Command and Control of Unmanned Systems in Distributed ISR Operations

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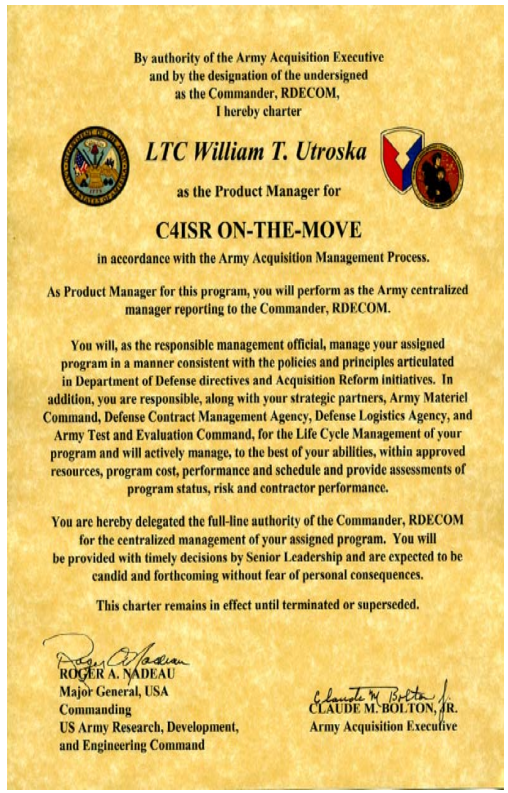
13th International Command and Control Research Technology Symposium
16-19 June 2008

Plan of Discussion

- Introduction to experiment setting
- The distributed communications network
- Unmanned sensor systems
- Experiment design
- Dependent measures
- Results
- Conclusions

C4ISR On The Move Campaign of Experimentation Charter: Provide a relevant environment/venue to assess emerging technologies in a C4ISR System-of-Systems (SoS) configuration to enable a Network Centric Environment IOT mitigate risk for FCS Concepts, Future Force technologies and accelerate technology insertion into the Current Force.

- Perform Systems of Systems (SoS) integration
  - Objective hardware and software
  - Surrogate & Simulated systems as necessary due to maturity, availability and scalability
- **Conduct Technical Live**, Virtual, and Constructive **technology demonstrations**
  - Component Systems Evaluations
  - Scripted end-to-end SoS Operational Threads
  - **Technology experiment/assessment in a relevant environment employing Soldiers**
- Develop test methodologies, assessment metrics, automated data collection and reduction, and analysis techniques



By authority of the Army Acquisition Executive
and by the designation of the undersigned
as the Commander, RDECOM,
I hereby charter

LTC William T. Utroska

as the Product Manager for

C4ISR ON-THE-MOVE

in accordance with the Army Acquisition Management Process.

As Product Manager for this program, you will perform as the Army centralized manager reporting to the Commander, RDECOM.

You will, as the responsible management official, manage your assigned program in a manner consistent with the policies and principles articulated in Department of Defense directives and Acquisition Reform initiatives. In addition, you are responsible, along with your strategic partners, Army Materiel Command, Defense Contract Management Agency, Defense Logistics Agency, and Army Test and Evaluation Command, for the Life Cycle Management of your program and will actively manage, to the best of your abilities, within approved resources, program cost, performance and schedule and provide assessments of program status, risk and contractor performance.

You are hereby delegated the full-line authority of the Commander, RDECOM for the centralized management of your assigned program. You will be provided with timely decisions by Senior Leadership and are expected to be candid and forthcoming without fear of personal consequences.

This charter remains in effect until terminated or superseded.

ROGER A. NADEAU
Major General, USA
Commanding
US Army Research, Development, and Engineering Command

CLAUDE M. BOLTON, JR.
Army Acquisition Executive

Ft. Dix Range

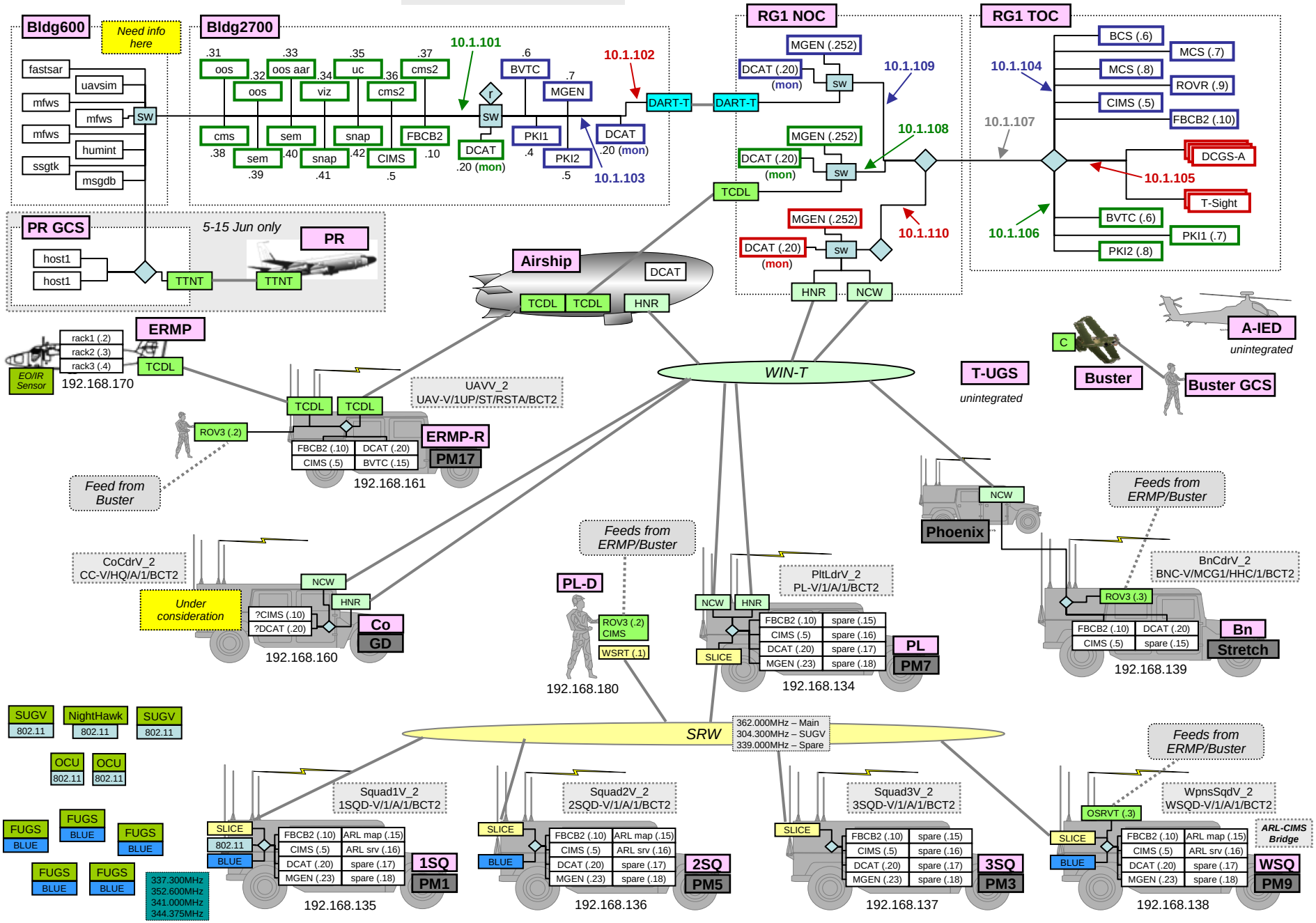
SENSORS

Fleet of instrumented vehicles

Daily Mission Runs

Test Range	Characteristics	Dates
Case 1, TAC 9D	Open rolling sandy areas with lightly forested sections.	18 and 25 July 2007
Case 2, TAC 12A	Open sandy areas with heavily forested sections including 'Vietnam Village', a set of three huts in a forested area.	19 and 20 July 2007
Case 3, MOUT	An urban site configured in a triangular shape.	24 July 2007

SV-1


Bldg600
Need info here
fastsar
uavsim
mfws
mfws
mfws
humint
ssgtk
msgdb
SW
Bldg2700
.31 oos
.32 oos
.33 oos aar
.34 viz
.35 uc
.36 cms2
.37 cms2
cms .38
sem .39
sem .40
snap .41
snap .42
CIMS .5
FBCB2 .10
r
SW
DCAT .20 (mon)
.6 BVTC
.7 MGEN
PKI1 .4
PKI2 .5
DCAT .20 (mon)
10.1.101
10.1.102
10.1.103
DART-T
DART-T
RG1 NOC
MGEN (.252)
DCAT (.20) (mon)
SW
10.1.109
MGEN (.252)
DCAT (.20) (mon)
SW
10.1.108
TCDL
MGEN (.252)
DCAT (.20) (mon)
SW
10.1.110
HNR
NCW
RG1 TOC
BCS (.6)
MCS (.7)
MCS (.8)
ROVR (.9)
CIMS (.5)
FBCB2 (.10)
10.1.104
10.1.107
DCGS-A
10.1.105
T-Sight
BVTC (.6)
PKI1 (.7)
PKI2 (.8)
10.1.106
PR GCS
5-15 Jun only
PR
host1
host1
TTNT
TTNT
Airship
DCAT
TCDL
TCDL
HNR
ERMP
rack1 (.2)
rack2 (.3)
rack3 (.4)
EO/IR Sensor
192.168.170
TCDL
UAVV_2
UAV-V/1UP/ST/RSTA/BCT2
TCDL
TCDL
ROV3 (.2)
FBCB2 (.10)
DCAT (.20)
CIMS (.5)
BVTC (.15)
ERMP-R
PM17
192.168.161
Feed from Buster
WIN-T
T-UGS
unintegrated
C
Buster
A-IED
unintegrated
Buster GCS
Phoenix
NCW
Feeds from ERMP/Buster
CoCdrV_2
CC-V/HQ/A/1/BCT2
Under consideration
NCW
HNR
?CIMS (.10)
?DCAT (.20)
Co
GD
192.168.160
Feeds from ERMP/Buster
PL-D
ROV3 (.2)
CIMS
WSRT (.1)
192.168.180
PltLdrV_2
PL-V/1/A/1/BCT2
NCW
HNR
SLICE
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
MGEN (.23)
spare (.15)
spare (.16)
spare (.17)
spare (.18)
PL
PM7
192.168.134
BnCdrV_2
BNC-V/MCG1/HHC/1/BCT2
ROV3 (.3)
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
spare (.15)
Bn
Stretch
192.168.139
SUGV 802.11
NightHawk 802.11
SUGV 802.11
OCU 802.11
OCU 802.11
FUGS BLUE
FUGS BLUE
FUGS BLUE
FUGS BLUE
FUGS BLUE
337.300MHz
352.600MHz
341.000MHz
344.375MHz
SRW
362.000MHz – Main
304.300MHz – SUGV
339.000MHz – Spare
Squad1V_2
1SQD-V/1/A/1/BCT2
SLICE
802.11
BLUE
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
MGEN (.23)
ARL map (.15)
ARL srv (.16)
spare (.17)
spare (.18)
1SQ
PM1
192.168.135
Squad2V_2
2SQD-V/1/A/1/BCT2
SLICE
BLUE
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
MGEN (.23)
ARL map (.15)
ARL srv (.16)
spare (.17)
spare (.18)
2SQ
PM5
192.168.136
Squad3V_2
3SQD-V/1/A/1/BCT2
SLICE
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
MGEN (.23)
spare (.15)
spare (.16)
spare (.17)
spare (.18)
3SQ
PM3
192.168.137
Feeds from ERMP/Buster
WpnsSqdV_2
WSQD-V/1/A/1/BCT2
OSRVT (.3)
SLICE
BLUE
FBCB2 (.10)
CIMS (.5)
DCAT (.20)
MGEN (.23)
ARL map (.15)
ARL srv (.16)
spare (.17)
spare (.18)
ARL-CIMS Bridge
WSQ
PM9
192.168.138

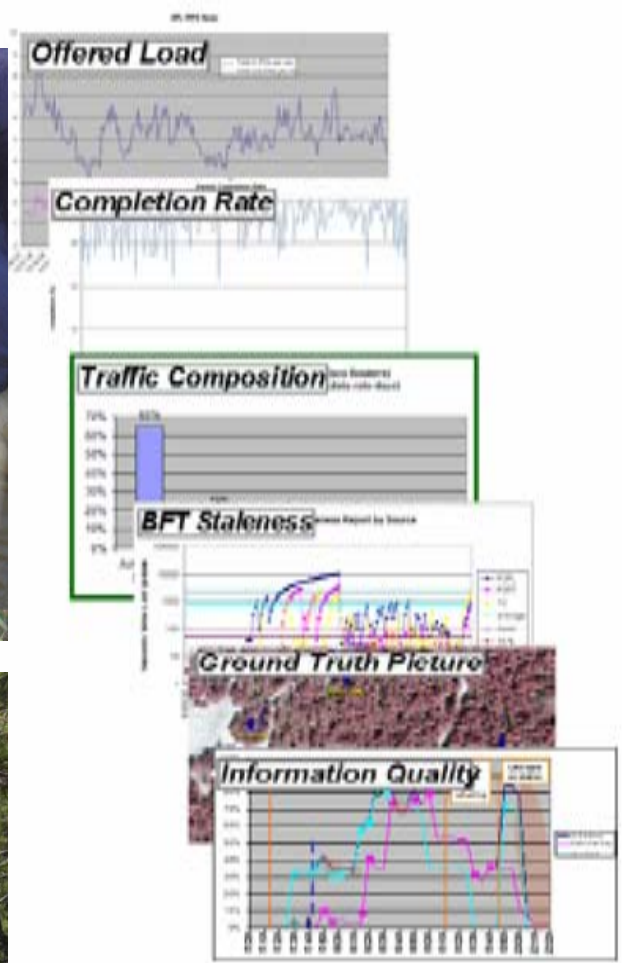
Participants

- **10 Soldiers from NJ ARNG**
- **Soldiers were organized into elements of a reconnaissance platoon**
- **Key leader positions included Platoon Leader, Platoon Sergeant, Robotics NCO, and two dismounted recon squads with sensors**
- **Sensors included:**
  - **Class 1 Unmanned Air System (UAS)**
  - **PackBot Unmanned Ground Vehicle (UGV)**
  - **Family of Unattended Ground Sensors (UGS)**
- **Soldiers operated ISR scenarios against an Opposing Force (OPFOR)**
- **Scenarios were designed to replicate current threats (IED emplacement, weapons storage, prisoner exchange, high value target meeting)**

Procedure

- Training
  - Equipment
  - FBCB2
- Scripted scenarios conducted over 5 days
- Dependent Measures
  - Situational Awareness
  - Workload: Mission Awareness Rating Scale (Matthews & Beal, 2002) and NASA TLX (Hart & Staveland, 1988)
- Cognitive Predictors of UGV Performance: Excursion Experiment to validate cognitive test battery

Data Collection Methods



Instrumentation, Field/Lab Data Collection, Interviews, Observation, Reduction, Analysis

SALUTE-AP

OPFOR Action (Ground Truth)	Size	Activity	Location	Uniform	Time	Assess-ment	Confidence 1-5 (low –high)	Prediction	Confidence 1-5 (low –high)
5 Civilians moving around, 4 OPFOR with weapons preparing to unload truck and build a structure	4 enemy 5 civ 2 unsure	Taking equip out of truck	48 WK 22345 58764	Black t-shirts, camo pants	1230	Enemy forces ready to build or deploy device	3	May be setting up an ambush firing point	3
2 standing guard / 2 erect radio antenna	2 red 2 civ	Building a structure	NC	NC	1300	Building a structure, possibly radio tower	4	Preparing to send messages	4
Take down antenna and depart	2 red 2 civ	Tearing down antenna, departing	NC	NC	1500	Activity is finished, group will RTB	5	Group may relocate, site may be used again	5

- *Based on SAGAT (Endsley, 2000)*
- *Utilizes standard Army reporting categories*
- *Causes minimal intrusion*
- *Easy to train*
- *Easy to administer and analyze*
- *Scored on low-medium-high scale*

ICCRTS Presentations:

Bowman & Kirin, 2006

Bowman & Thomas, 2007

SA: Mission Awareness Rating Scale

Answered on a 4 point scale from low to high:

1. Please rate your ability to ***identify*** *mission*-critical cues in this mission.
2. How well did you ***understand*** *what was going on during the mission?*
3. How well could you ***predict*** *what was about to occur next in the mission?*
4. How aware were you of ***how to best achieve*** *your goals during this mission?*

SOURCE:
Matthews, M. & Beal, S. (2002). Assessing situation awareness in field training exercises. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
McGuinness, B., & Ebbage, L. (2002). Assessing human factors in command and control: workload and situational awareness measures. Proceedings of the 2002 Command and Control Research and Technology Symposium, Monterey, CA.

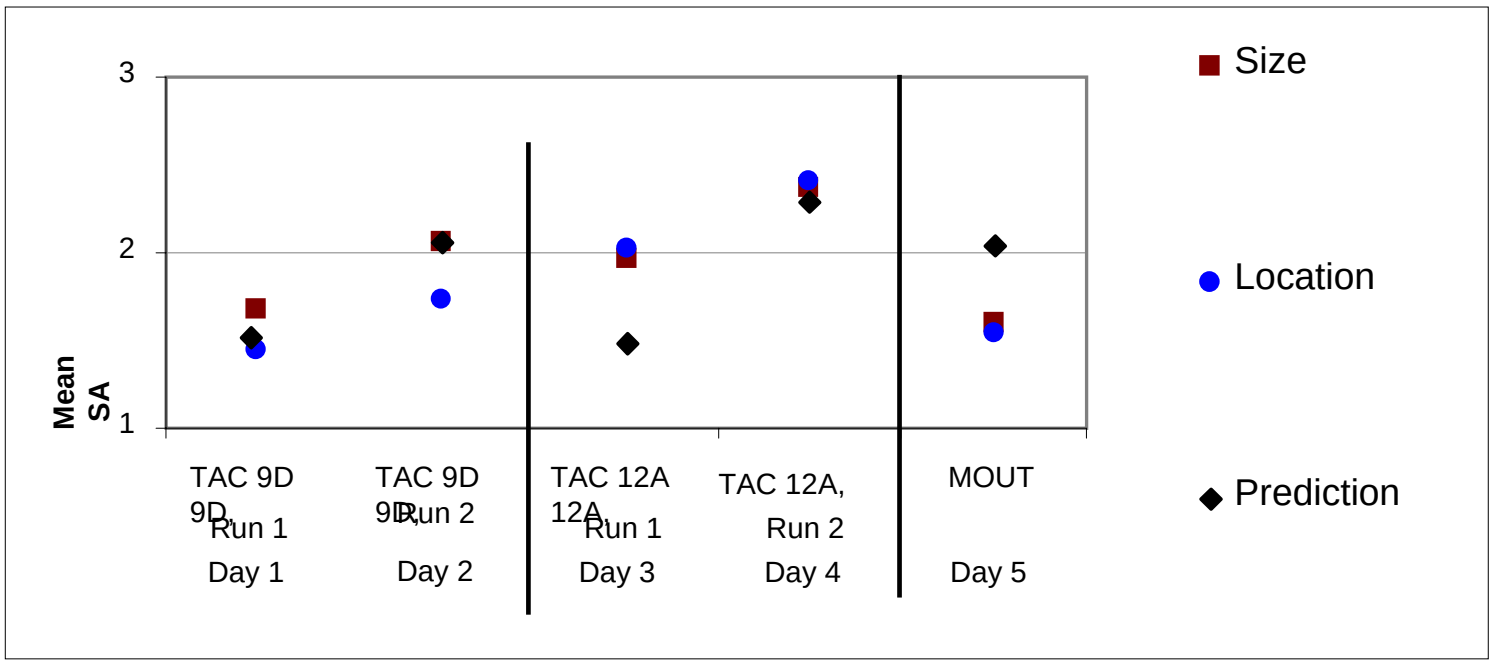
Workload: NASA TLX

1. *Based on six scales (mental demand, physical demand, temporal demand, performance, effort, and frustration level.*
2. *Ratings on 6 scales are weighted according to subject's evaluation of relative importance.*
3. *Ratings range from 1-100.*

SOURCE: Hart & Staveland, 1988

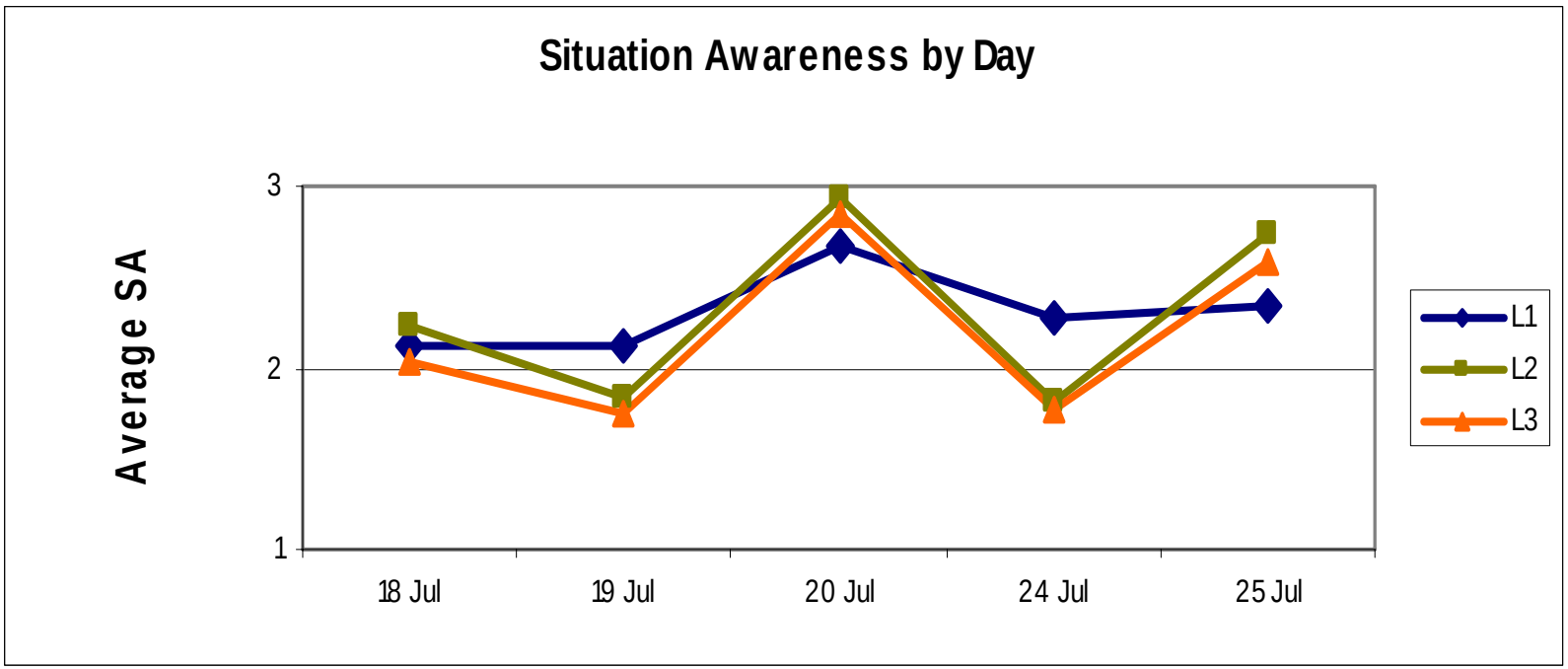
SA Results: Report type

- *On average, subjects differed in their ability to identify size, location, and possible future activities.*
- *Size, Location, and Prediction were statistically significant variables*



SA Results: Effect of Day

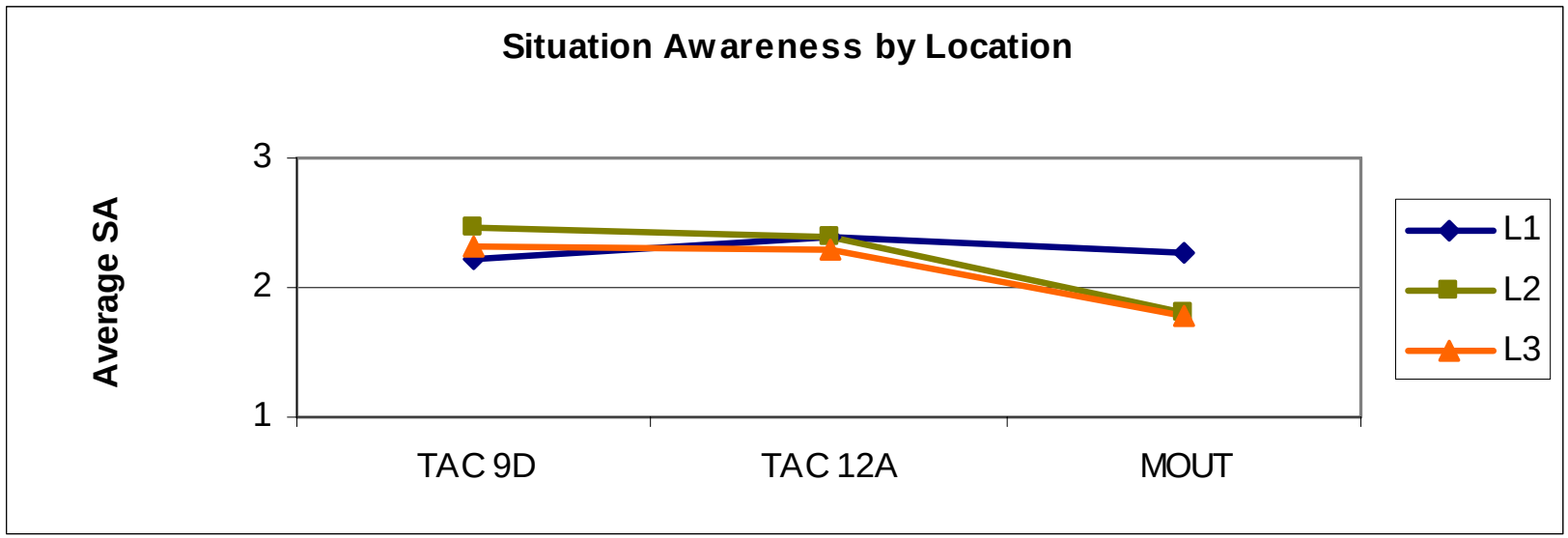
- *Level 1 and Level 2 and 3 SA variable*
- *20 and 25 July high scores influenced by availability of Class 1 UAS*



SA Results: Effect of Location

SA results for Level 1, 2, and 3 were consistent in open rolling terrain with slight vegetation.

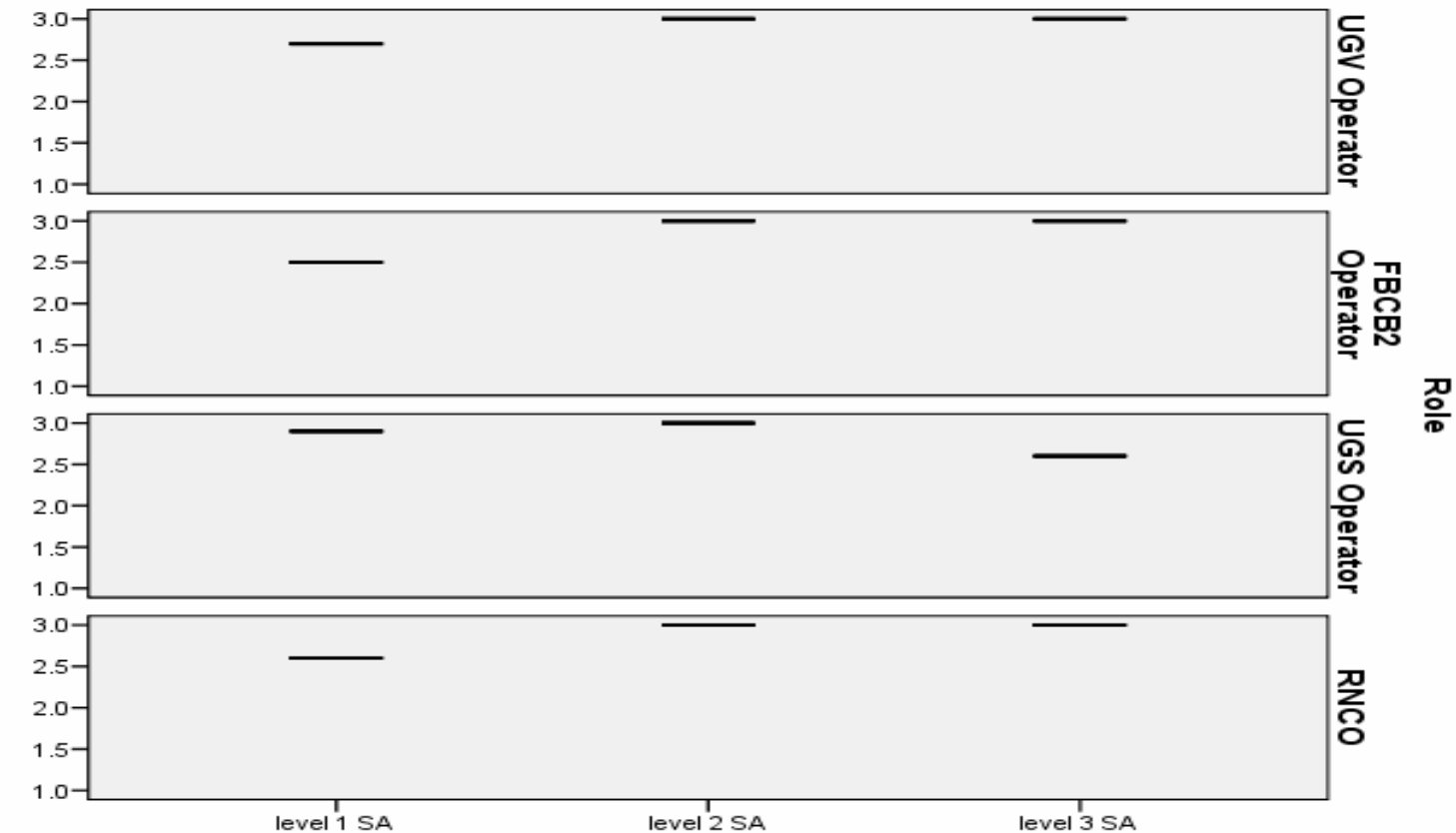
SA results for level 2 and 3 dropped noticeably in MOUT site where OPFOR activity was more complicated and more difficult to understand and predict.



SA Results: Effect of Role

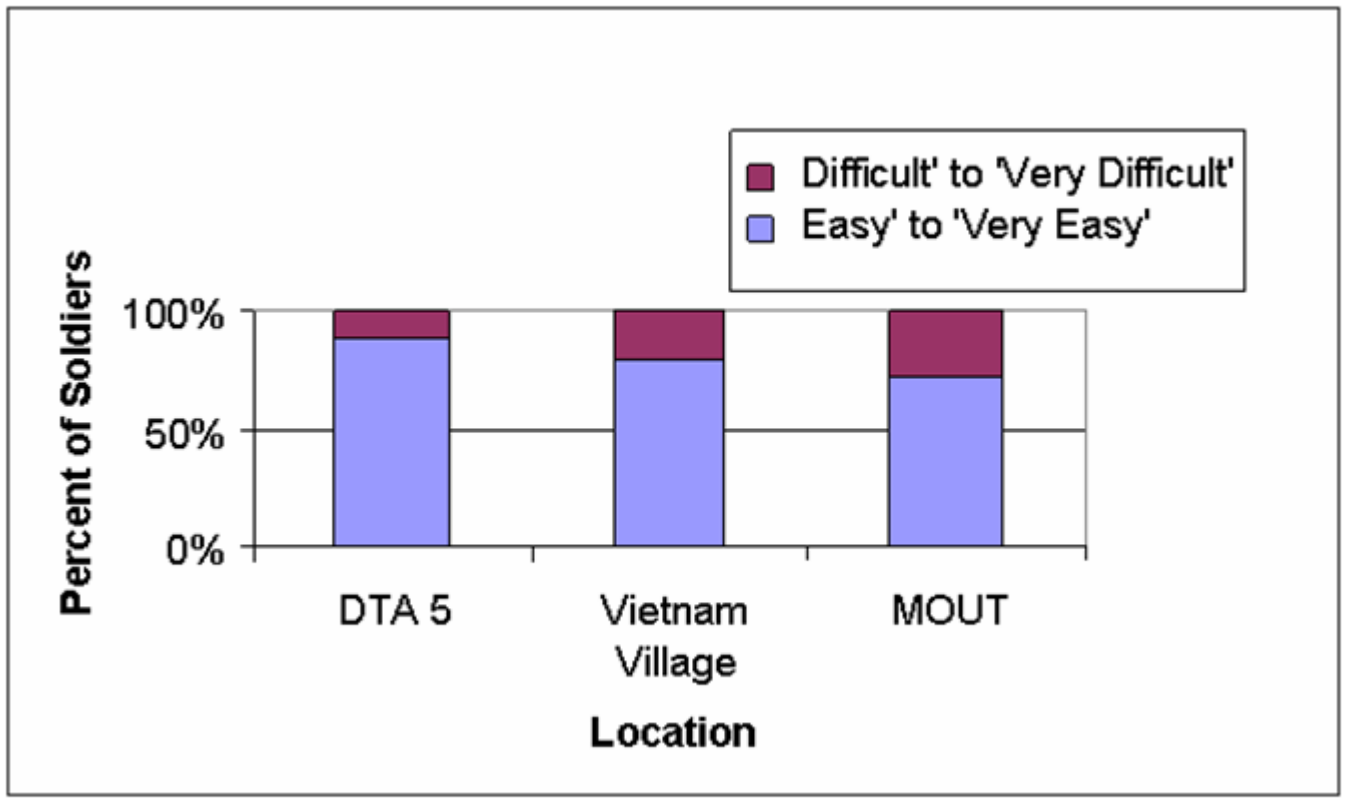
Slight differences in level 1, 2, and 3 for all operators; most noticeably UGS operator in level 3.

With respect to level 1, UGS and UGV operators had higher levels of SA due to robotics-eyes-on activity.



MARS SA Results

Consistent results to SALUTE-AP showing that SA was easier to achieve in open areas compared to MOUT site.

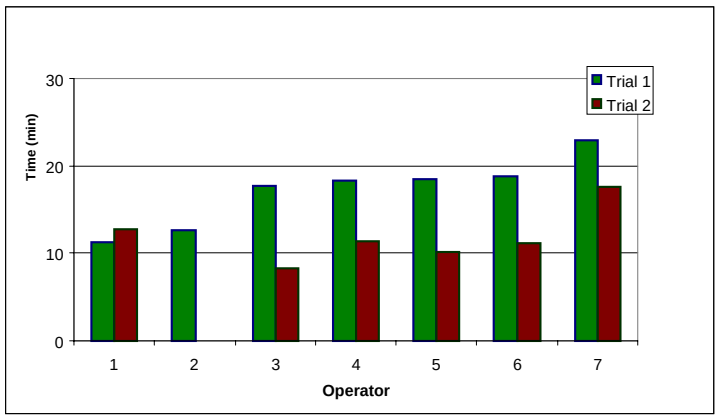


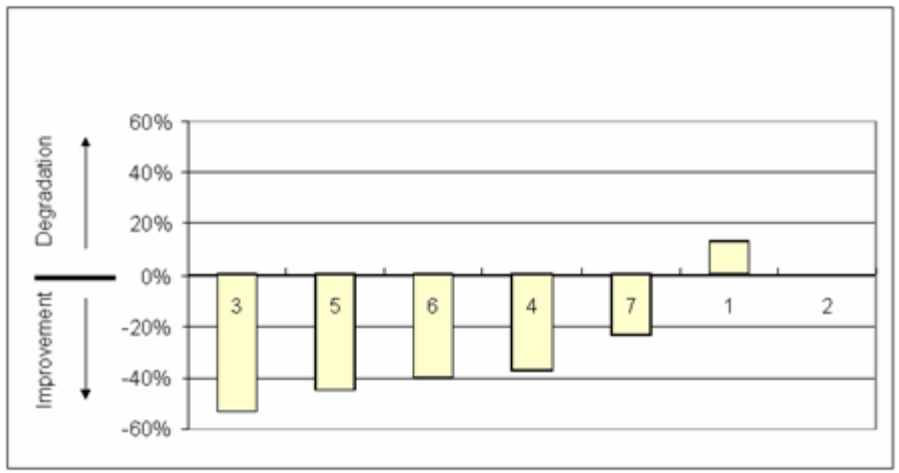
Workload

- *Mental Workload was the highest component of workload (M=63.57 (5.87), followed by temporal demand (M = 63.93 (7.13)) and frustration (M = 65.71 (6.35)).*
- *Highest average workload was reported on day two (M = 62.74 (5.05)).*
- *High workload on day two could be an explanation for lower SA scores on that day.*
- *Frustration was related to technology problems.*

Army Cognitive Readiness Assessment Test Battery

- **Designed to predict performance with the Packbot Unmanned Ground Vehicle (UGV) system with 9 Soldiers in two obstacle course settings.**
- **Rapid decision making, time estimation, and spatial orientation were found to be highly correlated to SUGV operation.**





Conclusions

- A suite of ISR technologies prove challenging to users
  - Display and information overload
  - Difficult to synchronize information from various sensors
- Cognitive attributes of rapid decision making, time estimation, and spatial orientation were demonstrated to be correlated with operating a UGV

Conclusions

- SALUTE-AP method robust to field conditions and a valid measure of SA levels
- Suite of sensors contributed to high level of SA in short time period, but at costs of physical and mental workload
- The ability to predict performance in operating these systems can optimize training time and reduce expensive operational accidents from unskilled operators.