MEASURING THE IMPACT OF RADAR SUPPORT OPTIONS ON AIR TRAFFIC CONTROL SITUATIONAL AWARENESS

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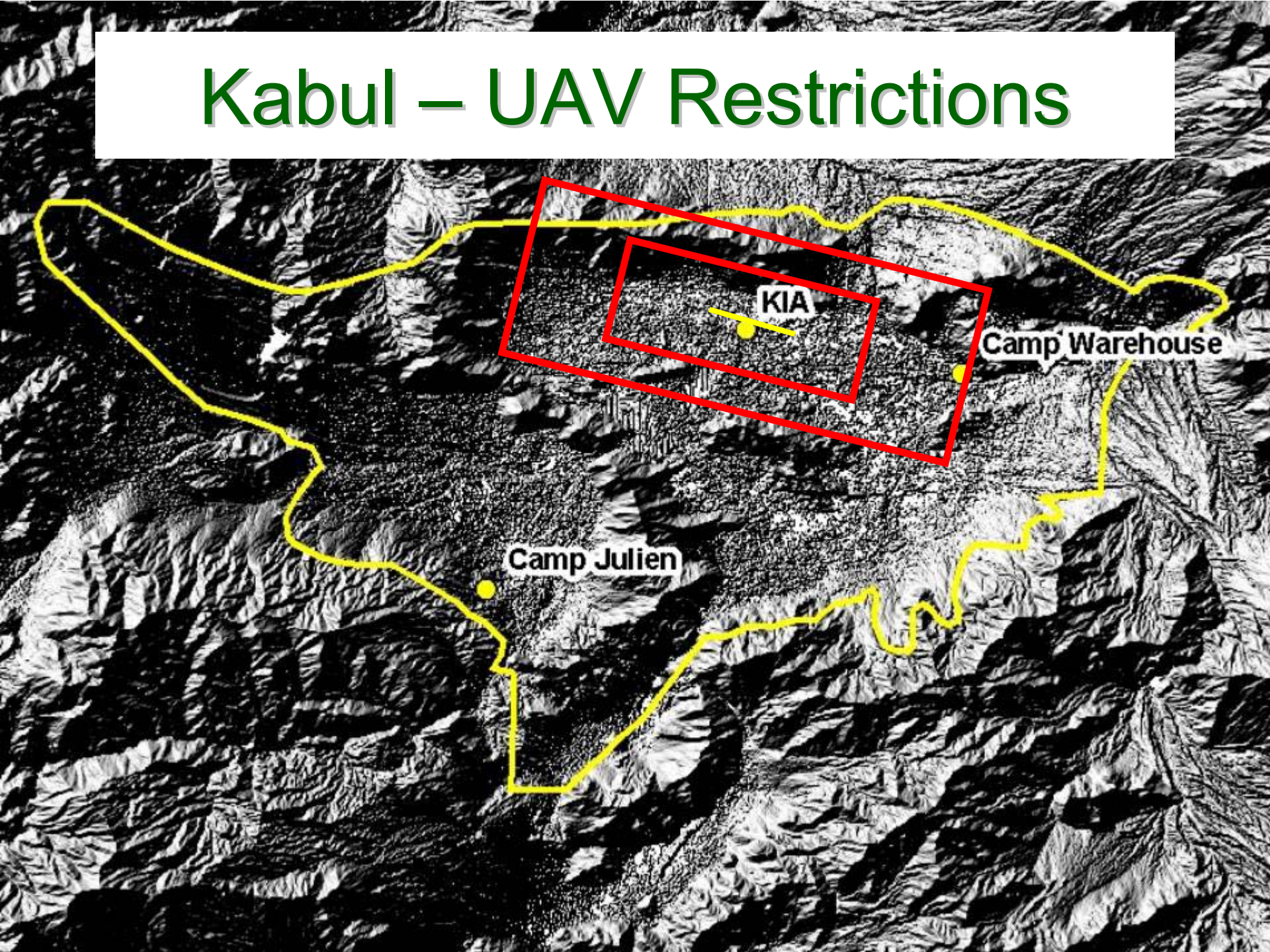
LOE 0301Aim and Objectives

- Aim: To assist in the evaluation of increases in airspace situational awareness for the range of options under consideration for Op Athena
- Objectives
  - Primary: To identify any differences in situational awareness enabled by the implementation of a particular radar support option
  - Secondary: To provide insights into the Concept of Operations (COO) and tactics, techniques, and procedures (TTPs) for the Tactical Unmanned Air Vehicles (TUAV) and Air Traffic Control/Air Defence radars in theatre

Kabul – UAV Restrictions



Ground radar Coverage of aircraft flying at 450m AGL

KIA Only

AOR Visibility:
87.6%

Warehouse and Julien

AOR Visibility:
98.1 %

KIA and Julien

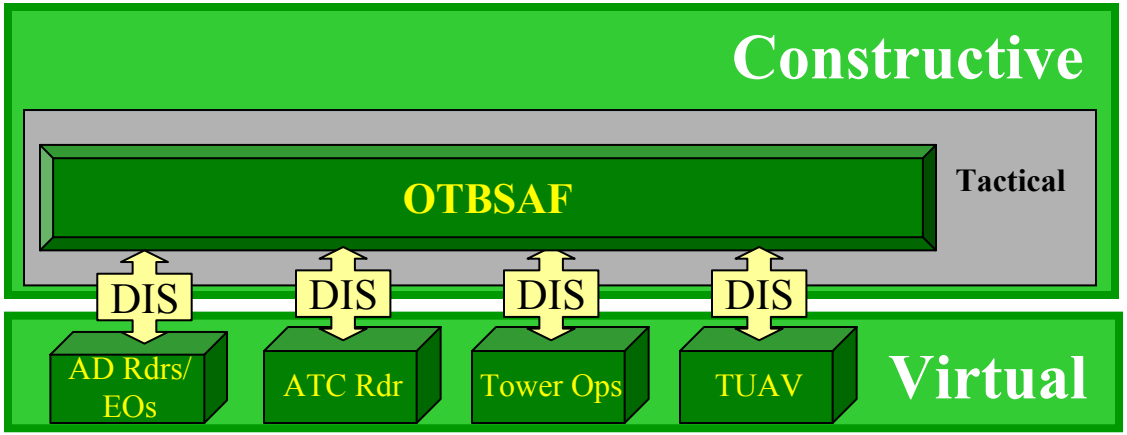
AOR Visibility:
99.5 %

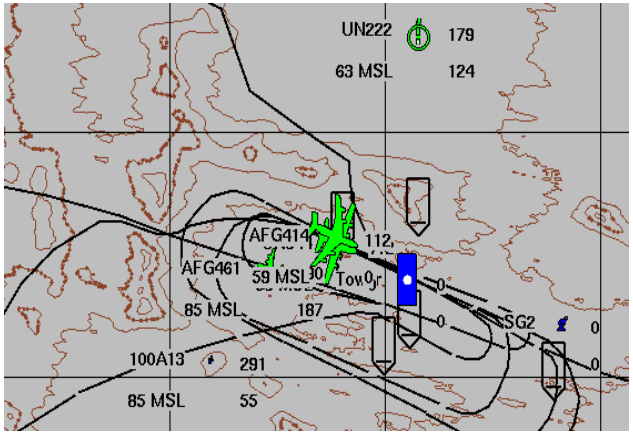
Radar Support Options

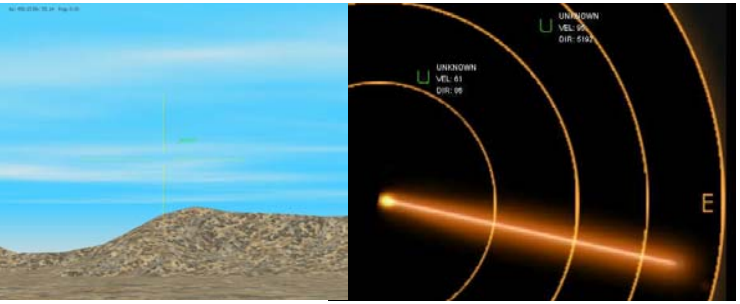
1. No Radar support
2. ADATS Air Defence radars at Camps Julien & Warehouse
3. Skyguard (SG) Fire Control Units at Julien and Warehouse

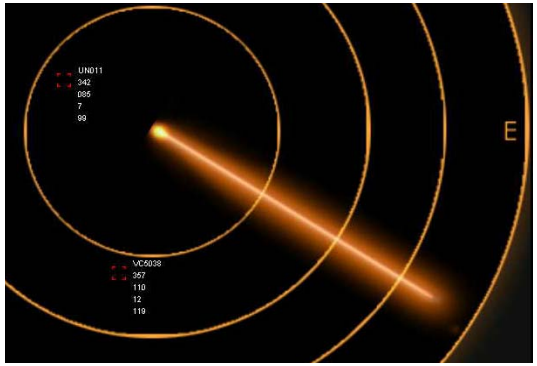
- QUAD ATC radar at KIA
- MPN25 ATC radar at KIA with tower display
- Mix of QUAD at KIA & SG at Camp Julien

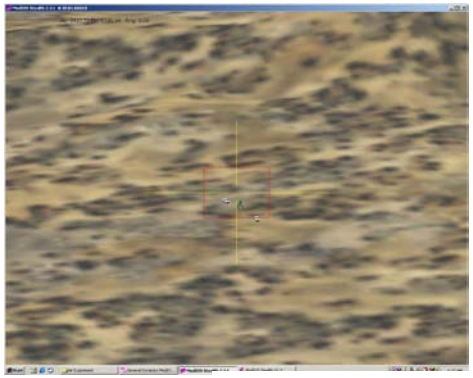
LOE 0301 Synthetic Environment



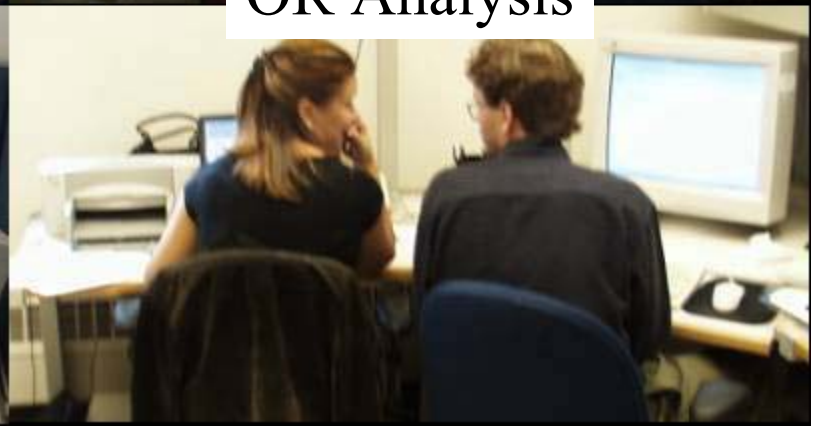








Participants



Experiment Schedule

	Mon 22	Tue 23	Wed 24	Thu 25	Friday 26
0800	Intro	Simulation	Quad/SG 2	SG 3	Excursions
0900	Briefing	Setup	MPN 2	Baseline 3	- Map
1000	Individual	and Final	Quad 2	SG 4	- Map/RSD
1100	Training	Confirmation	Baseline 2	ADATS 4	- ADSI
Lunch					
1300	Practice	Baseline 1	SG 2	Baseline 4	Judgements
1400	Session 1	Quad 1	ADATS 2	MPN 4	& Insights
1500	Practice	MPN 1	Quad/SG 3	Quad 4	Report
1600	Session 2	Quad/SG 1	Quad 3	Quad/SG 4	Writing
Supper					
1800	Practice	ADATS 1	MPN 3		
1900	Session 3	SG 1	ADATS 3		

Situational Awareness

Three levels of SA:

1. perception of the elements in the environment within a volume of time and space,
2. the comprehension of their meaning, and
3. the projection of their status in the near future

Endsley, M. R. (1987). SAGAT: A methodology for the measurement of situation awareness (NOR DOC 87-83). Hawthorne, CA: Northrop Corporation

SAGAT

Situation Awareness Global Assessment Technique

- Stop the simulation without warning
- Query ATCO for information from memory about situation (5 minutes to enter)
- Resume & repeat at random

SAGAT Data Scoring

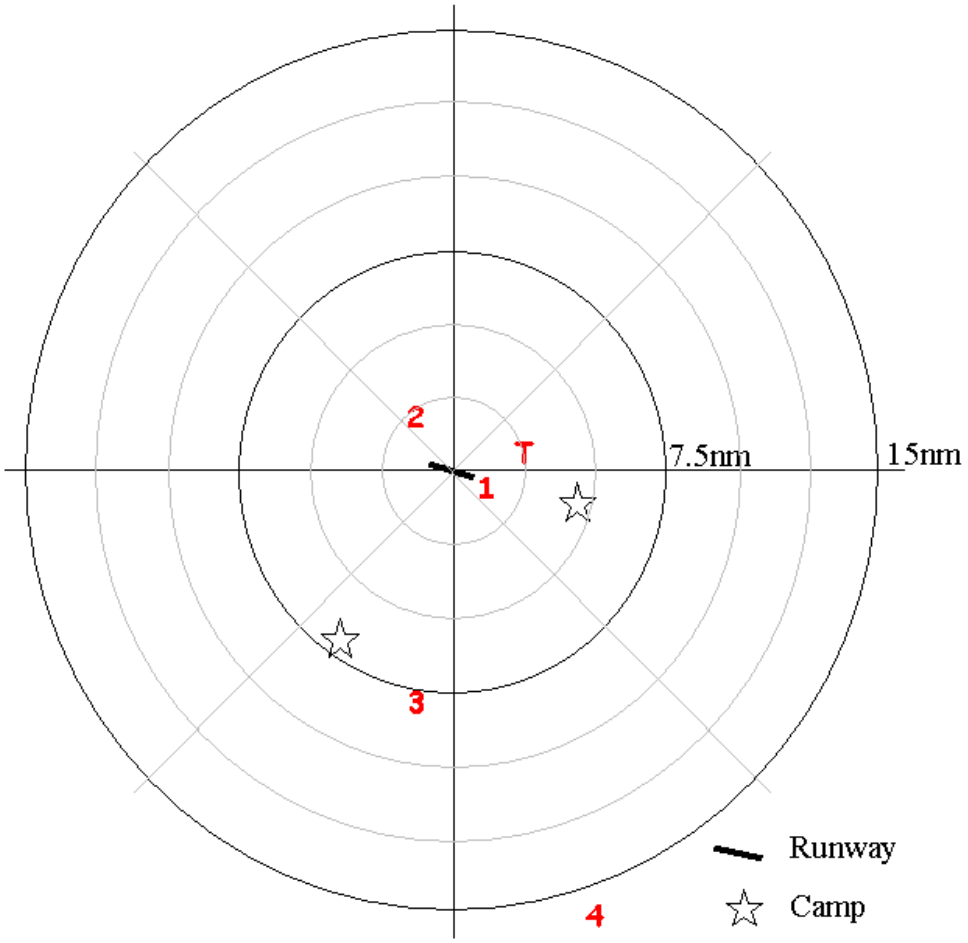
Score ->	5	4	3	2	1	0
Position Error	0 - 5 km	5-10 km	10-15 km	15-20 km	20-25 km	> 25 km
Altitude	0-150m	150-300m	300-450m	450-600m	600-900m	>900m
Type	Same	Large vs Small	Commercial vs Private	Cargo vs Other	Mil vs Civ	Air vs Ground
Speed Error	0-5 kts	5-10 kts	10-15 kts	15-20 kts	20-25 kts	> 25 kts
Heading Error	0-15 deg	15-30 deg	30-45 deg	45-60 deg	60-90 deg	> 90 deg
Altitude Change	Same		Level vs Climb/Descend		Climb vs Descend	
Heading Change	Same		Straight vs Right/Left		Right vs Left	
Activity	Same		Inbound vs Outbound	Local vs In/Out	EnRoute when not	Not when EnRoute
Emergency	Same				Yes when No	No when Yes

SAGAT Data Capture Methodology

Aircraft	Callsign	Type	Altitude	Speed	Heading	Alt Change	Head Change	Activity	Emergency
T	UAV	TUAV	8000	50		L	S	L	N
1	AVG132	DC-3	6200	150	290	D	S	I	N
2	LUF012	C-130	8000	300		C	R	O	N
3	UN013	Bell 412	7000	90		L	L	L	N
4	UN215	Cessna	7000	150		L	L	L	Y
5									
6									
7									
8									
9									

From closest to furthest approach, rank the aircraft that are or will be closest to the TUAV:

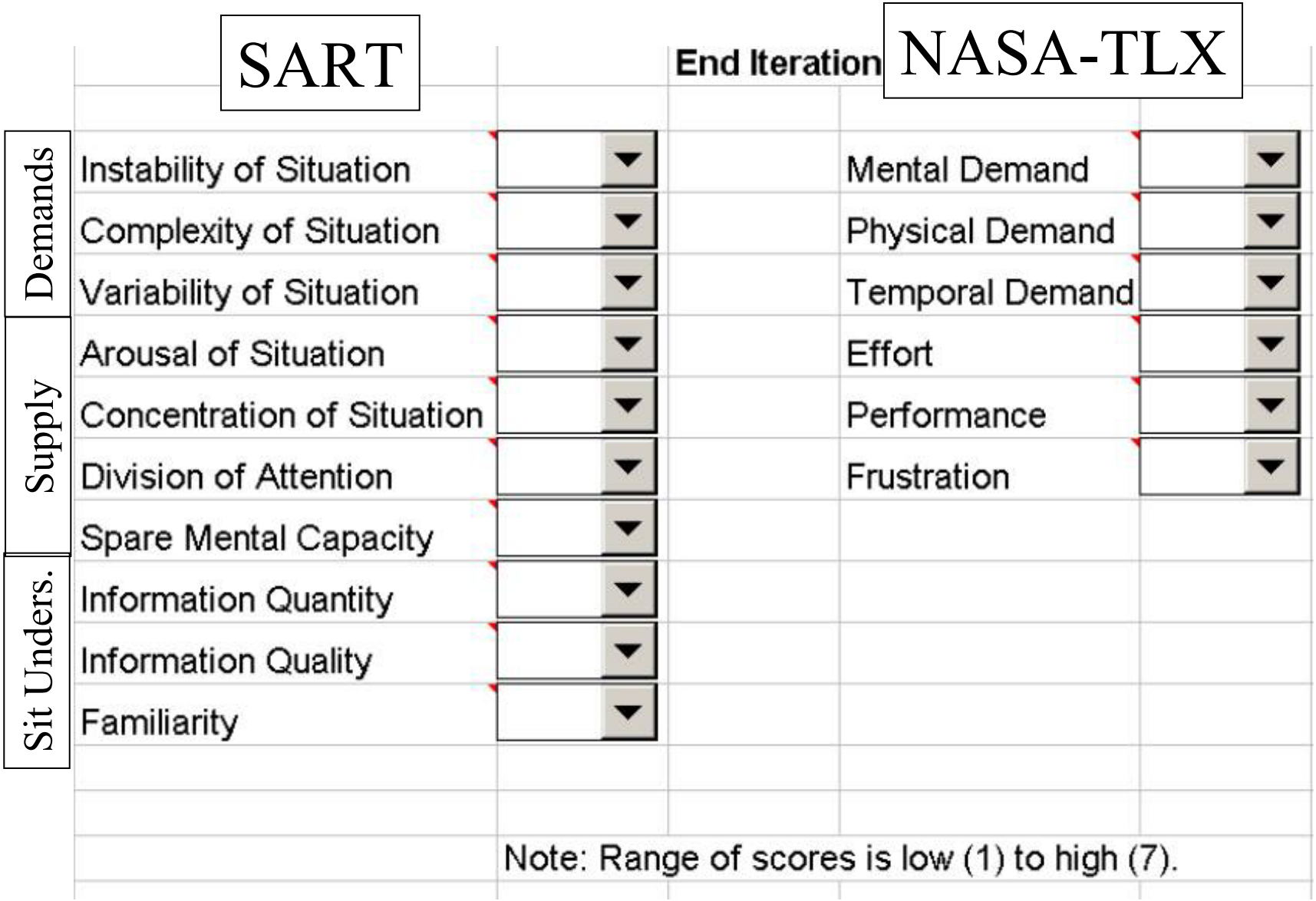
a. currently	1	2	3
b. in the next 2 min	3	2	4
c. in the next 5 min	3	2	4



Determining Weights

more important than ->	Altitude	Callsign	Heading	Location	Speed	Alt Change	Hdg Change	Activity	Emergency
Type									
Altitude									
Callsign									
Heading									
Location									
Speed									
Alt Change									
Hdg Change									
Activity									
Emergency									

Subjective Data Capture



Statistical Technique

- 4 runs with 3 SA scores per option
  - 12 raw score values -> not Normally distributed
  - Can't use t-test Parametric Methods
  - Instead => Mann-Whitney U-test

- Basic Premise of Mann-Whitney
  - "Rank Sums" are normally distributed
  - U statistic = Max(Rank Sum) – Obs(Rank Sum)

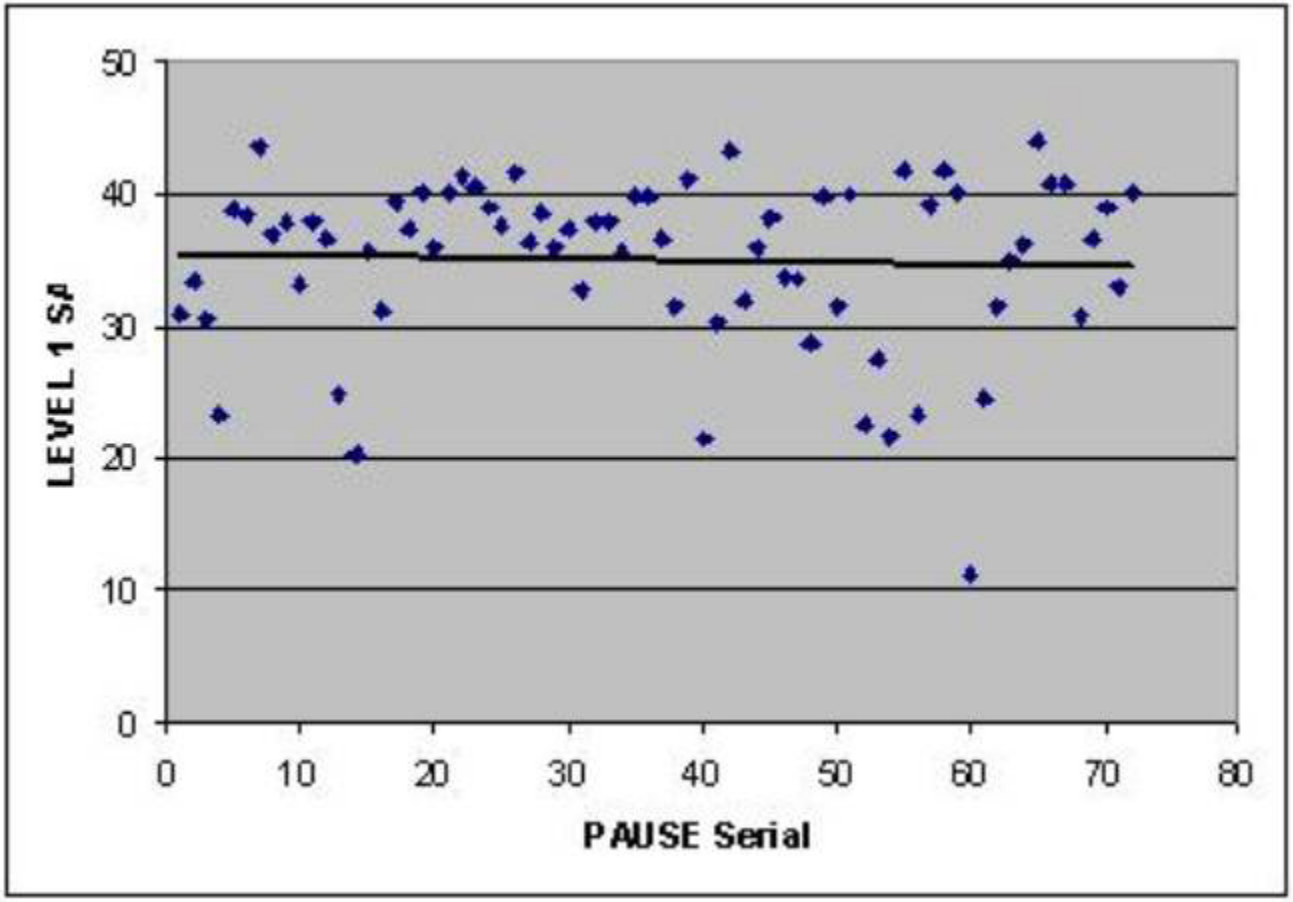
Example: Steps in Mann-Whitney test

Baseline	rank	Quad SG	rank
22.104	2	19.144	1
22.457	3	23.865	5
23.475	4	30.886	9.5
27.229	6	32.015	11
30.240	7	34.950	13
30.379	8	35.535	15
30.886	9.5	36.263	16
34.050	12	37.444	19
34.988	14	38.104	20
36.390	17	39.511	22
36.994	18	40.825	23
38.356	21	41.010	24
Count =	12		12
Sum =	121.5		178.5
Mu =	150		150
Sigma =	17.321		17.32
z =	-1.617	(P=94.7%)	1.617

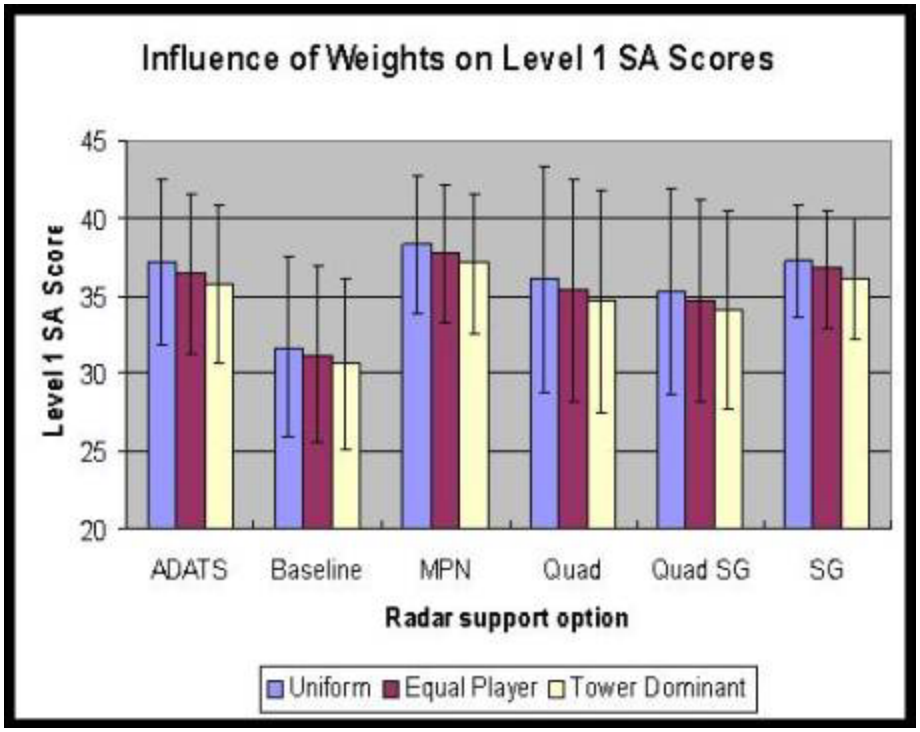
1st rank sum Mean
Mu=(1+n1+n2)/2*n1

$$z = \frac{\text{Sum} - \text{Mu} \pm .5}{\text{Sigma}}$$

Learning Curve/Maturation



SAGAT Results

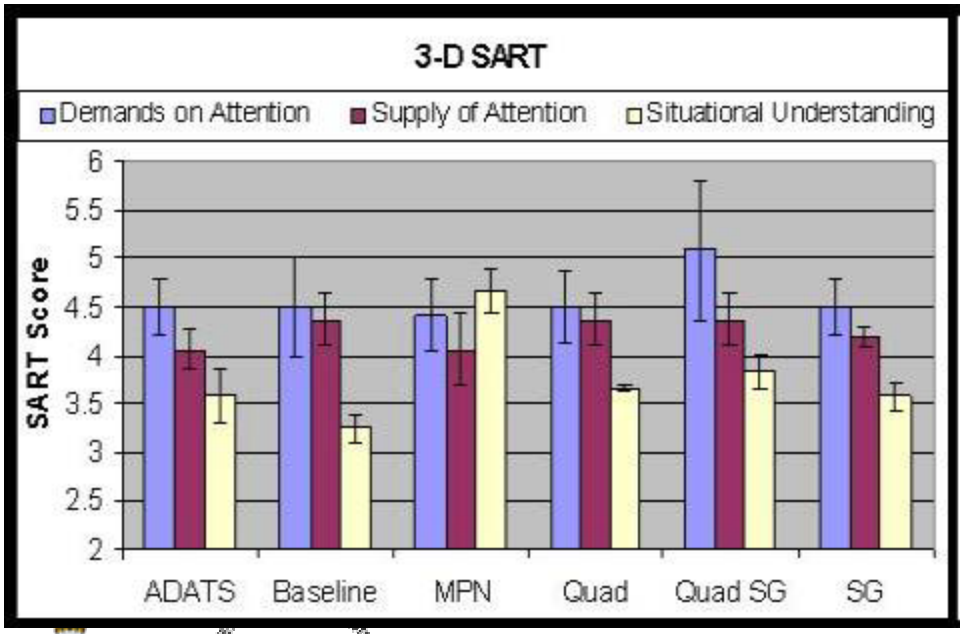


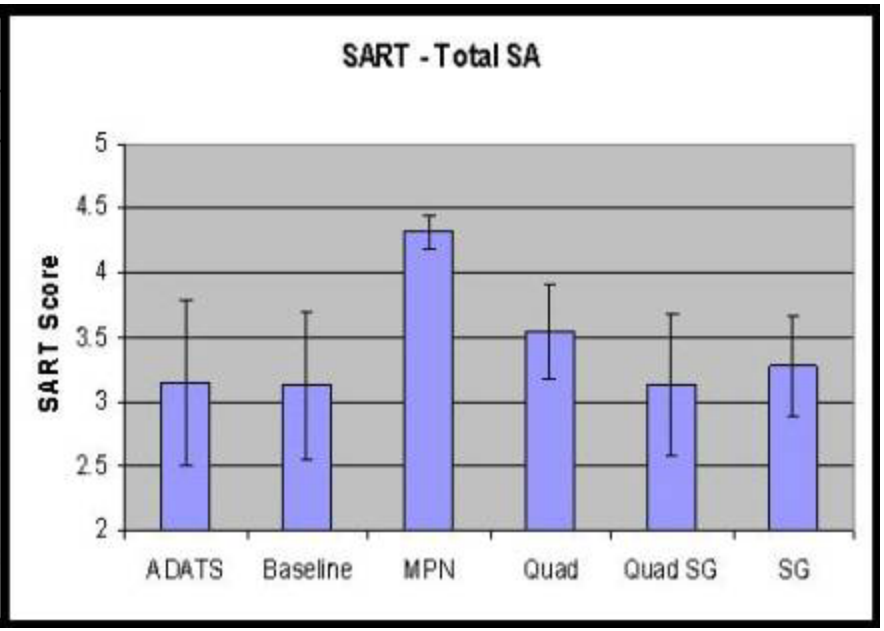
Confidence Levels

Radar Option	Uniform Weights	Equal player weights	Tower Dominent Weights
ADATS	98.0%	96.5%	96.3%
MPN	99.7%	99.4%	99.5%
QUAD	95.6%	93.0%	94.0%
QUAD/SG	94.4%	95.0%	95.0%
SG	99.0%	98.7%	99.1%

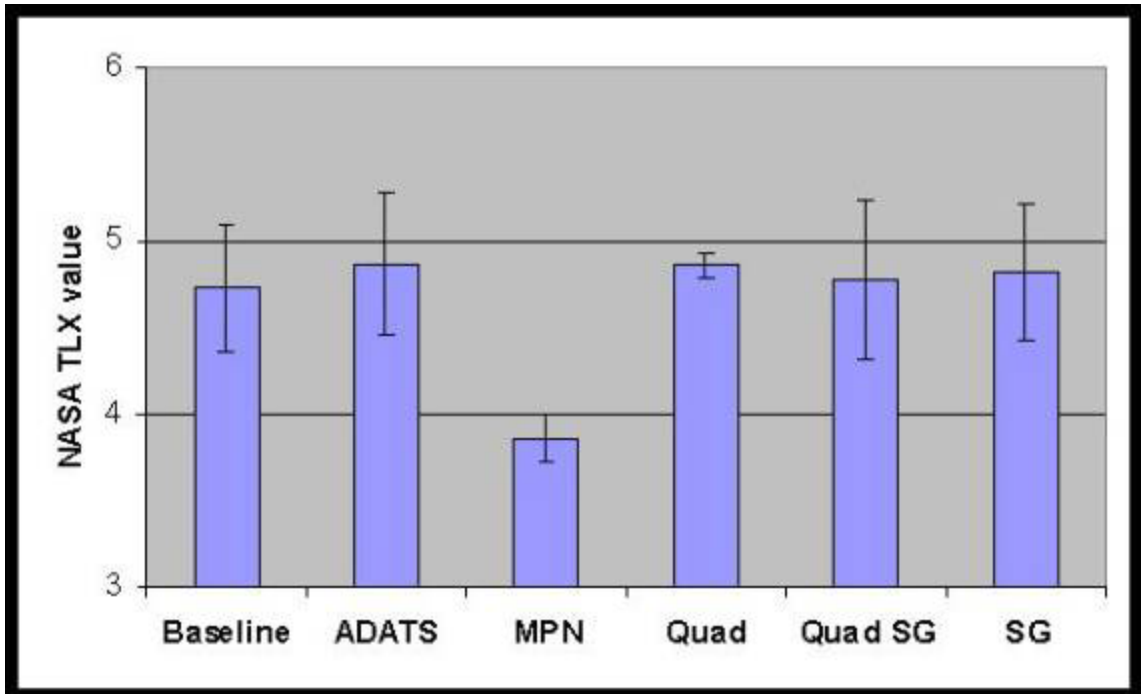
SART Results

Radar Option	Demands on attention	Supply of Attention	Situational understanding
ADATS	22.7%	75.2%	65.7%
MPN	0.0%	61.4%	**97.1%**
QUAD	0.0%	0.0%	**97.1%**
QUAD/SG	75.2%	0.0%	**97.1%**
SG	22.7%	53.0%	88.6%





NASA-TLX RESULTS



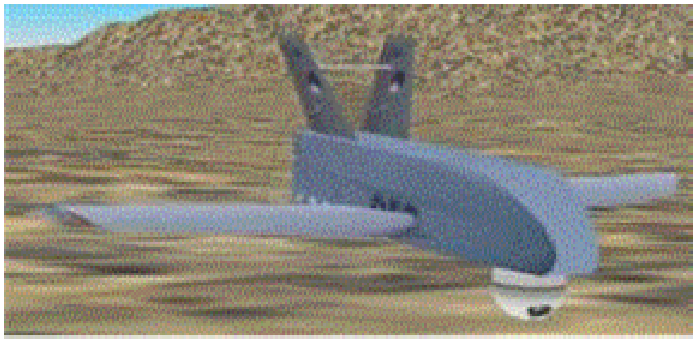
Radar Option	Confidence level vs Baseline	Confidence level vs MPN
MPN	97.1%	
ADATS	11.4%	97.1%
QUAD	0.0%	97.1%
QUAD/SG	0.0%	93.9%
SG	0.0%	97.1%

Qualitative Findings

- 3 Types of SA Aids in the Tower examined
  - TUAV moving map display (MMD)
    - Shows location of TUAV
  - MMD plus MPN-25 Radar Situation Display
  - Air Defence System Integrator (ADSI)
    - Integrates various radar pictures
- ATCO had better SA & SU with display in tower
  - Made fewer calls to aircraft
  - Could give directions relative to aircraft
- ADSI less familiar but the most useful
- As Tower SA improved, UAV Commander SA also improved and mission focus increased

Army Experimentation/OR Advances

- First coordination of CFEC and DLSE Experimentation
- First ASC conduct of Theatre Mission Specific experimentation in support of operations
- First use of rapid prototyping methodology to create the virtual simulations
- First employment of a SAGAT, SART and NASA-TLX designed to objectively capture comparative SA
- First implementation of EXCEL-based simultaneous data capture



Recommendations

- **Deploy one or more ATC or AD radars to Kabul to support TUAV Operations**

- **Place an SA aid in the Kabul tower (TUAV map display, MPN display, or ADSI) to assist in TUAV conflict resolution.**

Conclusions

Study has provided a solid foundation for

– decisions on UAV deployment and support

– future command & control experimentation

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Questions?