U.S. Army Research, Development and Engineering Command

A Visual Analytic for Improving Human Terrain Understanding

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Dr. Timothy P. Hanratty, Mr. Eric Heilman, Mr. John Richardson, Mr. Mark Mittrick

18th ICCRTS 19 June 2013

Outline

- Background
- HDPT System Overview
- Scenario for Field Study
- Field Study Method and Results
- Conclusion

Background: Developmental Reasoning

Military decision-making difficulties arise from time critical analysis

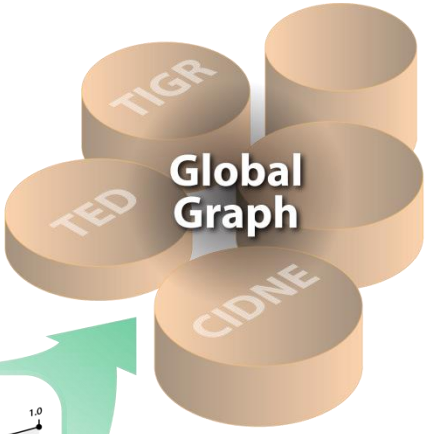
- Of data that
  - Has increased in Amount and types collected
  - Has become inconsistent and incomplete

The Tactical Information and Data Fusion Branch has developed a computerized Tool to

- Assist the military user in quickly analyzing large, inconsistent data sets
- Developed to utilize existing data frameworks

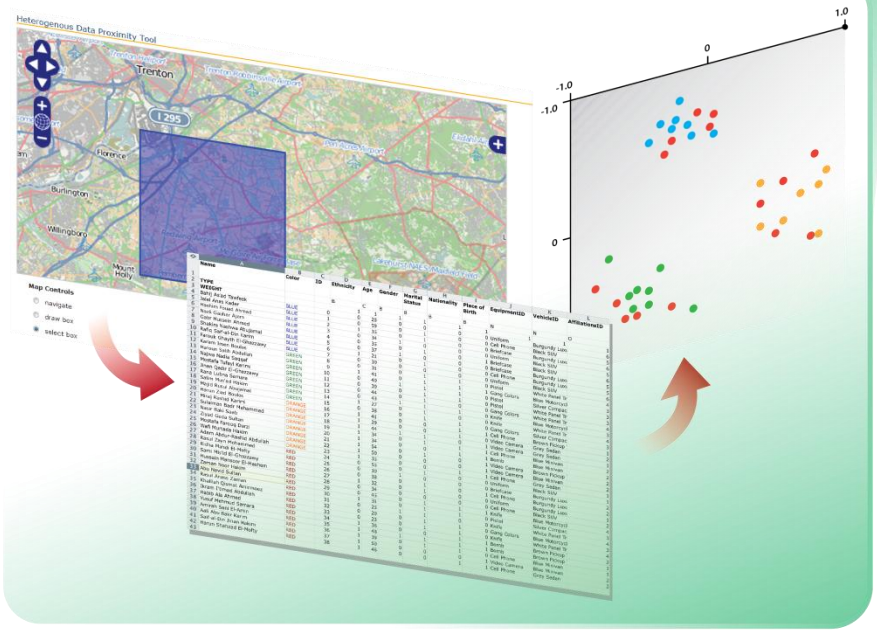
Background: A Solution

The Heterogeneous Data Proximity Tool (HDPT) Uses Multi-Dimensional Scaling (MDS) to reduce high-dimensional data spaces, such human terrain Data, into a human-readable visual analytic



Key Features:

- Tolerant of inconsistent data
- 3D Similarity Display
- Interfaced with DCGS-A OWF
- Mobile Input Device



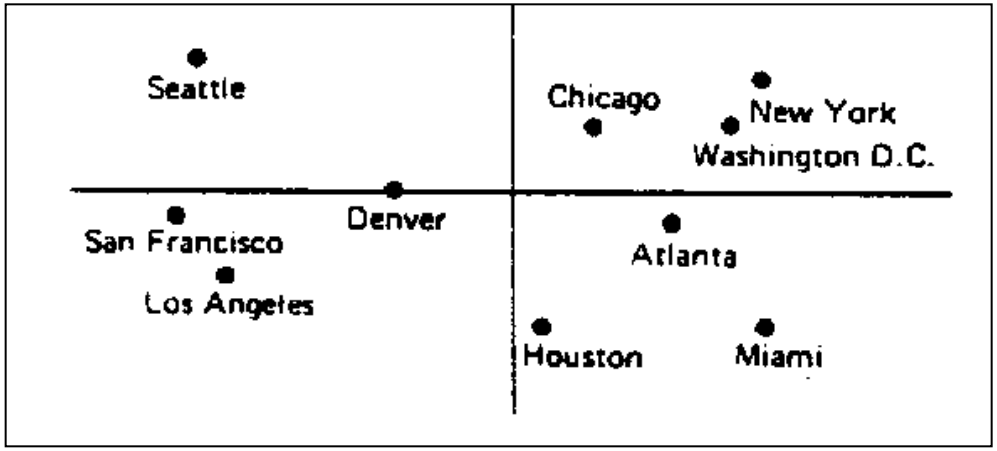
HDPT Algorithms: Multi-Dimensional Scaling

Multidimensional scaling (MDS) is a data analysis approach used to visually interrogate the similarity or dissimilarity between the pair-wise "distances" among a given set of objects.

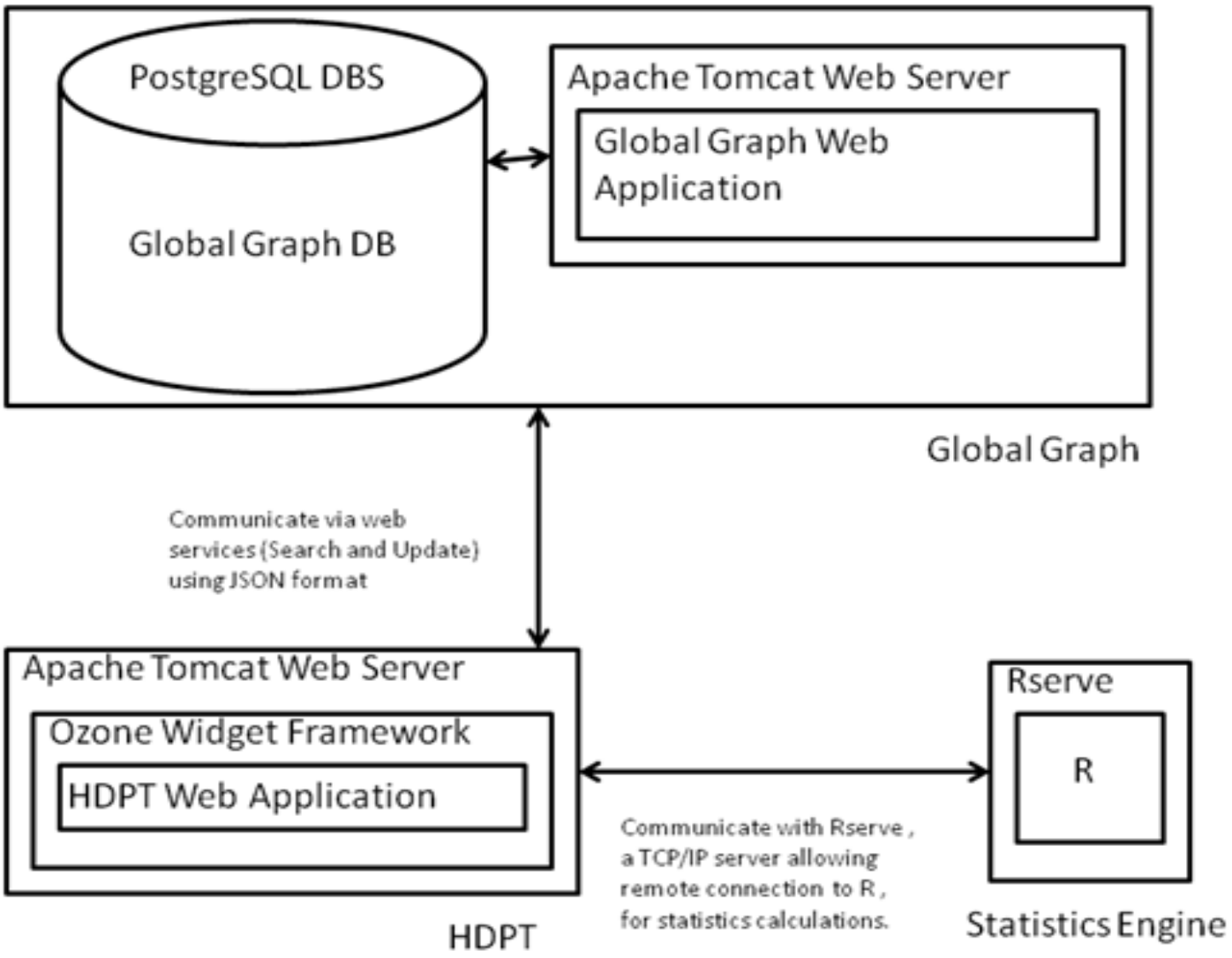
Atlanta	Chicago	Denver	Houston	Los Angeles	Miami	New York	San Francisco	Seattle	Washington, DC	
0	587	1212	701	1936	604	748	2139	2182	543	Atlanta
587	0	920	940	1745	1188	713	1858	1737	597	Chicago
1212	920	0	879	831	1726	1631	949	1021	1494	Denver
701	940	879	0	1374	968	1420	1645	1891	1220	Houston
1936	1745	831	1374	0	2339	2451	347	959	2300	Los Angeles
604	1188	1726	968	2339	0	1092	2594	2734	923	Miami
748	713	1631	1420	2451	1092	0	2571	2408	205	New York
2139	1858	949	1645	347	2594	2571	0	678	2442	San Francisco
2182	1737	1021	1891	959	2734	2408	678	0	2329	Seattle
543	597	1494	1220	2300	923	205	2442	2329	0	Washington, DC

This example from Forrest Young's *Understanding Multidimensional Scaling* uses the mileage between 10 American cities, shown in the table, as the objective similarity measure.

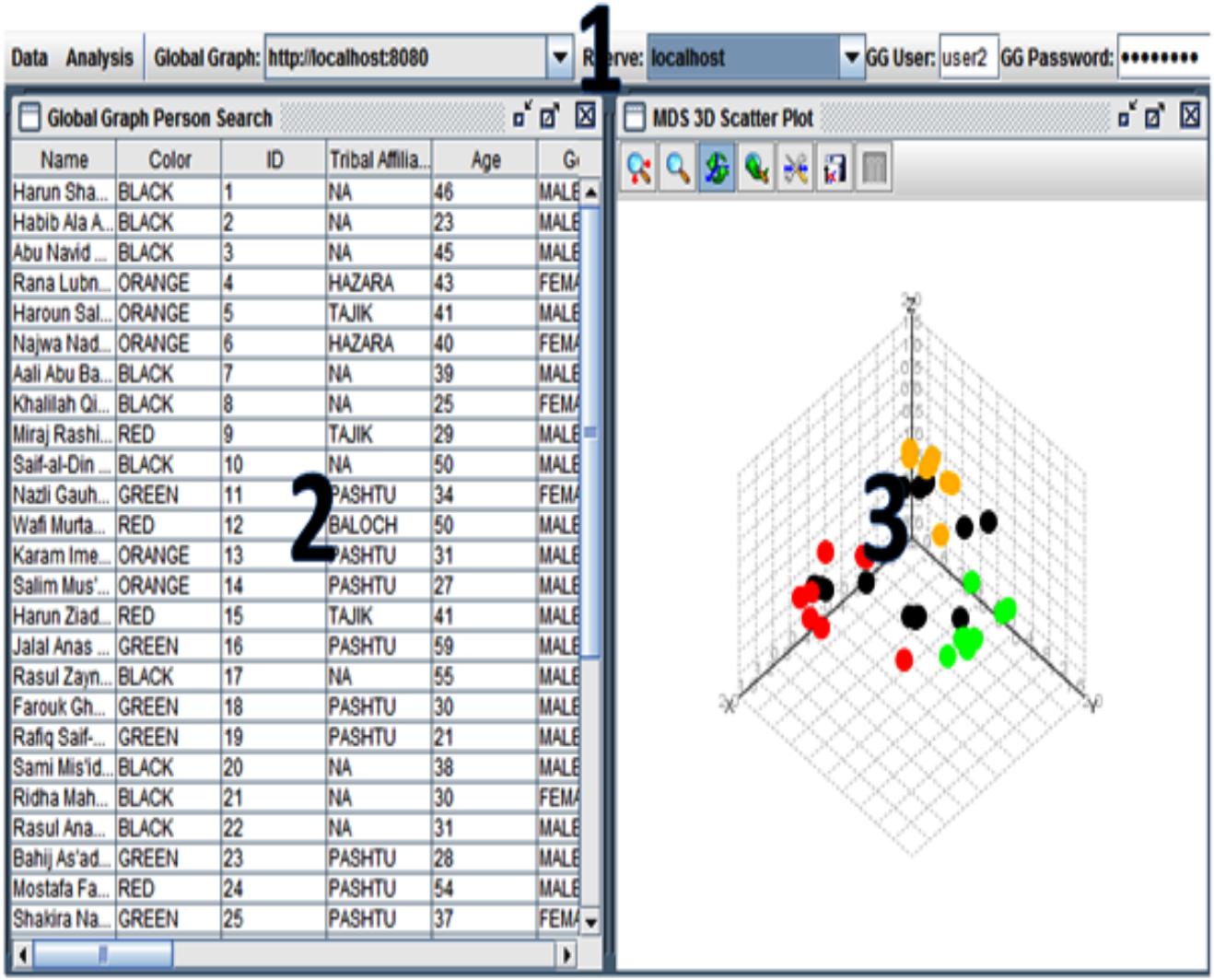
The associated MDS 2-D visualization output would appear something like that found in figure 1. Note: the geometric model allows one to discern the underlying structure and allow human interpretation.



HDPT Component Overview



HDPT Visual Tour



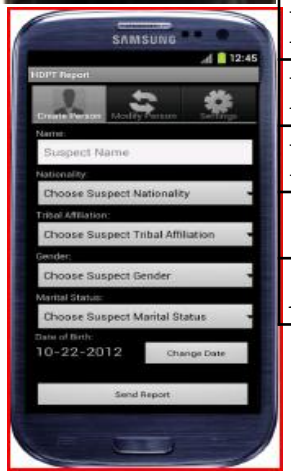
Name	Color	ID	Tribal Affilia...	Age	G
Harun Sha...	BLACK	1	NA	46	MALE
Habib Ala A...	BLACK	2	NA	23	MALE
Abu Navid ...	BLACK	3	NA	45	MALE
Rana Lubn...	ORANGE	4	HAZARA	43	FEMA
Haroun Sal...	ORANGE	5	TAJIK	41	MALE
Najwa Nad...	ORANGE	6	HAZARA	40	FEMA
Aali Abu Ba...	BLACK	7	NA	39	MALE
Khalilah Qi...	BLACK	8	NA	25	FEMA
Miraj Rashi...	RED	9	TAJIK	29	MALE
Saif-al-Din ...	BLACK	10	NA	50	MALE
Nazli Gauh...	GREEN	11	PASHTU	34	FEMA
Wafi Murta...	RED	12	BALOCH	50	MALE
Karam Ime...	ORANGE	13	PASHTU	31	MALE
Salim Mus'...	ORANGE	14	PASHTU	27	MALE
Harun Ziad...	RED	15	TAJIK	41	MALE
Jalal Anas ...	GREEN	16	PASHTU	59	MALE
Rasul Zayn...	BLACK	17	NA	55	MALE
Farouk Gh...	GREEN	18	PASHTU	30	MALE
Rafiq Saif-...	GREEN	19	PASHTU	21	MALE
Sami Mis'id...	BLACK	20	NA	38	MALE
Ridha Mah...	BLACK	21	NA	30	FEMA
Rasul Ana...	BLACK	22	NA	31	MALE
Bahij As'ad...	GREEN	23	PASHTU	28	MALE
Mostafa Fa...	RED	24	PASHTU	54	MALE
Shakira Na...	GREEN	25	PASHTU	37	FEMA

1. **Menu Bar –** Computer communications preferences, data search, and plot controls
2. **Search Window –** Modifiable table of entity attributes
3. **Plot Window –** Rotatable 3D similarity visual analytic

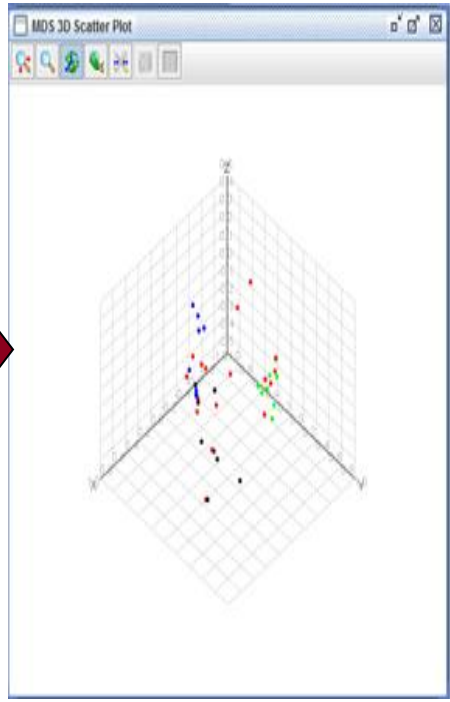
HDPT
C4ISR OTM CONOP

Data describing and individual was collected during morning and afternoon exercise events …

Tribal Affiliation
Marital Status
Nationality
Place of Birth
EquipmentID
VehicleID
Criminal Record
Education Level
Employment Type
Military Record
Religion
Skill
AddressID



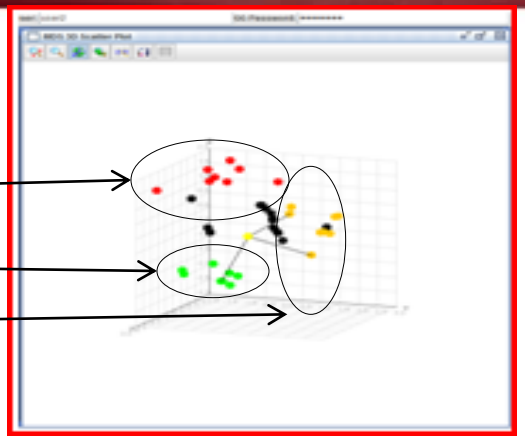
And sent to the TOC / DGCS-A Using a mobile device …



Where it was displayed by HDPT for analysis.

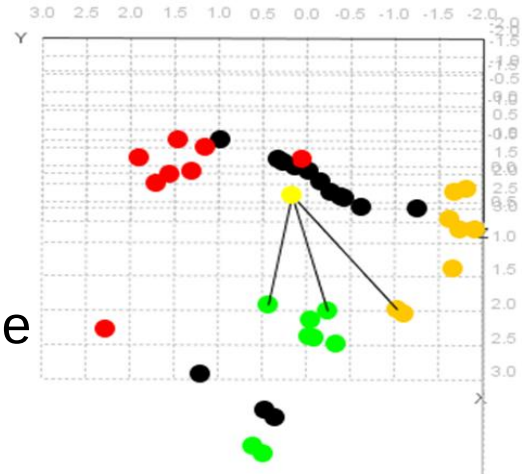
HDPT
C4ISR OTM Scenario

- Each entity is a node in the analytic
- Three reference sets of entities for HDPT:
  - Red or Insurgent
  - Green or Friendly
  - Orange or Criminal
- The black nodes are unknown entities

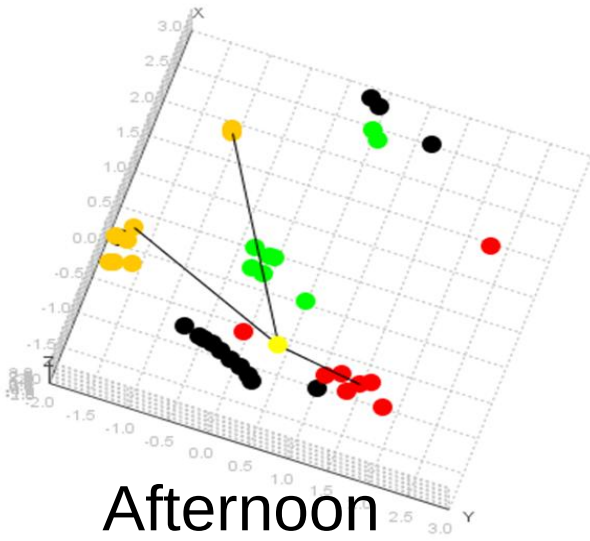


- Each entity had attributes as shown
- Unknown entity data was discovered during the exercise
- As attributes were discovered, unknown entities became similar to reference nodes
- Entities could change reference group similarity throughout the exercise day
  - Changing reference example

Name	SubID	Location	Org	Age	Gen	TA	MS	Nat	POB	Equip	VehicleID	CR	Ed	Emp	MR	Rel	Sk	Add
Bahij As'ad Tawfeek		39.98 / -74.43	Friendly	28	M	Pastun	M	HN	BIA	Uniform	Burgundy Luxury Sedan	No	High	WC	SS	Mld	ME	TSV

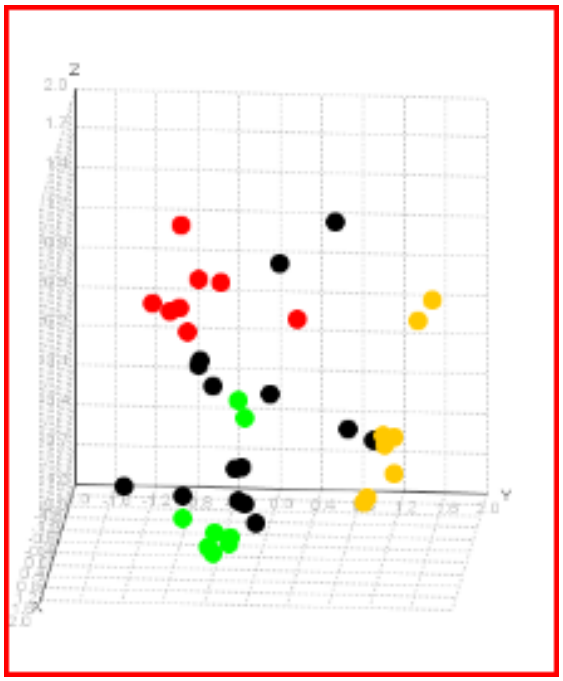


Morning



Afternoon

HDPT Study



Exercise Morning Analytic

Group Key	
C	Criminal
F	Friendly
I	Insurgent
U	Unknown

Strength Rating
1 - 5

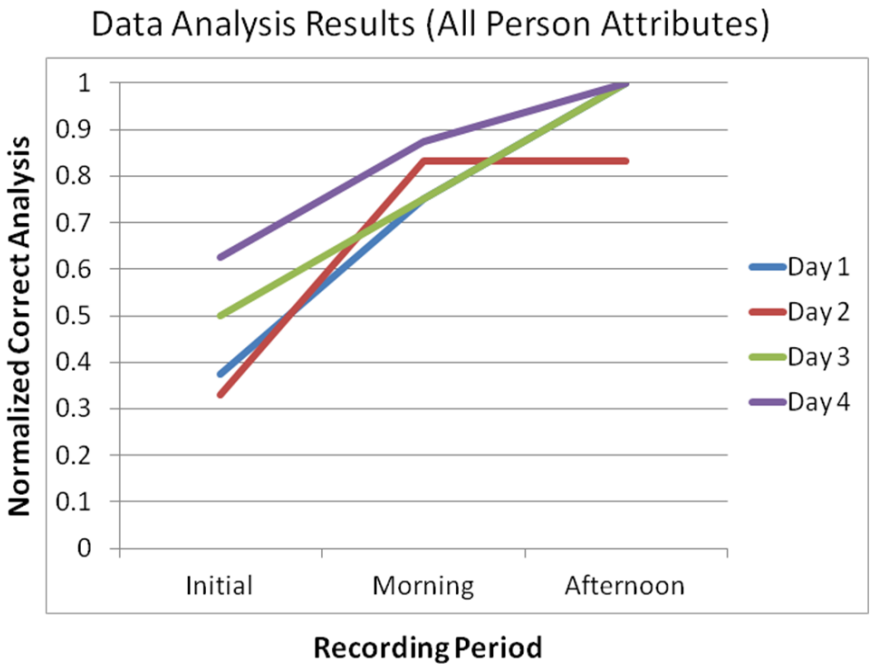
Aali Abu Bakr Karim (S13)	C4
Abu Navid Sultan (S1)	C1
Amirah Sani El-Amin (S12)	U5
Habib Ala Ahmed (S5)	F3
Harun Shahzad El-Mofty (S15)	U5
Hussain Mansoor El-Hashem (S9)	U5
Ikram I'timad Abdullah (S4)	F3
Khalilah Qismat Amirmoez (S3)	U3
Rasul Anass Zaman (S2)	U5
Rasul Zayn Mohammed (S6)	U3
Ridha Mahdi El-Mofty (S7)	F2
Saif-al-Din Jinan Hakim (S14)	I3
Sami Mis'id El-Ghazzawy (S8)	C3
Yusuf Mehmud Samara (S11)	U1
Zaman Noor Hakim (S10)	U5

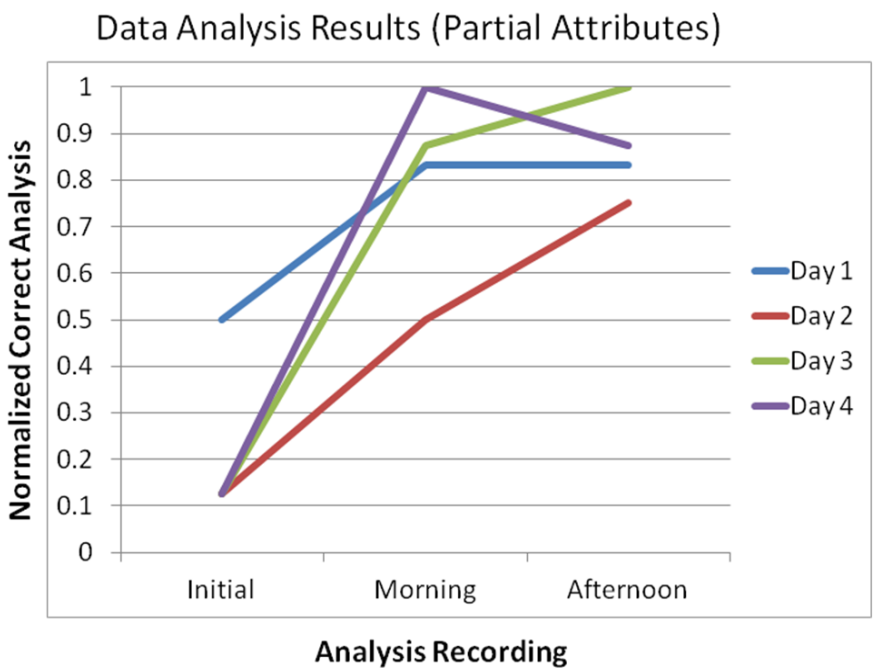
From analytics such as that above Soldiers were asked to identify the most likely reference group membership for each unknown entity node

Soldiers rated entity membership using a letter identifying each reference group or a “U” for undetermined and a Likert scale to describe their confidence in the determination

Completed rating sheets were compared to ground truth entity membership to determine HDPT analysis utility

HDPT Study Results





- Soldier ratings were gathered over 4 exercise days
  - Initialized nodes • Morning event nodes • Afternoon event nodes
- More attributes were discovered as the exercise day progressed
- Ground truth for unknown nodes was strictly enforced
  - The entire set of attributes was found for some entities (left graph)
  - A partial set of attributes was found for some entities (Right graph)

Soldiers determined correct group affiliation at 93% accuracy.

Conclusion

- HDPT provides a potentially valuable data analysis advantage
  - Soldiers gave high ratings for tactical usefulness and usability
- HDPT provides easy-to-use analytic capabilities for Soldiers untrained in intelligence analysis
- Results support further development and experimentation
  - Plans to return to 2013 C4ISR OTM field exercise with expanded capabilities