



Network Based Hard/Soft Information Fusion

PSU Overview & SYNCOIN

David Hall, Jake Graham, Jeff Rimland and Rick Tutwiler

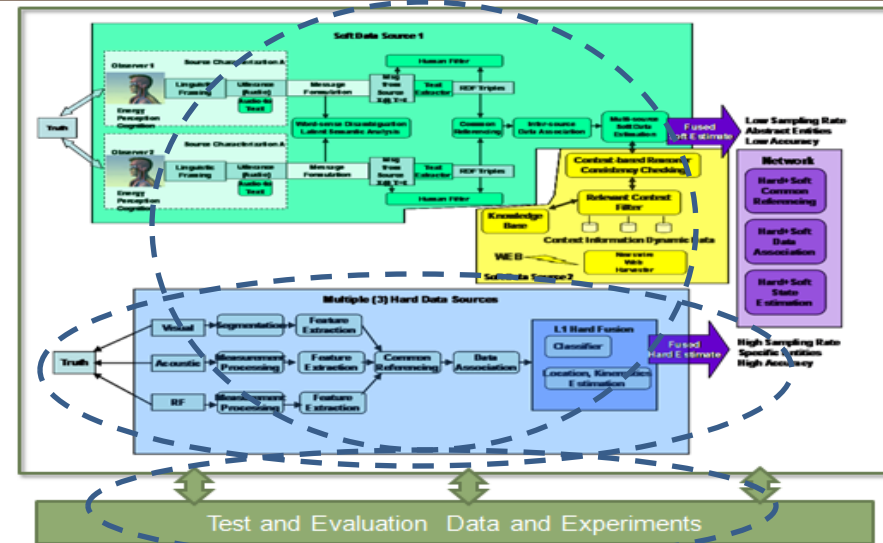


PENNSTATE



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



Main Scientific/Technical Accomplishments Overview of PSU 3rd Year Accomplishments



- **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. Mangalgi, 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



Penn State University

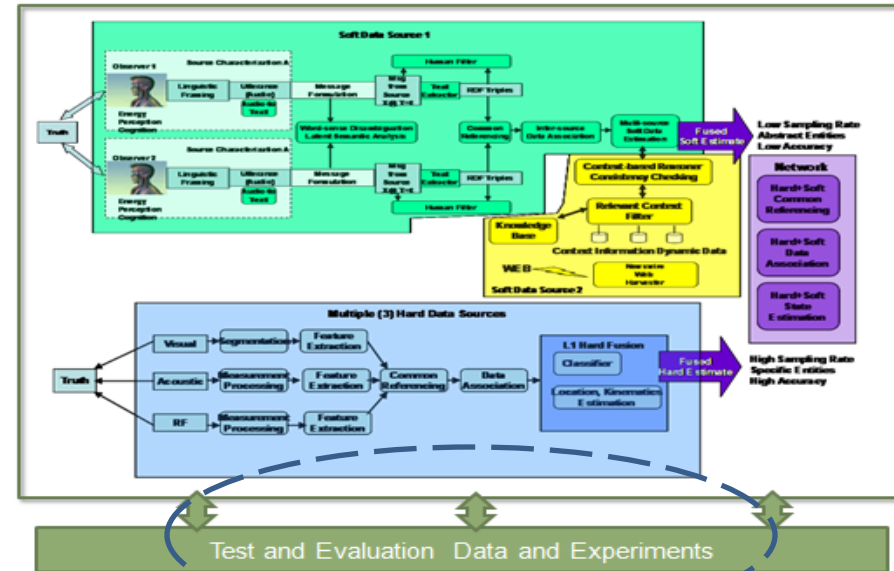
Data Generation

Jake Graham



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

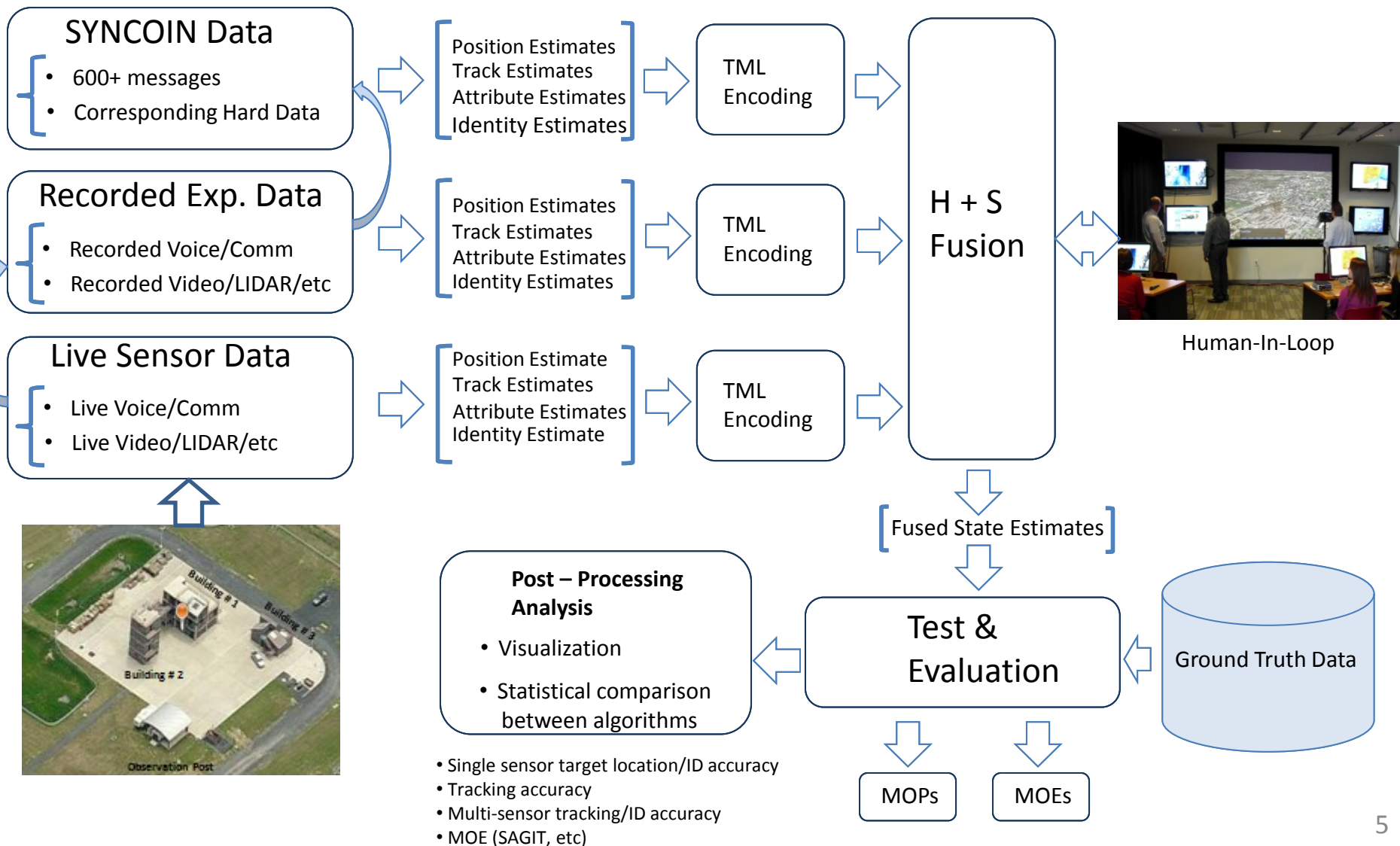
- Developed PSU-COIN data set
- Created ground truth products to check veracity of fusion processes
- Conducted 3 data shoots involving physical sensors and observers

Challenges

- Magnitude of data creation
- Maintaining consistency throughout dataset



Evaluation Concept





Conceptual Framework



Reference Materials

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



Operational Process

Synthetic Data

Engagement Space



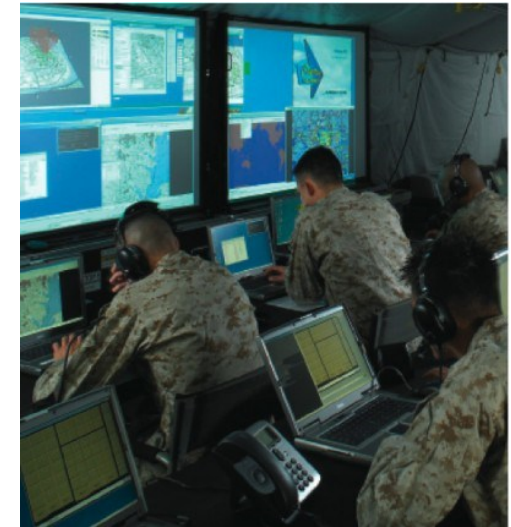
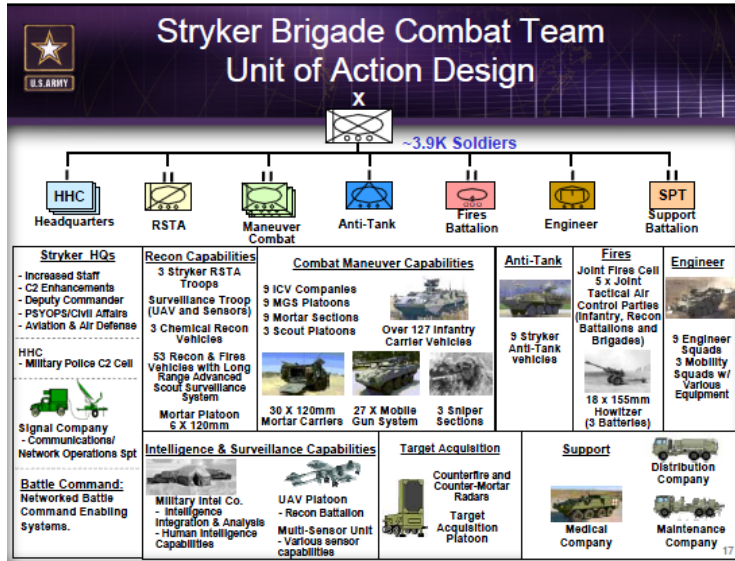
COIN Inspired

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



- 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)

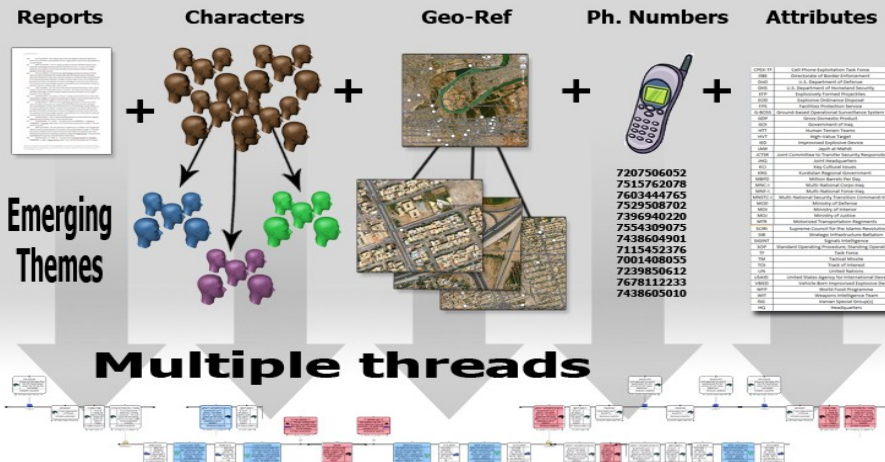
→ IED Ops & Networks



Methodology

SYNCOIN Build Strategy

COIN Inspired Vignette

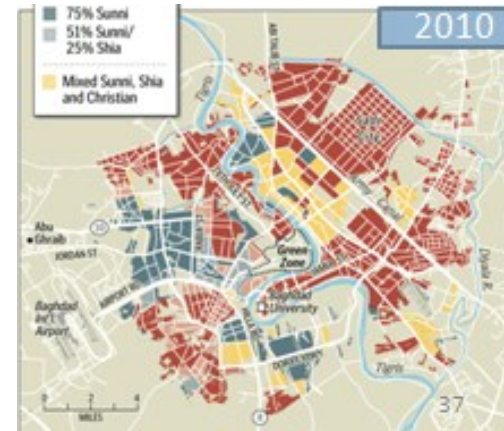


SYNCOIN message set considers the interpretation of ethno-religious groups, culture and political landscape and interactions with coalition forces during OIF

Name:	Sect:	Country of Origin	Age (Approx.)	Bionetrics (Hgt/Wgt)	Fingerprint	Iris Scan	Known Physical Characteristics
Wahneem Al Barye	Sunni	Iraq	19	5' 2" 100 lbs.	x	x	Missing left thumb
Nasser Muhammed	Sunni	Iraq	34	5' 10" 160 lbs.	x	x	Ball shaped birthmark on right wrist
Wahneem Sadat	Sunni	Iraq	31	5' 11" 170 lbs.	x	x	
Hassan Al-Jureidi	Sunni	Iraq	32	5' 9" 160 lbs.	x	x	
Sayed Ibn Ahmad Datal	Sunni	Iraq	24	5' 9" 150 lbs.	x	x	
Ayman Nouradness	Sunni	Iraq	31	6' 180 lbs.	x	x	Two different eye colors (L.Green, R.
Khalid Yousef Al Qasbi	Sunni	Iraq	23	6' 1" 160 lbs.	x	x	
Khaled Daher	Sunni	Iraq	39	5' 9" 140 lbs.	x	x	
Osama Al Karzem	Sunni	Syria	43	5' 8" 150 lbs.	x	x	
Almoud Serkaly	Sunni	Syria	25	5'10" 200 lbs.	x	x	Completely bald
Moustafa Fahmi	Sunni	Syria	21	5' 11" 210 lbs.	x	x	
Faisal Kiblawi	Sunni	Syria	23	5' 9" 160 lbs.	x	x	
Omar Salam	Sunni	Syria	32	5' 7" 160 lbs.	x	x	Known to favorite all white scarves
Yusef Abu Kheer	Sunni	Syria	40	5' 7" 150 lbs.	x	x	
Bassem Jweilatia	Sunni	Syria	44	6' 180 lbs.	x	x	Walks with cane, favors right leg
Basim Al Din	Sunni	Sudan	25	5' 10" 150 lbs.	x	x	

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..."

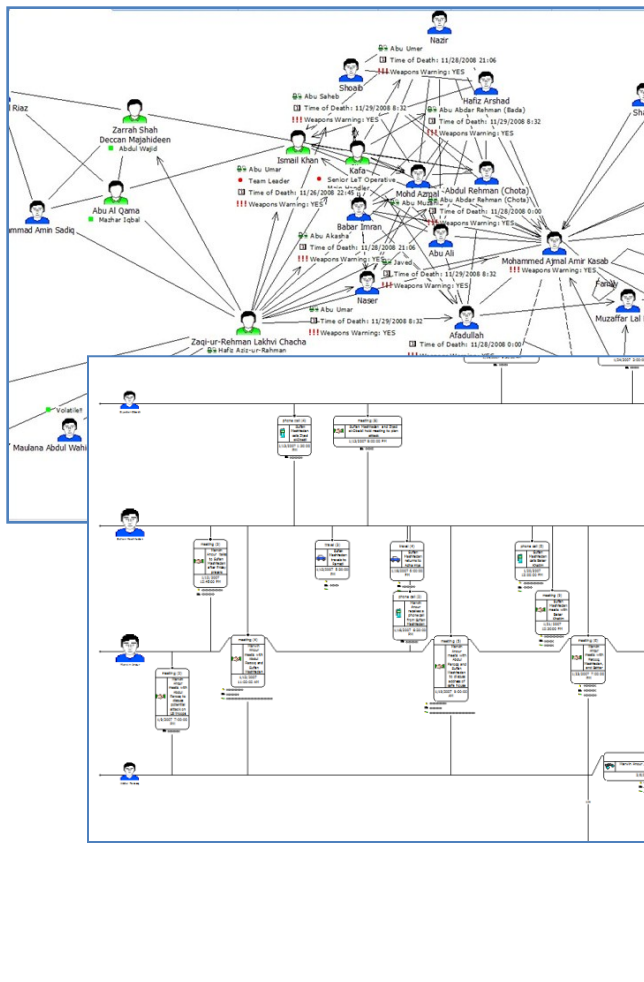




Establishing Ground Truth



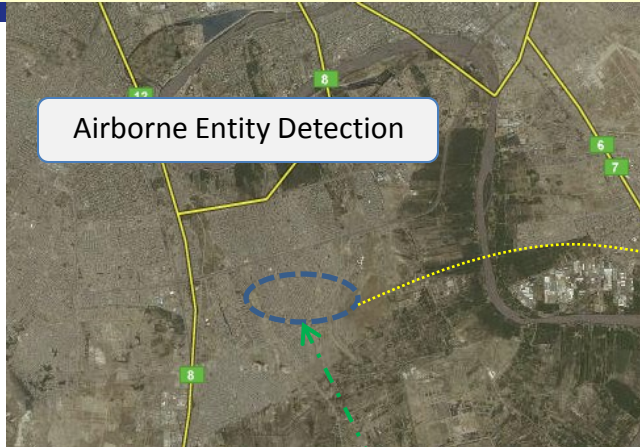
Ground truth data includes temporal and geospatial references, causal relationships, and ethno-religious and social network connections.



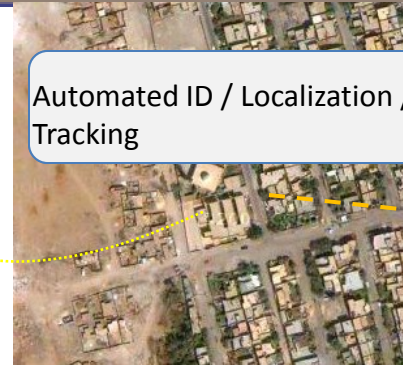
Date	Mug#	OrigNumber	OriginLocation	MGRSCoord	Originator	DestNumber	Destination	MGRSCoord	Recipient	Time Up	Time Down	Duration	Originator's Message
1/13/2007	305 (A.32)	795-312-8659	Adhmiyya		Unid. Male (Sufyan Maqshadi)	795-303-3861	Ramadi		Unid. Male (Diyaf al-Obeidi)	5:sec		3:sec	"My brother sends greetings"
1/15/2007	117 (B.8)	796-893-3981	Ramadi		Zyad al-Obeidi	792-154-5821	Adhmiyya		Unid. Male (Amer Mohi Ismael)	13:sec		10:sec	"Your friend in Doura may be a problem"
1/17/2007	131	794-825-5006	Zurbiyya		Unid. Male (Hussein Motach)	799-801-5644	Saydiyah		Adel	30:sec		30:sec	"Have Ali go to an internet cafe on Meebah St. near Baghdad"
1/22/2007	163	794-825-5006	Zurbiyya		Husein Motach	799-801-5644	Saydiyah		Adel	30:sec		30:sec	"Have Ali visit the museum"
2/1/2007	215	781-811-2233	Amin		Unid. Male (Ali Umar)	711-945-2178	Bayaa		Unid. Male (Amir Mahallati)	10:sec		10:sec	"Start buying carpets for the house like we discussed."
2/1/2007	221	715-545-2367	Bayaa		Unid. Male (Amir Mahallati)	743-860-4901	Saydiyah		Unid. Male (Kamran Khatlary)	13:sec		13:sec	"I will need new carpet for my house. I have a large family"
2/4/2007	232	743-860-4901	Saydiyah		Kamran Khatlary	743-860-5010	Ghartan		Unid. Male (Jalil Yaladi)	30:sec		30:sec	"Get carpeting for my friend. One large room."
2/4/2007	241 (B.15)	796-295-9104	Doura		Unid. Male (Murtad Agaj)	797-364-4601	Adhmiyya		Unid. Male (Mohammed Ali Hamid)	10:sec		10:sec	"That's his leg is much better and will be visiting him in the"
2/6/2007	251 (A.34)	796-303-3981	Ramadi		Zyad al-Obeidi	789-543-2523	Fallujah		Unid. Male (Yusef Sarhan)	5:sec		5:sec	"My brother sends greetings"
2/6/2007	257	743-860-4901	Ghartan		Jalil Yaladi	743-860-4901	Saydiyah		Kamran Khatlary	10:sec		10:sec	"Your friend will be pleased with his carpets."
2/6/2007	276 (B.21)	796-295-9104	Doura										
2/13/2007	300 (A.35)	789-543-3023	Adhmiyya		Shaher Aifar				Yemen	32	5' 8" 150 lbs.		X
2/21/2007	354	700-614-8055	Hila Road		Muhsay Ghayib				Yemen	27	5' 9" 160 lbs.		X
2/24/2007	355	707-811-2233	Amin		Talib Qub				Yemen	32	5' 9" 150 lbs.		X
2/25/2007	361	781-811-2233	Amin		Mustafa Kamal				Yemen	44	6' 1" 180 lbs.		X
2/26/2007	363	712-787-8532	Bayaa		Sulaiman Dayea				Yemen	46	5' 5" 155 lbs.		X
3/1/2007	IED	711-545-2176	Bayaa		Abdul Aleem				Yemen	38	6' 170 lbs.		X
3/6/2007	IED	711-545-2176	Bayaa		Abdul Jabbar				Yemen	41	5' 9" 155 lbs.		X
3/18/2007	IED	701-261-8011	Amin		Abed Abu Shakra				Yemen	28	6' 160 lbs.		X
3/21/2007	IED	781-723-5541	Yarmuk		Adham Kweili				Oman	28	5' 9" 150 lbs.		X
3/21/2007	IED	795-123-6659	Adhmiyya		Alaa Udeen				Oman	22	5' 10" 170 lbs.		X
3/22/2007	IED	767-811-2233	Amin		Ahmed Al Akram				Oman	21	6' 150 lbs.		X
3/22/2007	IED	796-303-3981	Ramadi		Ramess Al-Sabah				Egypt	23	5' 8" 160 lbs.		X
3/23/2007	IED	796-480-3875	East Rashid		Nagib Mandari				Egypt	26	5' 5" 130 lbs.		X
3/23/2007	IED	797-811-2233	Amin		Hosni Al Razi				Egypt	171	33°15'25.6334"N, 044°23'11.6801"E		Air Defense Center Assembly Site
3/24/2007	IED	793-121-5096	East Rashid		Sayed Mubarak				Egypt	172	33°15'25.6334"N, 044°23'11.6801"E		Bah al-Sharq
3/24/2007	IED	793-121-5096	East Rashid		Anwar Khan Imtiaz				Egypt	171	33°15'25.6334"N, 044°23'11.6801"E		Intersection of Mu'Alimeen Market in Doura's
3/24/2007	IED	793-121-5096	East Rashid		Tarik Al Amri				Egypt	174	33°15'25.6334"N, 044°23'11.6801"E		Assyrian Christian area of Dora
3/24/2007	IED	793-121-5096	East Rashid		Shay Khalizad				Egypt	176	33°15'25.6334"N, 044°23'11.6801"E		al-Khadim mosque
3/24/2007	IED	793-121-5096	East Rashid		Bashar Al-Khoree				Egypt	185	33°15'25.6334"N, 044°23'11.6801"E		al-Tsar
3/24/2007	IED	793-121-5096	East Rashid		Faris Farrakhan				Ma	192	33°15'25.6334"N, 044°23'11.6801"E		Doura Expressway in East Doura in Hila
3/24/2007	IED	793-121-5096	East Rashid		Sayed Trablousee				Ma	193	33°15'25.6334"N, 044°23'11.6801"E		Hila-Jadriya intersection
3/24/2007	IED	793-121-5096	East Rashid		Farooz Al Hassan				Ma	194	33°15'25.6334"N, 044°23'11.6801"E		St John the Baptist Children Church in Dora
3/24/2007	IED	793-121-5096	East Rashid		Farooq Ghazayli				Ma	198	33°15'25.6334"N, 044°23'11.6801"E		Christian neighborhood of Mu'Alimeen
3/24/2007	IED	793-121-5096	East Rashid		Haamza Al-Jabeer				Ma	202	33°15'25.6334"N, 044°23'11.6801"E		Safe House on Horajeh Road
3/24/2007	IED	793-121-5096	East Rashid		Haani Al-Jurr				Ma	203	33°15'25.6334"N, 044°23'11.6801"E		Rashid
3/24/2007	IED	793-121-5096	East Rashid		Bashar Al-Karachi				Ma	209	33°15'25.6334"N, 044°23'11.6801"E		Amin
3/24/2007	IED	793-121-5096	East Rashid		Michel Maro				Le	215	385 MB 4225 9475	33°23'25.8893"N, 044°23'11.6801"E	internet cafe on Ali Taleb Street
3/24/2007	IED	793-121-5096	East Rashid		Suleiman Shaifout				Le	217	385 MB 4225 9475	33°23'25.8893"N, 044°23'11.6801"E	Bayaa
3/24/2007	IED	793-121-5096	East Rashid						Le	222	385 MB 4225 9475	33°23'25.8893"N, 044°23'11.6801"E	al-Asaf Mosque in Adhmiyya
3/24/2007	IED	793-121-5096	East Rashid						Le	223	385 MB 4048 5741	33°15'07.4920"N, 044°21'53.8179"E	Shia Enclave in Baghdad
3/24/2007	IED	793-121-5096	East Rashid						Le	229	385 MB 4125 5455	33°23'19.0655"N, 044°23'05.5261"E	Tobagaji Square Cafe
3/24/2007	IED	793-121-5096	East Rashid						Le	232	385 MB 4125 5455	33°23'19.0655"N, 044°23'05.5261"E	Ghartan
2/4/2007	237 (B.14)	385 MB 4362 7988								33°15'25.1901"N, 044°23'40.9542"E		Doura Market	
2/4/2007	239	385 MB 4146 7793								33°14'13.9711"N, 044°22'17.8139"E		Hila Road and Dahreh Expressway	
2/5/2007	242 (B.15)	385 MB 48 79								33°14'49.927"N, 044°23'17.1507"E		Doura, Baghdad Iraq	
2/5/2007	244	385 MB 3849 8204								33°16'23.7711"N, 044°20'08.6216"E		al-Bayaa Mosque	
2/5/2007	245 (B.16)	385 MB 48 79								33°23'01.3542"N, 044°22'35.0828"E		Adhmiyya	
2/5/2007	248 (B.19)	385 MB 4314 7937								33°15'06.9028"N, 044°23'36.5697"E		Thafir Aga's Residence, House #5 60 Doura, Doura Iraq	
2/5/2007	248 (B.19)	385 MB 4551 7937								33°15'06.9096"N, 044°23'36.8174"E		Street 60 Doura Iraq	
2/6/2007	250 (B.20)	385 MB 4282 9483								33°23'29.3407"N, 044°23'07.6883"E		Antar Square Books Adamiya Iraq	
2/6/2007	252 (A.23)												House #23 on Dhubat Street
2/8/2007	265	385 MB 4031 8081								33°15'46.9782"N, 044°21'41.3953"E		Abandoned Railway Station	
2/10/2007	275	385 MB 4049 8129								33°16'03.1280"N, 044°21'36.5486"E		Hila Road and University Street Overpass	
2/10/2007	276 (B.21)	439 GM 07 41								33°22'44.3482"N, 077°06'44.9633"E		New Delhi, India	
2/10/2007	283 (A.29)												Qahtan Square
2/11/2007	292 (A.33)												Amiriya Market
2/12/2007	298 (A.33)												Amiriya Bomb Shelter
2/20/2007	318	385 MB 4049 8129								33°16'03.1280"N, 044°21'36.5486"E		Safe House in East Rashid	
2/20/2007	341 (B.19)	385 MB 2855 7999								33°15'23.6700"N, 044°13'58.8500"E		Bagdad International Airport	
2/20/2007	342 (B.40)	385 MB 4286 9474								33°23'24.7045"N, 044°23'08.4372"E		Forger's Shop Adhmiya Iraq	
2/22/2007	351 (B.42)	385 MB 42426 9435								33°23'13.1701"N, 044°23'06.5698"E		20th Street Bookstore Adamiya Iraq	
2/24/2007	350												Airport Road
2/24/2007	354												Hila Road
2/26/2007	363												Shurta
2/27/2007	364 (A.46)												Al Primary School in Bayaa
385 MB 42382 9469	33°23'24.1342"N, 044°23'49.7067"E												House #56 on Omran Bin Abdul Actz Street in Adhmiyya
385 MB 42471 9470	33°23'24.8231"N, 044°22'53.1466"E												Abandoned Building in Adhmiyya



Synthetic Fusion Processing



Airborne Entity Detection



Automated ID / Localization / Tracking

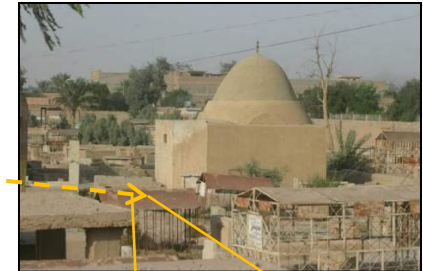


Image Annotation



Geospatial data mapping

Lat/Long 33.23895673330987 44.390881061553955

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

Text Extraction



ID	Name:	Sect:	Country of Origin	Age (Approx.)	Biometrics (Hgt/Wgt)	Fingerprint	Iris Scan	Known Physical Characteristics
1								
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-Bureidi	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-blac
9	Khalid				6'1" 160 lbs.	x		
10	Kaleel				5'9" 140 lbs.	x	x	
11	Osama				5'8" 150 lbs.	x	x	
12	Ahmed				5'10" 200 lbs	x	x	Completely bald
13	Moustafa Fanni	Sunni	Syria	21	5'11" 210 lbs.	x	x	
14	Faisal Kiblawi	Sunni	Syria	23	5'9" 160 lbs.	x		
15	Omar Silemi	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	Bashir 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-Soh	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 Alfay	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 pos
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 Koweili	Sunni	Oman	28	5'9" 150 lbs.	x	x	Known to favor galibea and not pants
31	Alaa Udoen	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

Database Mining

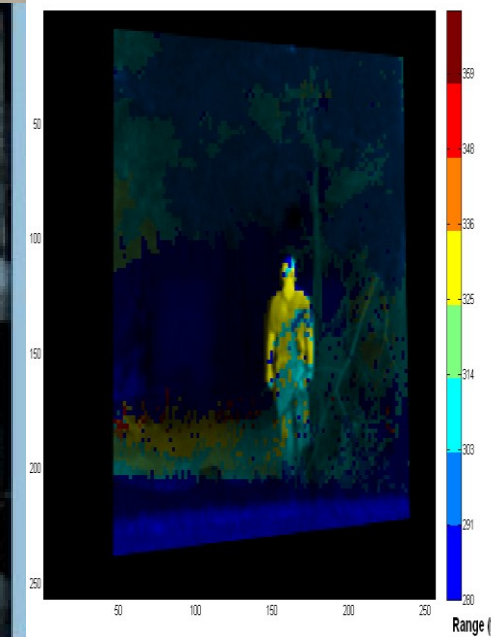
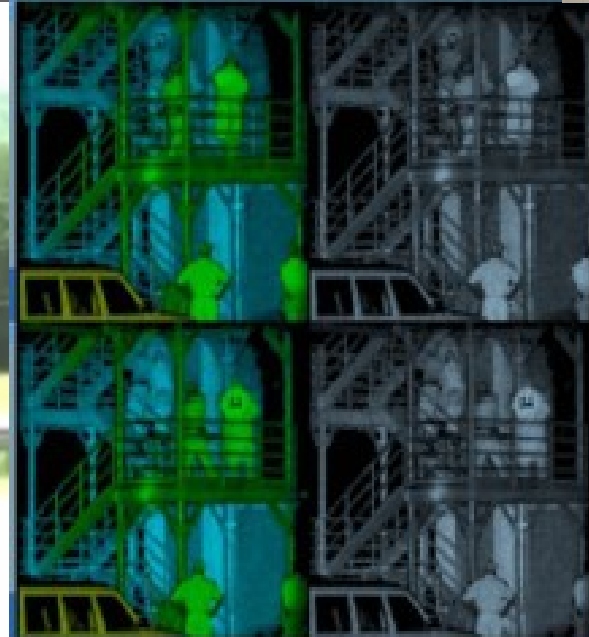


Summary of Data Shoots

Data Set	Collection Dates	Focus	Sensors
1	July 11 – 18, 2011	Urban environment <ul style="list-style-type: none">• Cars driving in urban environment• Arrival at destination/ passengers disengage• Covert action of small team• Crowd mingling• Explosive detonation, coordinated sniper fire, escape	<ul style="list-style-type: none">• LIDAR• VNIR• Video
2	Jan 9 – 11, 2012	Urban patrol environment <ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• LIDAR• VNIR HD gen-locked stereo camera pair
3	July 23-25, 2012	Urban setting: Multiple vignettes <ul style="list-style-type: none">• Scripted scenarios involving human, multiple vehicles, simulated crowd, IED events, arrest, jail transfer and breakout	<ul style="list-style-type: none">• LIDAR• VNIR 4 camera suite• VNIR HD gen-locked stereo



Off Campus Experiments





Example Sensor Exercise

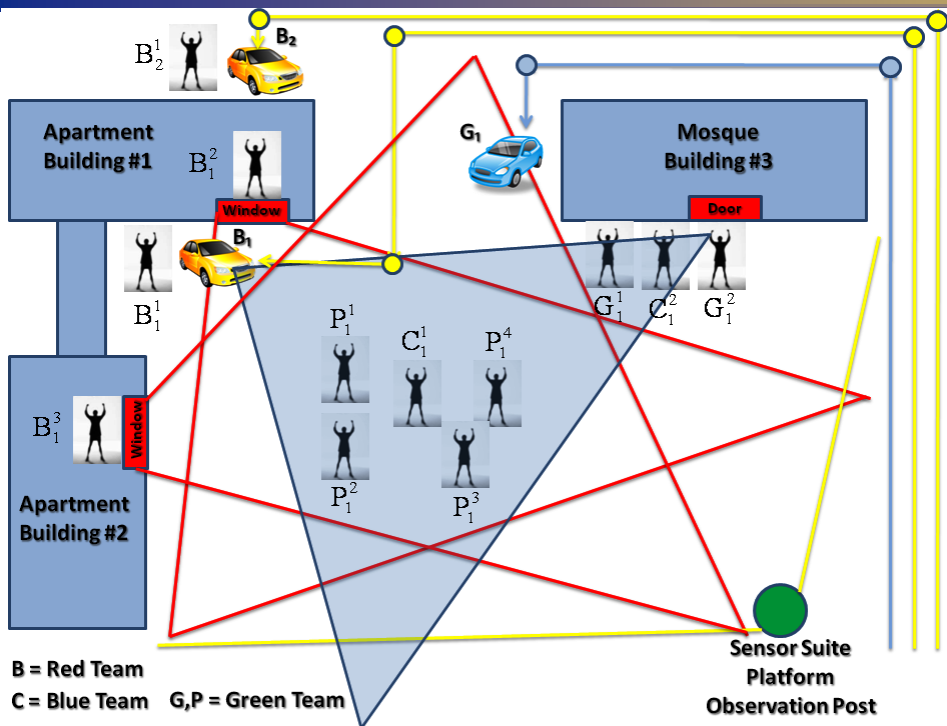
- Scenario/Theme: IED Attack / Coordinated Sniper Fire
- Participants: 21 (PSU+TSU)/ 3 vehicles
- Event Days: 3-5
- Sensors: 9+ Cameras, 1 Flash LIDAR, 2+ KINECT
- Mobile Devices: GeoSuite Mobile App on Android
- Event/Activity Synchronization: auditory/visual cues

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





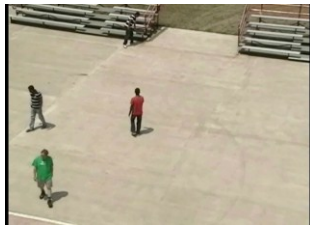
Hard Sensor Exercise Description





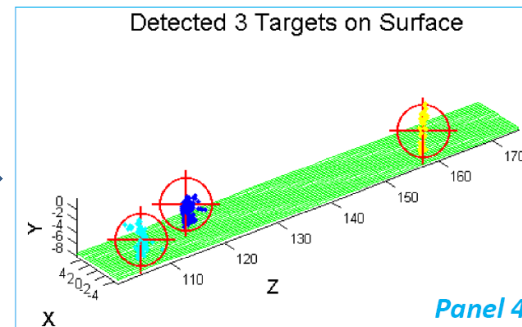
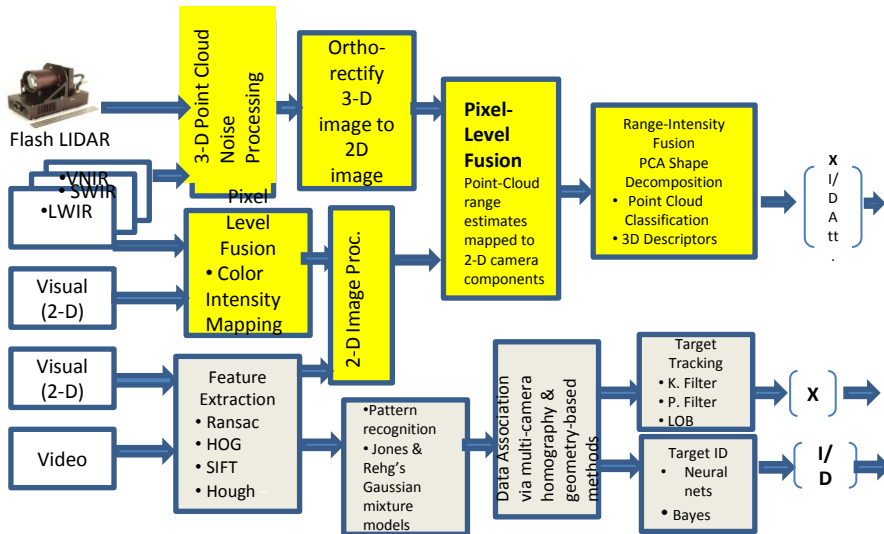
Notional idea of PSU Vignette

MICRO-VIGNETTE: Suspicious Person or Vehicle Motion (or IED or Sniper)



..... **HARD DATA:** Image sequence

FUNCTIONS: Person and/or Vehicle ID and Kinematic Tracking.



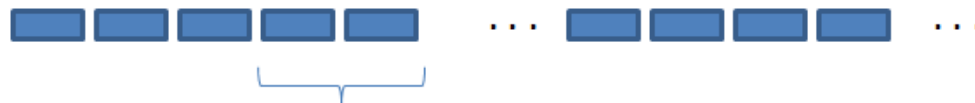
Panel 4

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



Hard/Soft Fusion Demonstration



Sunni subset of SYNCOIN data set
(approximately 100 messages over 4
month timespan)

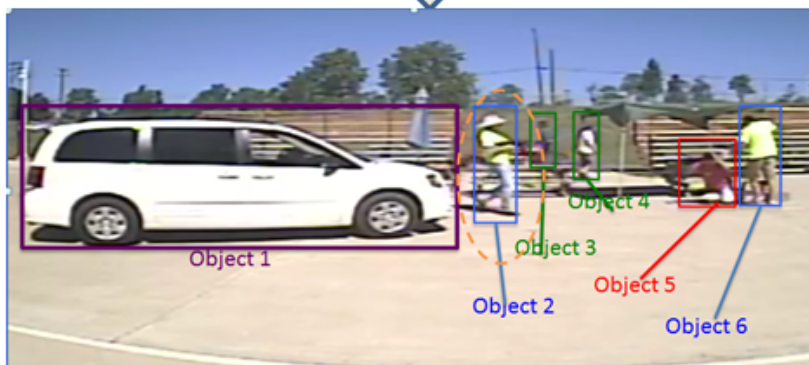


Selected mini-vignette involving approximately 10
messages & kidnapping, arrest & breakout activity



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.

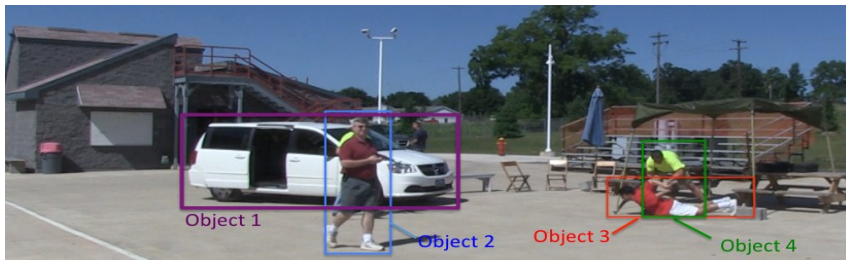


- Tractor extracted textual information
- Automated feature extraction/tracking from hard sensor processing
- TML encoded hard sensor feature data



“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



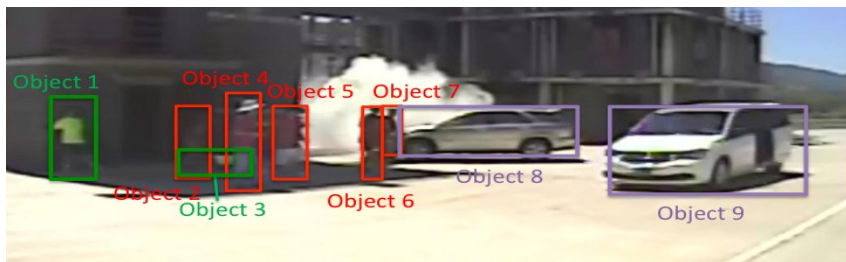
In frame two; our weapons trafficker has been turned over to the local Iraqi police.

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.

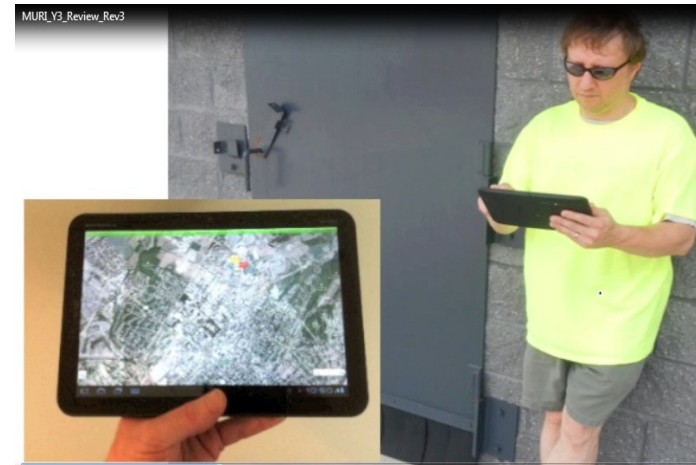


Demonstrations



Video Demonstration

- Data Collection at Pleasant Gap Facility
- Network and Infrastructure Software Developments
- Analyst Interaction with Data and Supporting Analysis Tools





Option Year Plans

Situation Assessment: PSU



PENNSYLVANIA STATE UNIVERSITY



- **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



Reference Materials



PENNSTATE



- 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
 - Initiated 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



Year-3 Publication list

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.



Year-3 Publication list: Continued

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



Year-3 Publication list: Continued



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



SYCOIN Ground Truth and Supporting Documentation



- 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 [12] and
- Word Cloud diagrams (based on *Wordle*) for each SYNCOIN thread [11].