Network Based Hard/Soft Information Fusion
PSU Overview & SYNCOIN

David Hall, Jake Graham, Jeff Rimland and Rick Tutwiler
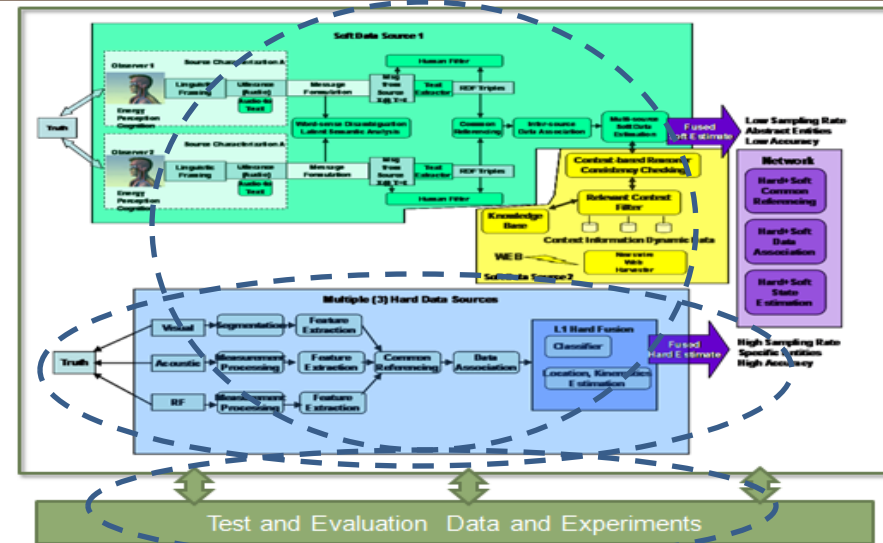
Objectives:

- Develop methods to fusion hard sensor data
- Establish Test and Evaluation approach and associated data
- Develop an integration environment that supports team collaboration, T&E, and transition

Scientific/Technical Approach

- Establish a framework for human-centric fusion
- Develop a T&E approach progressing from synthetic data to human in the loop experiments
- Create an architecture and infrastructure for algorithm integration and transition
- Design and implement algorithms for fusion of physical sensor data including new sensor types

Accomplishments

- Synthetic hard/soft data set
- New hard fusion processing algorithms
- Infrastructure for distributed fusion

Challenges

- Availability of calibrated hard & soft data
- Diversity of heterogeneous hard sensors
- Heterogeneous, distributed observing, data distribution and analysis environment

- # Synthetic hard/soft data set
  - Completed a synthetic hard/soft data set emulating COIN operations
  - Generated extensive foundational documents and ground truth products
  - Conducted 3, multi-day data collection events involving
  - Generated hard and soft data using multiple hard sensors and human actors

- # Fusion of hard sensor data
  - Implemented new algorithms for fusion of hard sensor data
  - Range imaging tracking, (Interacting Multiple Model (IMM)), Particle Filter tracking
  - VNIR Image fusion and Multi-Model Object characterization

- # Integration, transition and network based processing
  - Designed and implemented an integration & transition environment.
  - Extended SOA and Stream-based computing to hard/soft fusion problem

Project Statistics and Summary

Students supported/Degrees Awarded:
- 6 graduates/undergraduate students: J. Borck, J. Fry, A. Mangalgiri, S. Carman, S. Bhatnagar, J. Rimland
- 4 faculty (D. Hall, J. Graham, M. McNeese, R. Tutwiler)
- Degrees awarded: (MS, PhD) : D. Sudit (PhD)
- Degrees awarded (anticipated): 4 M.S. degrees and 1 PhD anticipated during 2012
- Degrees in progress: J. Rimland (PhD),

Publications:
- Peer reviewed journal article - 1
- Refereed conference papers – 12
- Book and book chapters - 4
- Technical reports – 5
- Presentations - 9

Technology Transitions:

- Interactions with industry
- Collaborations with Penn State Police Services regarding local major events
- Interaction with General Dynamics C4 Systems
- Collaboration with Raytheon on IR&D
- Collaboration with Lockheed Martin on IR&D
- i2 Corporation (interaction with Analyst Notebook
- USAF NORTHCOM on Homeland security
- Distributed SYNCOIN to 15 organizations and individuals

- Interactions with other government agencies
- Discussion with NAVSEA Warfare Centers (NSWC Crane)
- Proposed Red Cell collaboration effort with Kira Hutchinson (from JIEDDO)
- Centre County Emergency Management Services
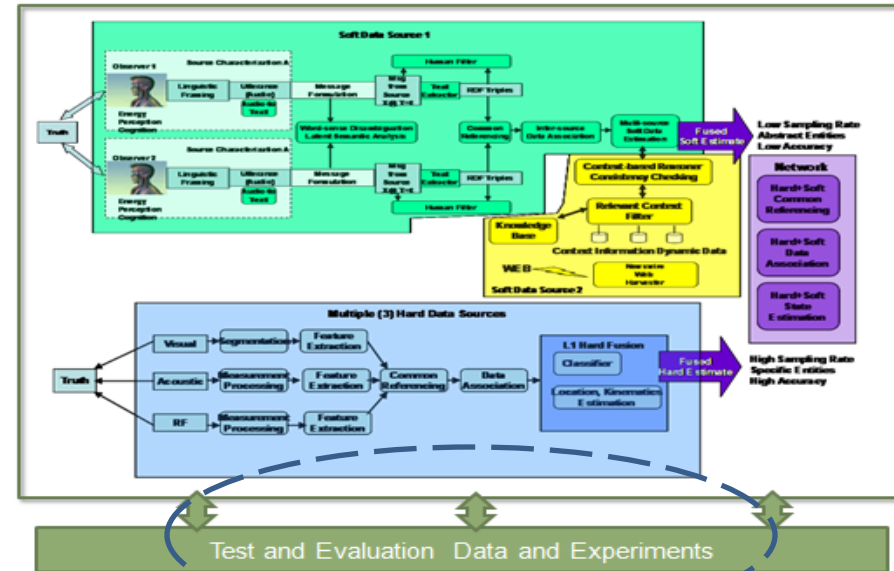- Discussions with USAF NORTHCOM regarding Homeland Security

Objectives:

- Development of synthetic soft data products
- Enhancement of STEF Data Set
- Creation of hard sensor opportunities w/in soft data set (synthetic hard data build)
- DoD Benefit:
- Establishes baseline for algorithm development in future MURI research

Scientific/Technical Approach

- Hermeneutical approach considering the interpretation of ethno-religious groups, culture and political landscape and interactions with allied forces during OIF
- Military aspects of COIN domain (IED events, support networks and motivations)
- Realistic but does not reveal specific tactical or operational tradecraft

Accomplishments

- Developed PSU-COIN data set
- Created ground truth products to check veracity of fusion processes
- Conducted 3 data shoots involving physical sensors and observers

Challenges

- Magnitude of data creation
- Maintaining consistency throughout dataset

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Evaluation Concept

SYNCOIN Data
- 600+ messages
- Corresponding Hard Data

Position Estimates
Track Estimates
Attribute Estimates
Identity Estimates

→ TML Encoding →

Recorded Exp. Data
- Recorded Voice/Comm
- Recorded Video/LIDAR/etc

Position Estimates
Track Estimates
Attribute Estimates
Identity Estimates

→ TML Encoding →

H + S Fusion

Human-In-Loop

Live Sensor Data
- Live Voice/Comm
- Live Video/LIDAR/etc

Position Estimate
Track Estimates
Attribute Estimates
Identity Estimate

→ TML Encoding →

[Fused State Estimates]

Post – Processing Analysis
- Visualization
- Statistical comparison between algorithms

Test & Evaluation

Ground Truth Data

- Single sensor target location/ID accuracy
- Tracking accuracy
- Multi-sensor tracking/ID accuracy
- MOE (SAGIT, etc)

MOPs   MOEs

Conceptual Framework

Reference Materials

(i.e. PIRs, cultural data, etc.)

⬇

Operational Process

Synthetic Data

Engagement Space

⬆

COIN Inspired

Characteristics

- Synthetic soft-sensor data base construction consistent with the dominant security environment of Iraq 2010 to support data fusion in MURI research project

- COIN informed storyline

- Focus on people, events, locations, & movements in & around Baghdad

- Creation of corresponding set of products to support SYNCOIN data, grounded in truth

Commander's Orientation

Stryker Brigade Combat Team Unit of Action Design
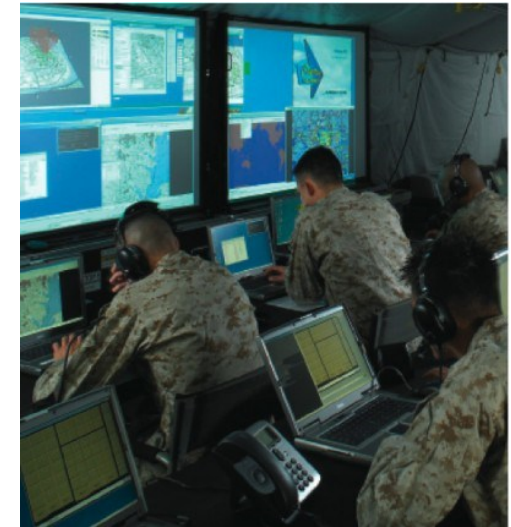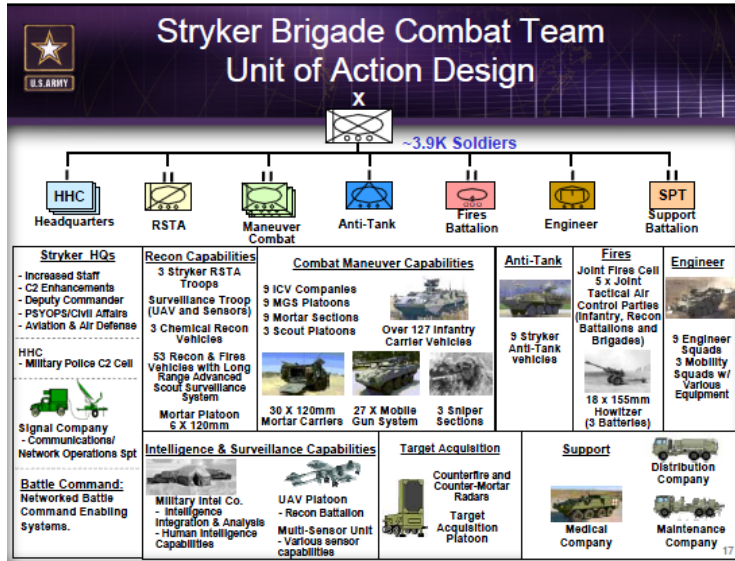
- BCT Commander
- COIN Operations
- Multiple lines of Operations
  - Information
  - **Combat Operations**
  - Development of HN security force
  - Essential Services
  - Governance
  - Economic Development

•**Win over, exhaust, divide, capture, or eliminate the senior and mid-level insurgent leaders and network links**
•**Frustrate insurgency recruitment**
•**Disrupt base areas and sanctuaries**
•**Deny outside patronage (external support)**

IED Ops & Networks

Methodology

SYNCOIN Build Strategy
COIN Inspired Vignette

Reports + **Characters** + **Geo-Ref** + **Ph. Numbers** + **Attributes**

Emerging Themes

7207506052
7515762078
7603444765
7529508702
7396940220
7554309075
7438604901
7115452376
7001408055
7239850612
7678112233
7438605010

Multiple threads
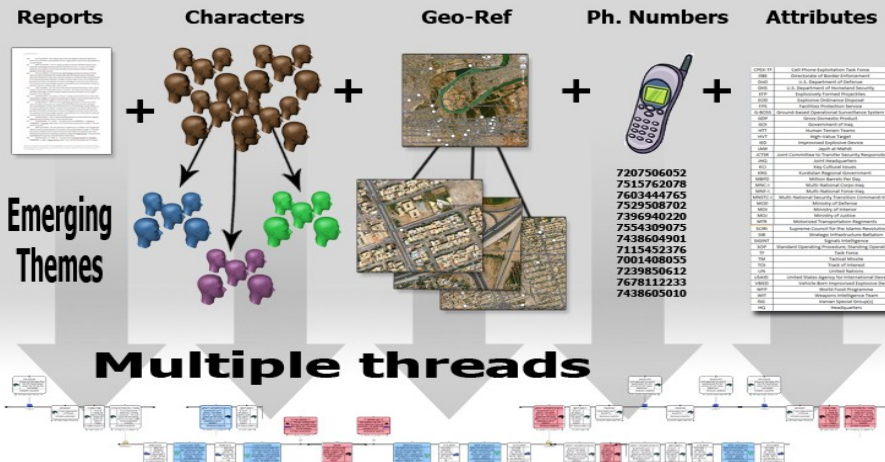
SYNCOIN message set considers the interpretation of ethno-religious groups, culture and political landscape and interactions with coalition forces during OIF

Excerpt from *"Rashid IED Cell"* Vignette:

"IED post-incident exploitation and investigations have revealed evidence indicating a shift in tactics across Baghdad away from insurgent controlled operations to localized for-hire IED operations. Essentially, IED attacks in and about Baghdad have become largely a for-profit, criminal-controlled enterprise …criminal activities in general remain elevated and are often difficult to distinguish from sectarian violence or other violence…"

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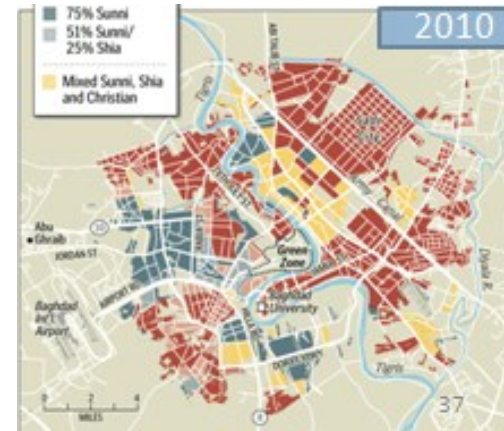
Ground truth data includes temporal and geospatial references, causal relationships, and ethno-religious and social network connections.
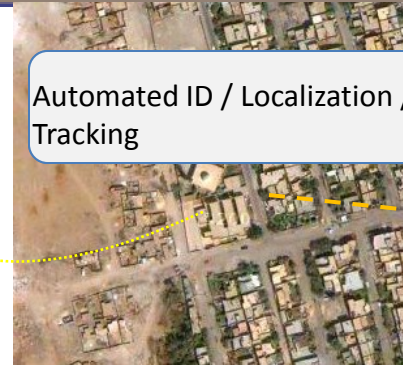
Synthetic Fusion Processing
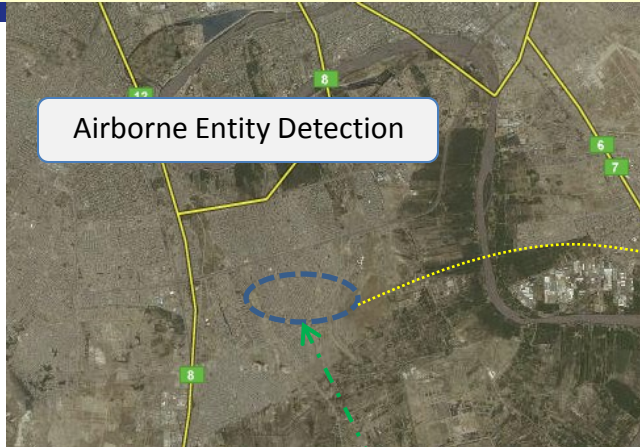
Airborne Entity Detection

Automated ID / Localization / Tracking
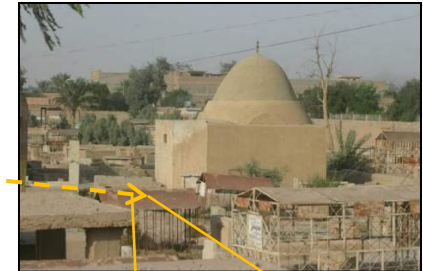
Image Annotation

Geospatial data mapping

Lat/Long 33.23895673330987   44.390881061553955

4. 01/13/07 -- BCT forces have linked two of cache sites //MGRSCOORD: 38S MB 44202 79352 and 38S MB 44227 79081// discovered on 01/10/07 with a bomb factory discovered in Dora //MGRSCOORD: 38S MB 43655 78909// on 01/04/07. Evidence of Iranian supplied trigger devices found at two of the cache sites match others found at the Dora bomb factory.

5. 01/16/07 -- BCT Forces conducting cordon and search operations in Rashid have come across several large wea... ...MGRSCOORD: 38S MB 40472 79584// ... ...recently used in and around Baghdad ... ...Rashid weapons have markings that indicate they were manufactured in Iran as recently as 2006.

Text Extraction

Database Mining

	Name:	Sect:	Country of Origin	Age (Approx.)	Biometrics (Hgt/Wgt)	Fingerprint	Iris Scan	Known Physical Characteristics
1	Name:	Sect:	Country of Origin	Age (Approx.)	Biometrics (Hgt/Wgt)	Fingerprint	Iris Scan	Known Physical Characteristics
2								
3	Mahmoud Al-Banya	Sunni	Iraq	19	6' 2" 150 lbs.	x	x	Missing left thumb
4	Nasser Mohammed	Sunni	Iraq	34	5' 10" 160 lbs.	x	x	Ball shaped birthmark on right wrist
5	Mahamad Sadat	Sunni	Iraq	31	5' 11" 170 lbs.	x		
6	Hassan Al-Buredi	Sunni	Iraq	32	5' 9" 160 lbs.	x	x	
7	Sayeed Ibn Ahmad Dalal	Sunni	Iraq	24	5' 9" 150 lbs.	x	x	
8	Ayman Nouradeen	Sunni	Iraq	31	6' 160 lbs.	x	x	Two different eye colors (L-Brown; R-black)
9	Khalie				6' 1" 160 lbs.	x		
10	Kalee				5' 9" 140 lbs.	x	x	
11	Osam				5' 8" 150 lbs.	x	x	
12	Ahme				5'10" 200 lbs	x	x	Completely bald
13	Moustafa Fahmi	Sunni	Syria	21	5' 11" 210 lbs.	x		
14	Faisal Kiblawi	Sunni	Syria	23	5' 9" 180 lbs.	x		
15	Omar Silami	Sunni	Syria	32	5' 7" 160 lbs.	x		Known to favorite all white scarves
16	Yussef Abu Kheer	Sunni	Syria	40	5' 7" 150 lbs.	x	x	
17	Bashar Jowblatia	Sunni	Syria	44	6' 180 lbs.	x	x	Walks with cane; favors right leg
18	Bashir Al-Din	Sunni	Sudan	25	5' 10" 150 lbs.	x	x	
19	Riyad Al-Solh	Sunni	Sudan	39	5' 6" 150 lbs.	x	x	
20	Shareef Hamza Al-Malak	Sunni	Sudan	26	5' 8" 160 lbs.	x	x	Permanent "boot" on right leg
21	Hamid Al-Gizzr	Sunni	Sudan	43	5' 10" 170 lbs.	x	x	
22	Shaheer Alfar	Sunni	Yemen	32	5' 8" 150 lbs.	x		
23	Shady Ghrayib	Sunni	Yemen	27	5' 9" 160 lbs.	x		
24	Talib Qutb	Sunni	Yemen	32	5' 9" 190 lbs.	x		Missing left eye; patch or glass eye possible
25	Mustafa Kamal	Sunni	Yemen	44	6' 1" 180 lbs.	x	x	
26	Sulaimaan Dayea	Sunni	Yemen	46	5' 5" 150 lbs.	x	x	
27	Abdul Aleem	Sunni	Yemen	38	6' 170 lbs.	x	x	
28	Abdul Jabaar	Sunni	Yemen	41	5' 9" 150 lbs.	x	x	
29	Abed Abu Shakra	Sunni	Yemen	28	6' 160 lbs.	x	x	
30	Adham Kweili	Sunni	Oman	28	5' 9" 150 lbs.	x	x	Known to favor gallibea and not pants
31	Alaa Udeen	Sunni	Oman	22	5' 10" 160 lbs.	x	x	Wears thick glasses
32	Ahmad Al-Akram	Sunni	Oman	27	5' 10" 170 lbs.	x		
33	Ali Ameen	Sunni	Oman	21	6' 150 lbs.	x	x	Known to shave beard but not mustache

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Summary of Data Shoots

Data Set	Collection Dates	Focus	Sensors
1	July 11 – 18, 2011	**Urban environment** • Cars driving in urban environment • Arrival at destination/ passengers disengage • Covert action of small team • Crowd mingling • Explosive detonation, coordinated sniper fire, escape	• LIDAR • VNIR • Video
2	Jan 9 – 11, 2012	**Urban patrol environment** • IED search and destroy mission (house to house) • IED rigged cadaver to ambush infantry patrol unit • All experiments filmed on foot from a fixed location to illustrate standard patrol operations	• LIDAR • VNIR HD gen-locked stereo camera pair
3	July 23-25, 2012	**Urban setting: Multiple vignettes** • Scripted scenarios involving human, multiple vehicles, simulated crowd, IED events, arrest, jail transfer and breakout	• LIDAR • VNIR 4 camera suite • VNIR HD gen-locked stereo

Off Campus Experiments
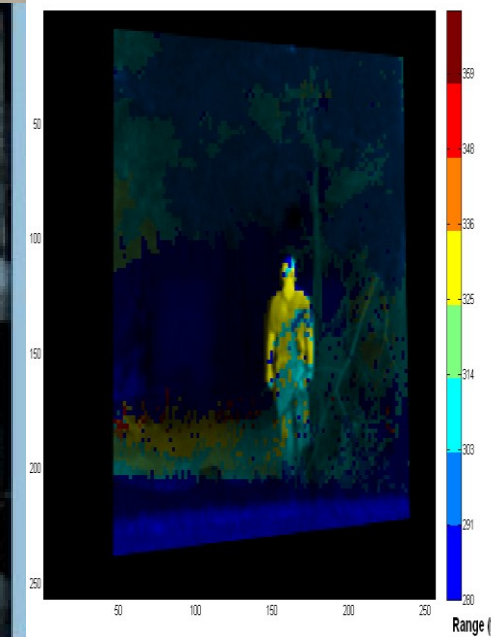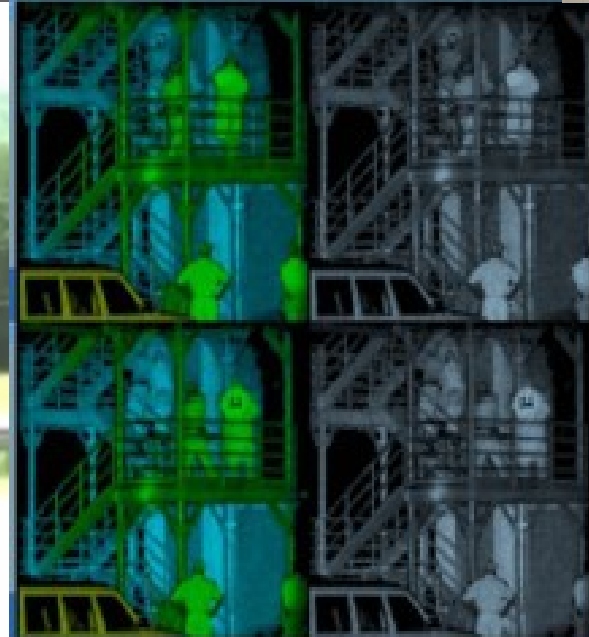
Example Sensor Exercise

- Scenario/Theme: IED Attack / Coordinated Sniper Fire

- Participants: 21 (PSU+TSU)/ 3 vehicles

- Event Days: 3-5

- Sensors: 9+ Cameras, 1 Flash LIDAR, 2+ KINECT

- Mobile Devices: GeoSuite Mobile App on Android

- Event/Activity Synchronization: auditory/visual cues

Each Data Collect requires several weeks of planning/coordination; 3-5 days of data collection; followed by multiple weeks of processing equating to over .5 TB of data

Hard Sensor Exercise Description

B = Red Team
C = Blue Team   G,P = Green Team

Building # 1
Building # 3
Building # 2
Observation Post

50 feet
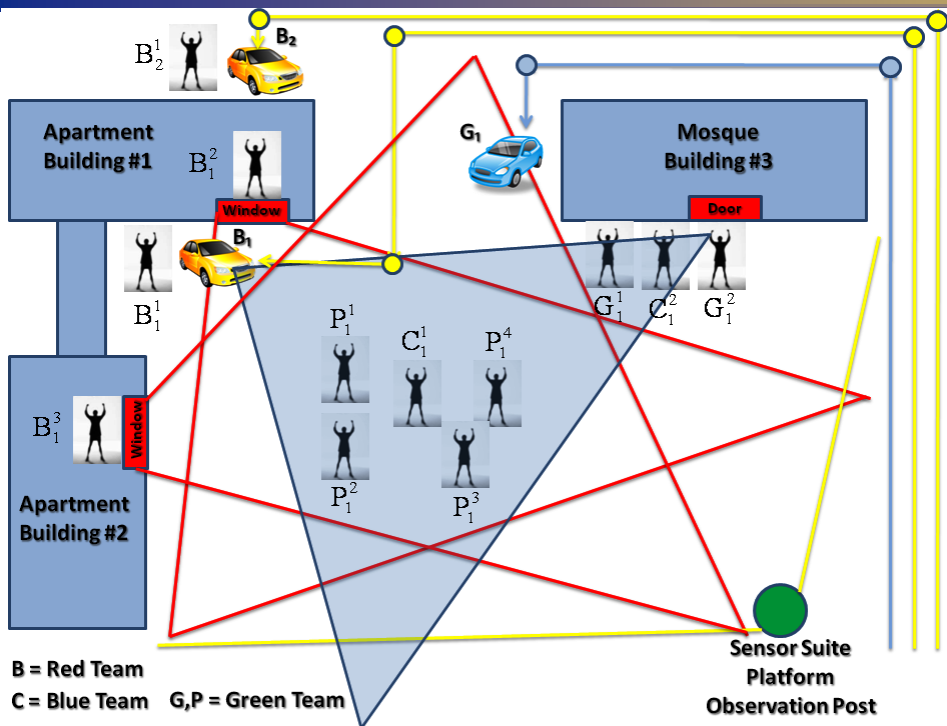
Notional idea of PSU Vignette

MICRO-VIGNETTE: Suspicious Person or Vehicle Motion (or IED or Sniper)
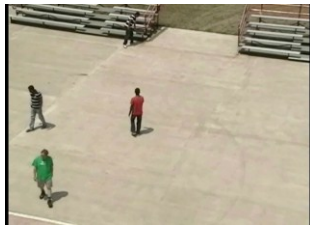
· · · · · · · · ·   **HARD DATA:** Image sequence

FUNCTIONS: Person and/or Vehicle ID and Kinematic Tracking.
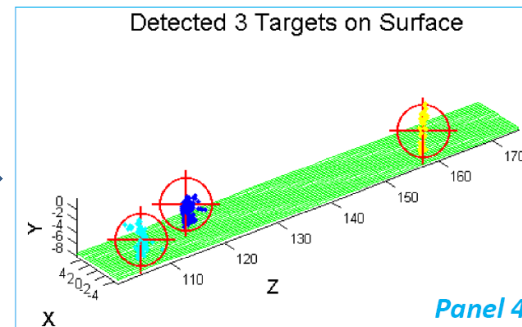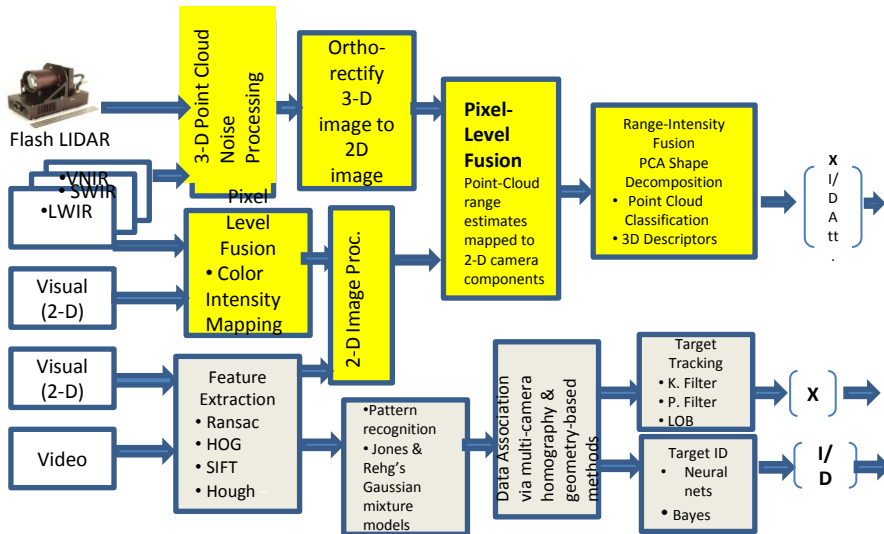
PSU GENERATES: TML messages containing Person and/or Vehicle kinematic track estimates
 (format TBD; eg start/stop (current) locations, locus, Person ID, Vehicle ID, etc)

(Associable) SOFT DATA: Messages to be generated and possibly folded in to existing
SUN Scenario –or-possibly use SUN Soft as exists
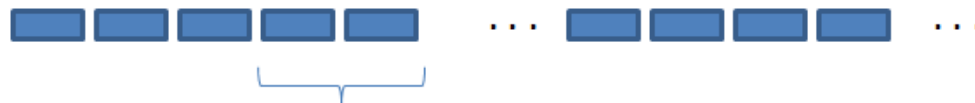
Sunni subset of SYNCOIN data set (approximately 100 messages over 4 month timespan)

Selected mini-vignette involving approximately 10 messages & kidnapping, arrest & breakout activity

Data collected from Pleasant Gap data shoot using physical sensors to emulate vignette activities

5. 01/27/10 -- BCT forces detained a Sunni munitions trafficker after search of his car nets IED trigger devices. Dhanun Ahmad was placed in custody after his arrest along the Dour'a Expressway //MGRSCOORD: 38S MB 47959 80868// in East Dora.
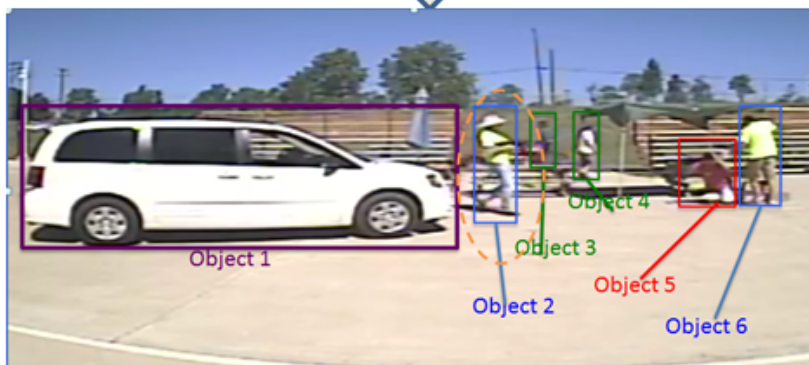
- Tractor extracted textual information
- Automated feature extraction/tracking from hard sensor processing
- TML encoded hard sensor feature data

Object 1
Object 2
Object 3
Object 4
Object 5
Object 6

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"Four Frames"
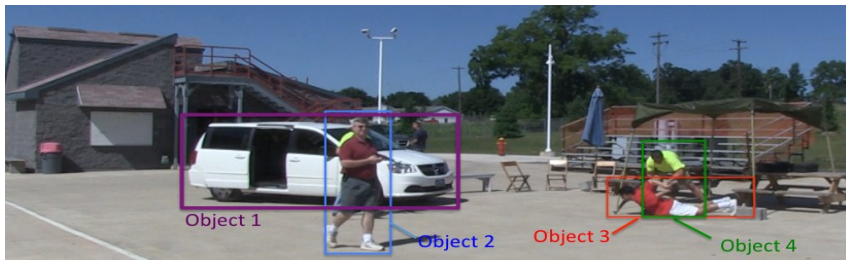
Frame 1

In frame one; we see the arrest of a weapons trafficker with known ties to the Iranian Special Group.

Frame 2

In frame two; our weapons trafficker has been turned over to the local Iraqi police.

Frame 3

In frame three; we see what appears to be the illicit purchase of ordinance, presumably for the purpose of making an improvised explosive device.

Frame 4
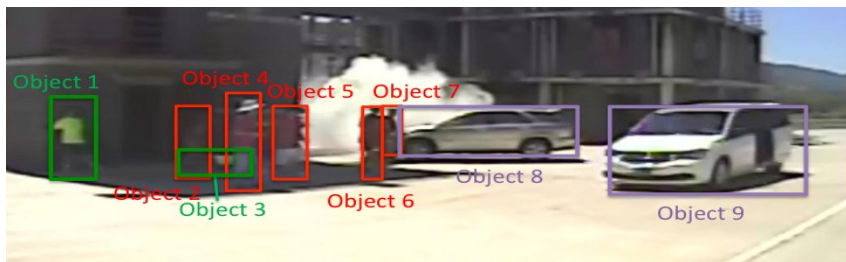
In our final frame; we see the use of the IED to facilitate the breakout of our weapons trafficker, Mahmud Ahmad.

Demonstrations

Video Demonstration

- Data Collection at Pleasant Gap Facility
- Network and Infrastructure Software Developments
- Analyst Interaction with Data and Supporting Analysis Tools
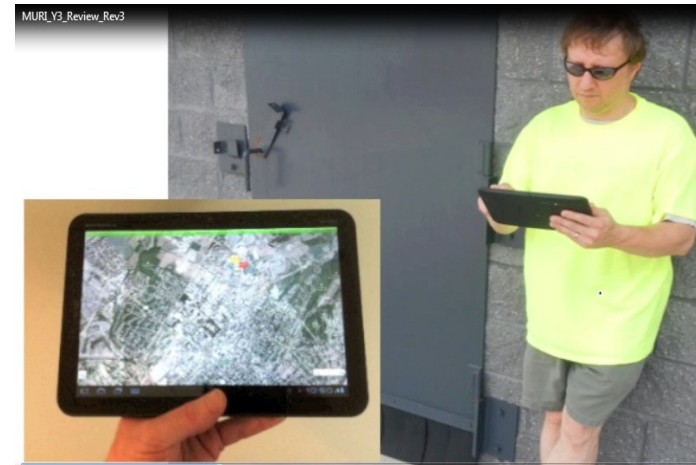
- # Capability Goal:
  - Provide capability for human in the loop experiments at all levels including; data collection (knowledge elicitation), human annotation of hard sensor data, human-on-the-loop analysis, and analyst/observer collaboration

- # Research Goals:
  - Collect additional human-in and on-the loop experimental hard/soft
  - Conduct statistically significant human in the loop experiments to evaluate effectiveness of;
    - "crowd-sourcing " of observational data (e.g., knowledge elicitation tools, focus of attention)
    - Value added of human annotation of hard data
    - Overall effectiveness of hard/soft fusion for situation awareness
    - Effects of collaboration and transactive memory

- Summary of First Two Year Accomplishments
- List of Publications
- Distribution of SYNCOIN Data
- List of SYNCOIN Supporting Document and Data

Summary of Year-2 Accomplishments

- **Test and evaluation** – Developed a T&E approach progressing from synthetic hard and soft data set to human experiments
  - Provided operational perspectives for MURI team to understand tactical military COIN operations
  - Conducted evaluation of HASTEN data set and incorporated concepts into SYNCOIN
  - Initated the development of SYNCOIN, a synthetic hard and soft data set including interlaced scenarios, 600 text messages and synthetic hard data
  - Created initial ground truth products (utilizing Analyst Notebook) to check the veracity of fusion processes
  - Developed a plan for human in the loop experiments
  - Initiated human in the loop experiments and demonstrations in an off-campus setting

- **Fusion of hard sensor data** – Established plans and implemented algorithms to fuse hard sensor data
  - Selected set of hard sensors based on four criteria (LIDAR, SWIR, LWIR, Visual Video, and Acoustic)
  - Developed prototype applications for target identification, localization and tracking in MATLAB and C++
  - Implemented MATLAB fusion/geo-mapping capability
  - Implemented and demonstrated algorithms to fuse 3-D (LIDAR) and 2-D (video) data for target identification and tracking of vehicles and humans in complex urban and non-urban observing environments
  - Explored Situation Awareness Dashboard application using the Command Post of the Future (CPOF)

- **Integration and transition** – Supported the design and implementation of an integration & transition environment.
  - Developed baseline information architecture and service oriented architecture approach for integration, test and transition,
  - Implemented and demonstrated proof-of-concept service oriented architecture (SOA)
  - Acquired, assessed and implemented the Fusion Exploitation Framework (FEF) transition environment at Penn State I
  - Developed proof of concept system to encode/decode/transmit hard/soft data in OGC-compliant formats
  - Investigated technologies, standards, and applications

Papers published in peer-reviewed journals

- 1. Matthew S. Baran; Richard L. Tutwiler; David L. Hall; Donald J. Natale, "Surface reconstruction for 3-D remote sensing" (*In Progress for submission to IEEE Trans. Image Processing*)

Papers published in non-peer-reviewed journals or in conference proceedings

- D. Sudit, S. Kumara and D. Hall, "Complex mathematical model for soft processes in information fusion," *Proceedings of the ISERC 2012 Conference*, Orlando, FL, April, 2012
- J. Rimland, D. Hall and J. Graham , "Human cognitive and perceptual factors on JDL level-4 hard/soft fusion", *Proceedings of the SPIE Conference on Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications 2012*, vol. 8407, Baltimore, MD, April 23-27, 2012
- J. Graham, J. Rimland and D. Hall, "A COIN-inspired synthetic data set for qualitative evaluation of hard and soft fusion systems", *Proceedings of the 14th International Conference on Information Fusion*, Chicago, IL, July, 2011
- M. S. Baran, C. J. Natale, R. Tutwiler, M. McQuillan, C. Griffin, J. Daughtry, J. Rimland and D. Hall, "Hard sensor fusion for COIN inspired situation awareness", *Proceedings of the 14th International Conference on Information Fusion*, Chicago, IL, July, 2011
- Matthew S. Baran; Richard L. Tutwiler; David L. Hall; Donald J. Natale "3DSF: three-dimensional spatiotemporal fusion", *SPIE Defense Transformation and Net-Centric Systems 2011*, pp. 80620E-1 - 80620E-10, 25 May 2011.
- J. Graham and D. Hall, "The use of Analytic Decision Game (ADG) methods for test and evaluation of hard and soft data fusion systems and education of a new generation of data fusion analysts,", accepted for the *Proceedings of the National Symposium on Sensor Data Fusion (NSSDF),* Washington, DC, 22-16 October, 2012
- D. Hall, G. Iyer, M. Ballora, R. Cole, H. Kruesi and H. Greene, "Use of auditory displays in anomaly detection", *Proceedings of the National Symposium on Sensor and Data Fusion*, Oct. 24-28, 2011
- D. Kretz, B. Simpson and J. Graham, "A Game-Based Experimental Protocol for Identifying and Overcoming Judgment Biases in Forensic Decision Analysis", accepted for the *IEEE International Conference on Technologies for Homeland Security*, Waltham, MA, 13-15 November, 2012
- J. Rimland, D. Coughlin, D. Hall and J. Graham, "Advances in data representation for hard/soft information fusion", *Proceedings of SPIE 2012*, Baltimore, MD
- Matthew S. Baran; Richard L. Tutwiler; David L. Hall; Donald J. Natale , "Surface reconstruction for 3-D remote sensing", *Proceedings of SPIE 2012*, Baltimore, MD
- J. Rimland and J. Llinas, "Network and infrastructure considerations for hard and soft information fusion processes", *Proceedings of the FUSION 2012*, July, 2012
- J. Rimland and M. Ballora, "Multi-stage data exploration using visualization and sonification" Abstract submitted to SPIE 2013, August, 2012.
- J. Rimland and S. Shaffer, "Software development for distributed hard and soft information fusion: best practices and lessons learned." Abstract submitted to SPIE 2013, August, 2012.

Papers presented at peer-reviewed conferences

- D. L. Hall, "Asymmetric Information Warfare: Challenges and Opportunities in Information Fusion," keynote presentation at the 2012 DoDIIS Worldwide Conference, April 2nd, 2012, Denver, CO
- D. L. Hall, invited participation in ETUR Panel: "Developments and issues in uncertainty representation", FUSION 2011: International Society of Information Fusion, Chicago, Ill, July 6, 2011
- Richard L. Tutwiler,"3DSF: three-dimensional spatiotemporal fusion", *SPIE Defense Transformation and Net-Centric Systems 2011*, pp. 80620E-1 - 80620E-10, 25 May 2011.
- J. Rimland, "Hard sensor fusion for COIN inspired situation awareness", *Proceedings of the 14th International Conference on Information Fusion*, Chicago, IL, July, 2011
- J. Rimland, "Human cognitive and perceptual factors in JDL level 4 hard / soft data fusion", Presented at SPIE 2012, April 26, 2012
- J. Rimland, "Advances in data representation for hard/soft information fusion", Presented at SPIE 2012, April 26, 2012
- Matthew S. Baran, "Surface reconstruction for 3-D remote sensing", *Proceedings of SPIE 2012*, Baltimore, MD
- R. J. Poore, "Automated Tracking of Objects from LiDAR/VNIR fused data", *Proceedings of SPIE 2012*, Baltimore, MD.

Other presentations

- J. Graham, "SYNCOIN: a synthetic dataset for evaluating hard and soft fusion algorithms," presentation to SI Org University Innovation Day Share [IT], 2 August 2012, Chantilly, VA

Manuscripts

- R. L. Tutwiler, *MURI Hard Sensor Fusion Performance Characterization*, Technical report, May, 2011
- J. Graham, *SYNCOIN Data Set*, Technical report prepared for the Penn State Network Centric Cognition and Information Fusion (NC2IF) Research Center, IST Building, University Park, PA 16802, revised, December, 2011
- J. Graham, Scene *Setter for MURI Demonstration*, Technical report prepared for the Penn State Network Centric Cognition and Information Fusion (NC2IF) Research Center, IST Building, University Park, PA 16802, July 30, 2012
- N. Giacobe, *SYNCOIN Word Clouds*, Technical report prepared for the Penn State Network Centric Cognition and Information Fusion (NC2IF) Research Center, IST Building, University Park, PA 16802 May 1, 2012
- J. Graham et al, *Analyst Notebook Charts*, Technical report prepared for the Penn State Network Centric Cognition and Information Fusion (NC2IF) Research Center, IST Building, University Park, PA 16802, May 1, 2012

Books and Book Chapters

- D. Hall, J. Llinas, C. Chong, K. C. Chang, editors, *Distributed Data Fusion for Network-Centric Operations,* CRC Press*,* August, 2012
- D. L. Hall, "Perspectives on Distributed Data Fusion", chapter 1 in *Distributed Data Fusion for Network-Centric Operations,* CRC Press*,* August, 2012, edited by D. Hall, J. Llinas, C. Chong and K. C. Chang
- J. Rimland, "Service-Oriented Architecture for Human-Centric Information Fusion," chapter 13 in *Distributed Data Fusion for Network-Centric Operations,* CRC Press*,* August, 2012, edited by D. Hall, J. Llinas, C. Chong and K. C. Chang
- D. Hall, "The Emergence of Human-Centric Information Fusion," chapter 27 in *Distributed Sensor Networks*, 2nd edition, 2012, edited by S. Iyengar and R. Brooks

Distribution of SYNCOIN Data

- Peter Willet, University of Connecticut
- Gavin Powell, ADS Innovation Works, UK, government technical area lead for TA 6 - Distributed Coalition Information Processing for Decision-Making)
- David Nicholson, BAE Systems, London, UK
- David Dearing, Stottler Henke Associates
- David Braines, Hursley Emerging Technology Services
- Erick Blasch, Air Force Research Laboratory Sensors Directorate (AFRL/SNAA)
- Marco Pravia, BAE Systems
- Kamal Premaratne, University of Miami
- James Law, SPAWARSYSCEN – U. S. Navy Space and Naval Warfare Systems Center
- Chase Cotton, Network Science Collaborative Technology Alliance Program (CTA), U. S. Army Research Laboratory
- ETURWG – Evaluation of Techniques for Uncertainty Representation Working Group, International Society of Information Fusion (ISIF)
- International Technology Alliance
- Brian Simpson, Raytheon Corporation
- Simon Maskell, QinetiQ, UK
- Charlotte Shabarkh, Aptima, Woburn, MA

- A listing of all SYNCOIN synthetic messages identified by vignette/threads [5];
- A textual "scene setter" for the overall SYNCOIN messages and for each vignette/thread [6] ;
- Description of the build strategy [4];
- An acronym list [7];
- Identification and location of all events and activities - providing both latitude, longitude, MILGRID coordinates and associated labels of places, events and activities [8];
- Reference maps for SYNCOIN [9];
- Database schema for each thread (events, objects, locations, persons, and activities) [10];
- *Analyst Notebook* social network analysis diagrams for each thread [12and
- Word Cloud diagrams (based on *Wordle*) for each SYNCOIN thread [11].