptive employment of sensors
- **Year 1 Outcomes**
  - Sparsity constrained distributed fusion for threat detection
- **Long range Impact**
  - Tools for robust, reliable, real-time threat detection, localization & classification
  - Development of novel sensing sensing systems



Dynamics-Based Detection and Tracking of Explosive Threats -- Camps, Sznaier,Tadmor (NU)

- **Purpose and Relevance:**
  - Robust detection of potential threats using multimodal (e.g. video, micro-pulse radar, IR), physically distributed sensors.

- **Innovative Aspects:**
  - Dynamic models as the key to handle a "data deluge":



Detecting events via jumps in Hankel rank

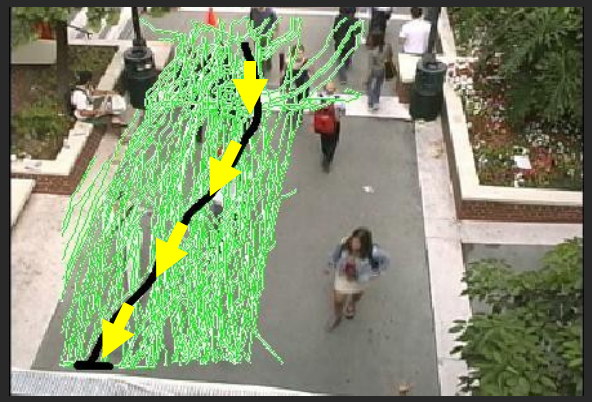
- **Year 1 Outcomes:**
  - Robust tracking , contextually anomalous event detection.

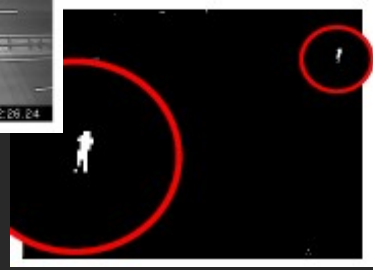
- **Long range Impact:**
  - Real time threat detection/assessment via integration and analysis of very large amounts of surveillance data.
  - Sensor coordinated threat response and impact mitigation.

Distributed Anomaly Detection

Saligrama, Castañón, Karl (BU), Radke (RPI)

- **Motivation and Purpose**
  - Detection of suspicious, anomalous, irregular behavior in highly cluttered urban scenarios
- **Innovative Aspects**
  - Learning of normal patterns of behavior
  - Detection and annotation of anomalies
  - Automated methods for pattern discovery in high-dimensional data
- **Year 1 Outcomes**
  - Activity characterization in urban cluttered scenes from distributed video
  - Detection of anomalous motion in crowds
- **Long range Impact**
  - Robust surveillance system for pervasive and persistent detection of anomalies.
  - Creation of framework for optimal analysis of high dimensional data





Multi-platform passive and active synthetic aperture radar for IED detection -- Yazici (RPI), Castañón , Karl (BU)

- Purpose –
  - Develop waveform, polarization, frequency, space and time adaptive receive and transmit algorithms for IED control wire detection using multistatic airborne RF antennas
  - Scan large area (20 m/sec) with high resolution in all weather
- Innovative Aspects –
  - RF based IED detection algorithms that take advantage of multistatic geometries and waveform diversity to maximize detection probability and to minimize false alarm rate
  - New adaptive synthetic aperture image formation algorithms based on vector wave equation that provide material characterization
- Year 1 Outcomes – Optimize trajectories of the airborne antennas to maximize the detectability of IED control wires
- Long range Impact – New algorithms will lead to small UAV based IED defeat systems