



Measuring the Impact of Situational Awareness on Digitised Force Effectiveness

Paper 136: 15th International Command and Control
Research Symposium

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Dstl/PUB45948

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24 June 2010

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Study Overview

Study Aim

- To measure the impact of differing Communications Information Systems (CIS) capability on force effectiveness (FE) at the tactical level
 - Develop methodology
 - Conduct pilot study

Scope

- BG level
- Land oriented
- Comparing a baseline analogue BG (Clansman) with two Epochs of digitally enabled BG (BCIP5)

Hypothesis

‘ the digitisation of a BG HQ, its superiors, subordinates and BG enablers improves the timely delivery of appropriate effects, leading to improvements in Blue force effectiveness ’

Conclusions

- Successfully developed and applied innovative analytical method for measuring benefits of CIS
- Results showed that Blue force effectiveness and C2 effectiveness improve with the introduction of digitised CIS

Overview of Method

Network Modelling

ORBAT details

Tx/Rx details

Task/System Factors

State of the Environment

Individual Factors

System capability
Interface Design
Stress and Workload
Complexity
Automation

Feedback

SITUATION AWARENESS

Perception of Elements in Current Situation (Level 1)

Comprehension of Current Situation (Level 2)

Projection of Future Status (Level 3)

Decision

Performance of Actions

Goals and objectives
Preconceptions (Expectations)

Information Processing Mechanisms

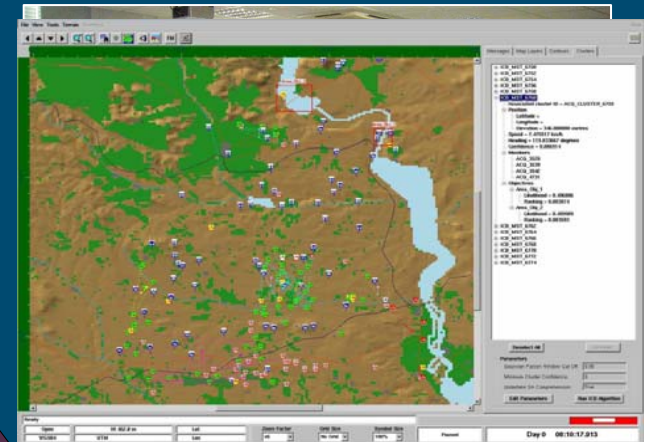
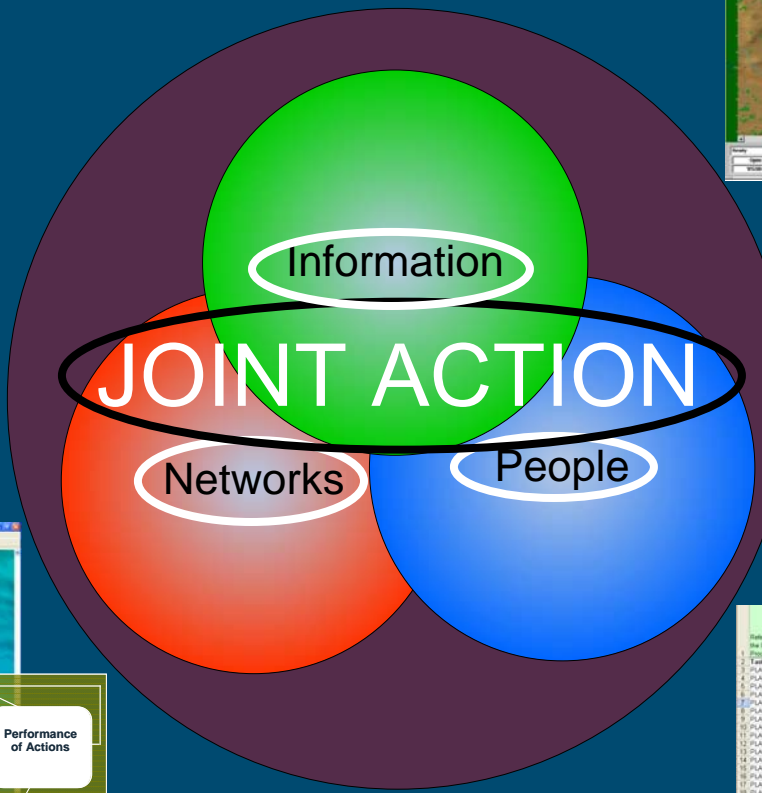
Long-Term Memory Stores

Automaticity

Abilities
Experience
Training

Generic decision-making model centred on the situation awareness process

Endsley, M. 'Toward a theory of situation awareness in dynamic systems', Human Factors 37(1):32-64, 1995



Commander's Situation Awareness Score (version 1.0)

Command level: Epic
Command role: Game term: Game identifier:
Organization: Date: 50 100

- How accurate do you consider the positions of friendly forces in your area of interest to be? Very accurate (high) or very inaccurate (low)
- How aware are you of all enemy's friendly forces in your area of interest? Very aware (high) or not very aware (low)
- How accurate do you consider the positions of enemy forces in your area of interest to be? Very accurate (high) or very inaccurate (low)
- How aware are you of all enemy's enemy forces in your area of interest? Very aware (high) or not very aware (low)
- How close to ground truth do you think your current operations picture is with respect to:

Local Exchange Ratio

Information Exchange Requirements (IER)

Reference to the Business Process	Who needs it	Why the recipients need it	Who provides it	Priority	Mode	When is the message sent? This is the time interval between the time the message is sent and the time it is received	When is the message received? This is the time interval between the time the message is received and the time it is used	Size of the message (in bytes)
1	PLAN 9.2	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 WINFO	High	Data	-1506	1506
2	PLAN 9.2	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 WINFO	High	Data	-1261	1261
3	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 TAG, ORG	Medium	Data	-1570	1570
4	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 EN, LOGS	Medium	Data	-1603	1603
5	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 ENADISEP	High	Data	-1817	1817
6	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	1 ENADISEP	Medium	Data	-1616	1616
7	PLAN 9.3	Eng Sqr	BO1 HQ	3 EN STRIP	Medium	Data	-1619	1619
8	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 WINFO	Medium	Data	-1572	1572
9	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 BARRSP	Medium	Data	-1614	1614
10	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	1 ENADISEP	Medium	Data	-1524	1524
11	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	1 ENADISEP	Medium	Data	-1480	1480
12	PLAN 9.3	BO1 HQ	Eng Sqr	16 AMPADSP	Medium	Data	-1620	1620
13	PLAN 9.3	BO1 HQ	Eng Sqr	16 AMPADSP	Medium	Data	-1473	1473
14	PLAN 9.3	BO1 HQ	Eng Sqr	16 AMPADSP	Medium	Data	-1620	1620
15	PLAN 9.3	BO1 HQ	Eng Sqr	16 AMPADSP	Medium	Data	-1342	1342
16	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1619	1619
17	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1680	1680
18	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1616	1616
19	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1620	1620
20	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1471	1471
21	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1619	1619
22	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	16 HELDISEP	Medium	Data	-1680	1680
23	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 STRIP	Medium	Data	-1620	1620
24	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1619	1619
25	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1524	1524
26	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
27	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1480	1480
28	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
29	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
30	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
31	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
32	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
33	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
34	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
35	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
36	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
37	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
38	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
39	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260
40	PLAN 9.3	BO1 HQ	Site A HQ, Flanking BO2 HQ, Flanking	3 COMBATREP	Medium	Data	-1260	1260

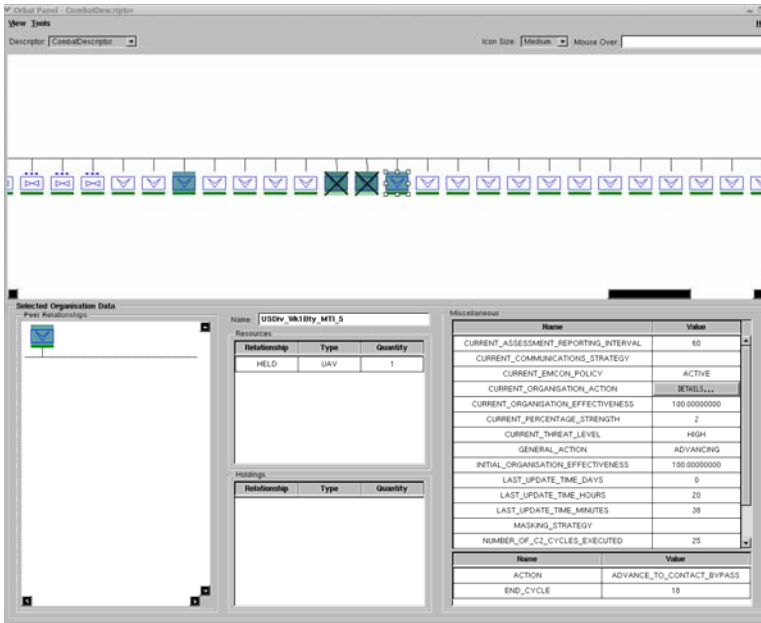


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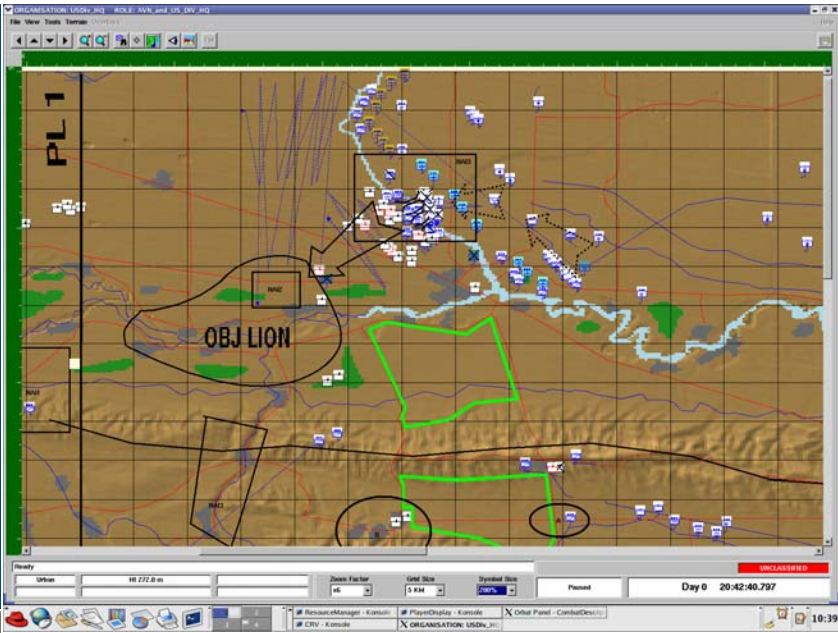
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WISE



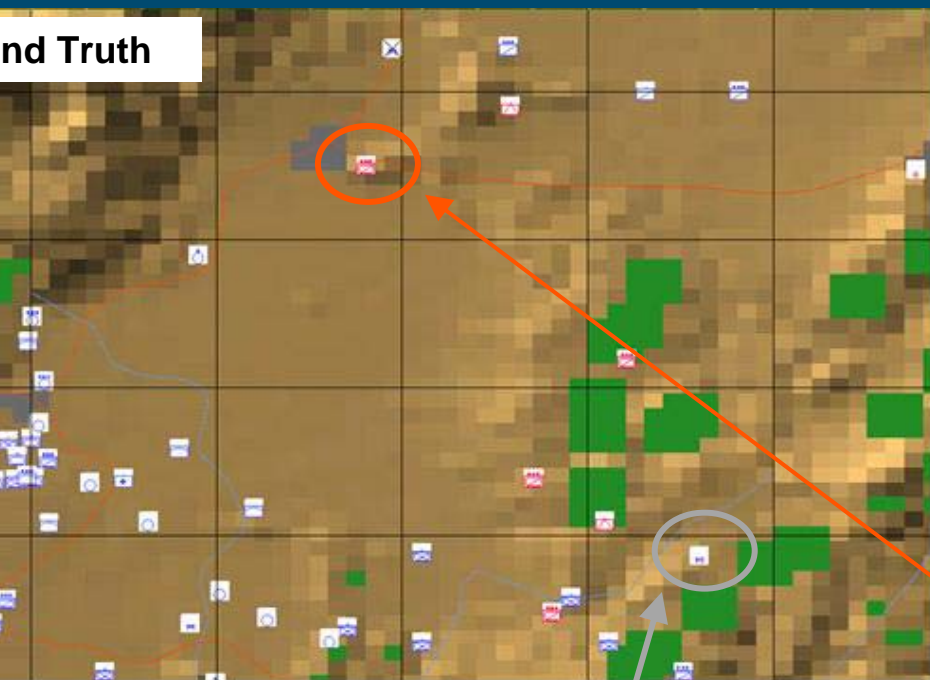
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Ground Truth



Ground truth is 'where units are in the model'

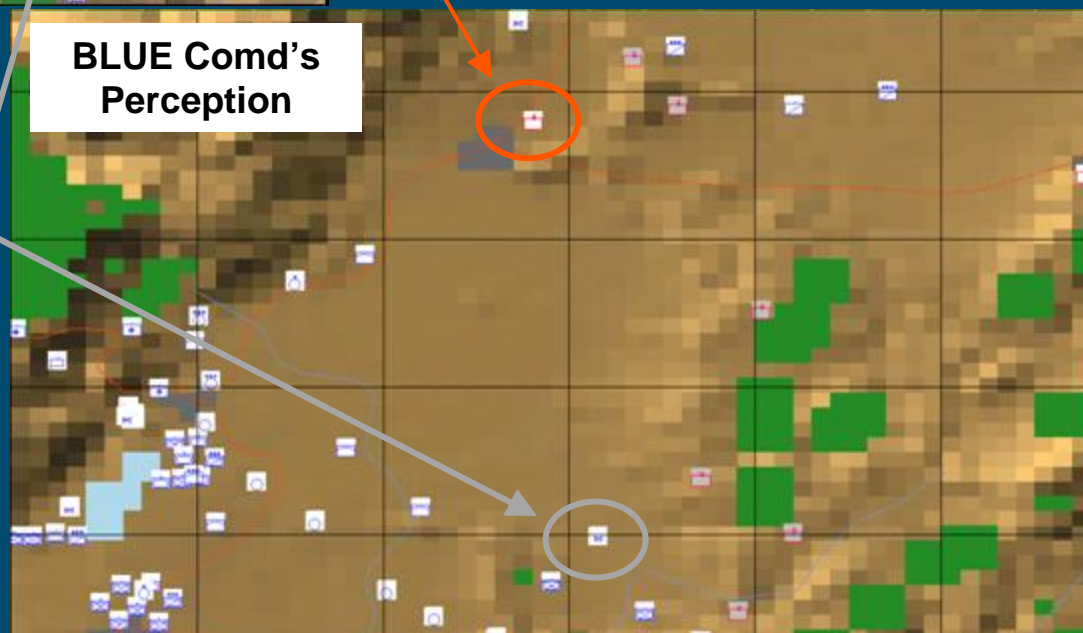
Perception is 'where the comd(s) think the units are'

Comd(s) work based on the contents of their perception not Ground Truth

Acquired Red

BLUE Comd's Perception

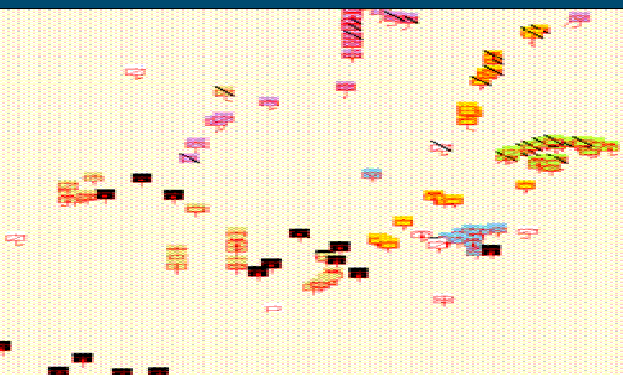
Blue Locs



Situation Awareness (SA) Analysis

Level 1 SA
Perception of
Elements

Calculates the contribution made to SA by the positions achieved by the organisation (i.e. friendly / neutral picture) and information about the side units, using positional accuracy and composition compared to ground truth.



WISE 'Perception'

Level 2 SA
Comprehension

Uses the acquisitions achieved to infer likely enemy groupings leading to a measurement of the comprehension of the situation.



Indicators of Collective Behaviour (ICB)

Level 3 SA
Projection

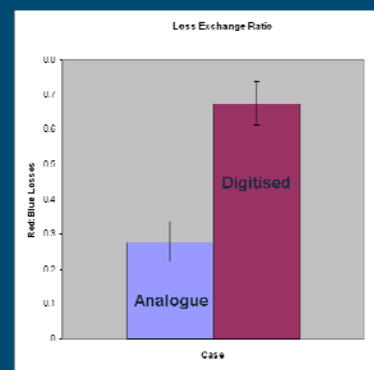
Based on inference of intent of likely enemy groupings with respect to a set of enemy objectives.

Underpinning Subjective Self-Rated Analysis (SART and COSAQ)

Phase 1 Results

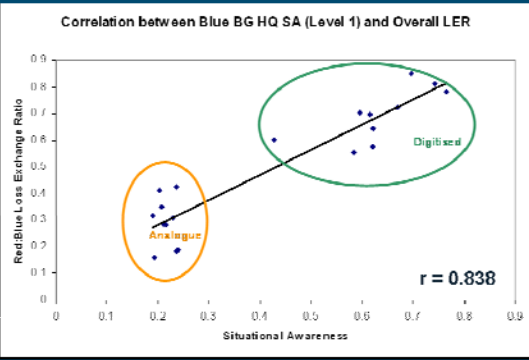
Phase 1 of study:

- Developed an initial set of measures for L1, L2 and L3
- Compared Analogue versus Digitised (Epoch 4)
- Calculated L1 for correlation with FE and trialled L2 and L3
- Measured subjective assessments objectively using SART



Loss Exchange Ratio (RED losses: BLUE losses)
 Non parametric stats test – Mann Whitney U Test
 $U=0.0, p=0.000$ (two-tailed)

Loss Exchange Ratio vs. Level 1 Situational Awareness
 Non parametric stats test – Spearman Rank Test
 $r=0.638, n=10, p=0.01$ (two-tailed)



SART DATA CAPTURE SHEET

Name: _____ Date: _____
 Team: _____ Time: _____
 Test run: _____

SART SCALE

Item	low	high
1 Demand on Attentional Resources		
2 Intensity of Situation		
3 Complexity of Situation		
4 Variability of Situation		
5 Supply of Attentional Resources		
6 Anxiety		
7 Concentration of Attention		
8 Division of Attention		
9 Spare Mental Capacity		
10 Understanding of Situation		
11 Information Quality		
12 Information Quantity		
13 Familiarity with Situation		
14 Situational Awareness		

Phase 2 Experimental Design

Three cases examined but only one gamed in phase 2

Case	Own Side Reporting Frequency (seconds)			Own Side Reporting Delays (seconds)			Enemy/Neutral Reporting Frequency (seconds)			Enemy/Neutral Reporting Delays (seconds)			Peers
	PI → Coy	Coy → BG	BG → Bde	PI → Coy	Coy → BG	BG → Bde	PI → Coy	Coy → BG	BG → Bde	PI → Coy	Coy → BG	BG → Bde	
Analogue ¹	30	360	360	0	90	90	30	360	360	0	90	90	None
Digitised (Epoch 3) ²	30	360	360	0	0	0	30	360	360	0	0	0	Limited
Digitised (Epoch 4) ³	30	360	360	0	0	0	30	360	360	0	0	0	Extensive

representative of CLANSMAN: Delays on reporting due to manual encryption for insecure voice. The reporting frequency for Bde to report a consolidated ISTAR product to BG was set at 1 hour.

representative of BCIP Epoch 3: No peer links other than for AH (to BG). No delays have been included for message passing as systems are encrypted. The reporting frequency for Bde to report a consolidated ISTAR product to BG was set at 6 minutes.

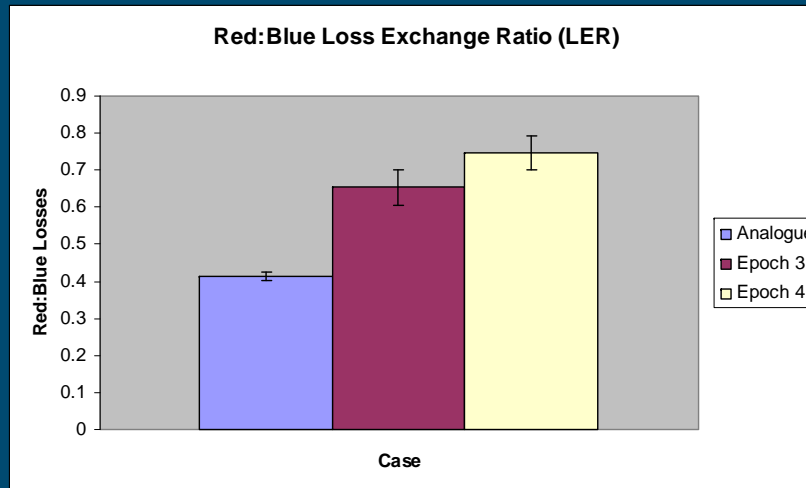
representative of BCIP Epoch 4: Significant number of peer relationships so that an all-informed net is generated. No delays have been included for message passing as systems are encrypted. The reporting frequency for Bde to report a consolidated ISTAR product to BG was set at 6 minutes.

10 replications of each game and the two previous games with IERs

Experimental Case Study (1)

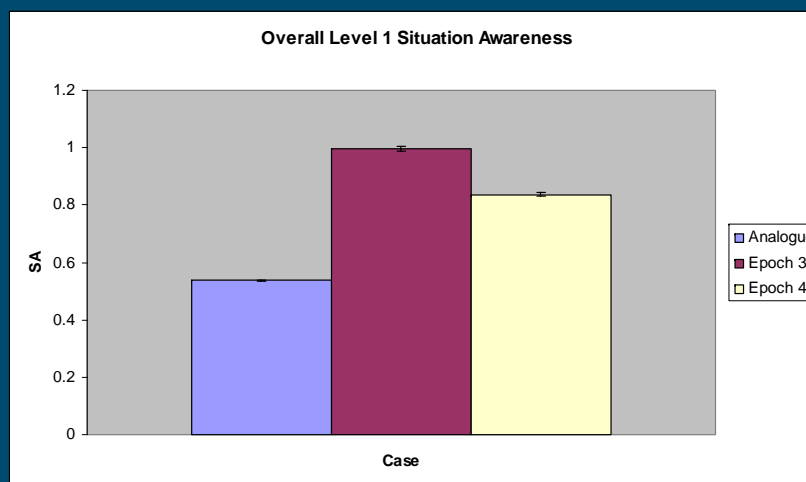
Force Effectiveness

- The loss exchange ratio improves with the introduction of digitisation (i.e. there are a greater proportion of red losses than blue losses)



Level 1 Effectiveness

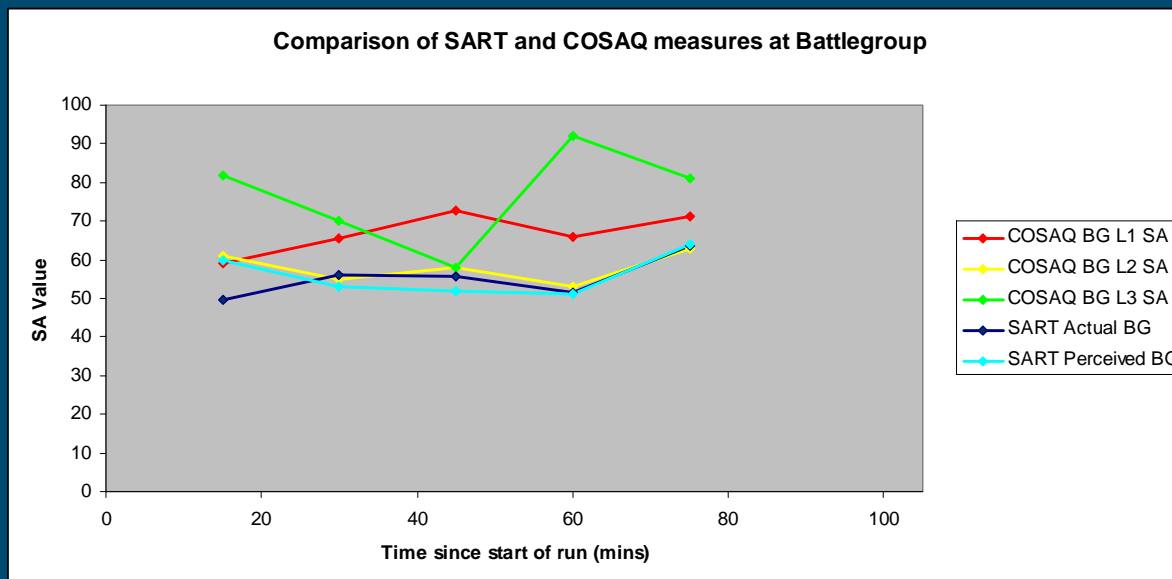
- Level 1 SA is significantly better in the two digitised cases than in the analogue case
- The Epoch 3 case shows higher SA due to more targeted use of ISTAR assets during the game



Comparison of Subjective Measures

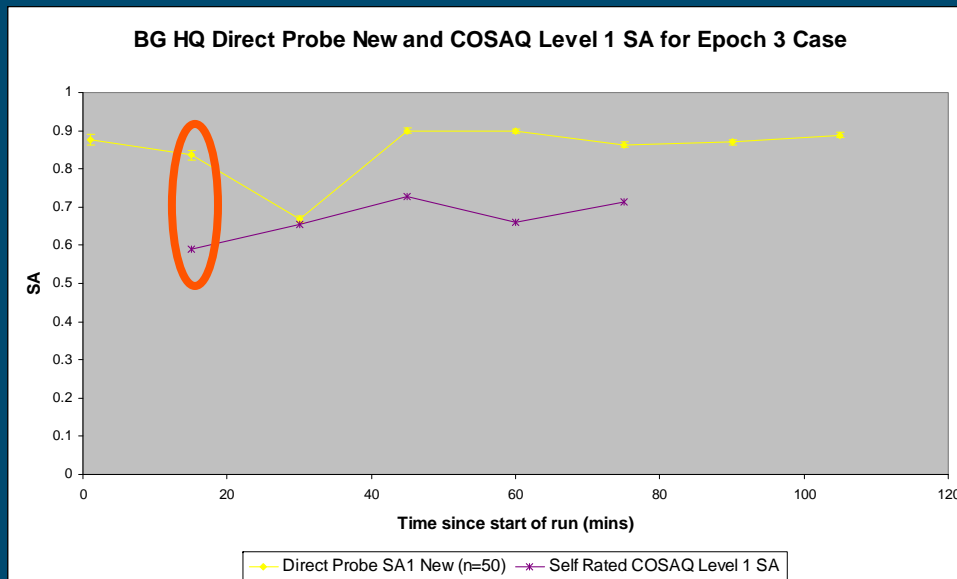
Compared Situation Awareness Rating Technique (SART) & Commander's SA Questionnaire (COSAQ)

- SART actual and perceived scores are a reasonably good match to the COSAQ L2 score
- SART actual follows a similar trend to COSAQ L1 but it is consistently lower
- SART is unable to reflect COSAQ L3



Comparing Subjective & Direct Probe

The graph presents the COSAQ and direct probe L1 SA measures for the Epoch 3 case

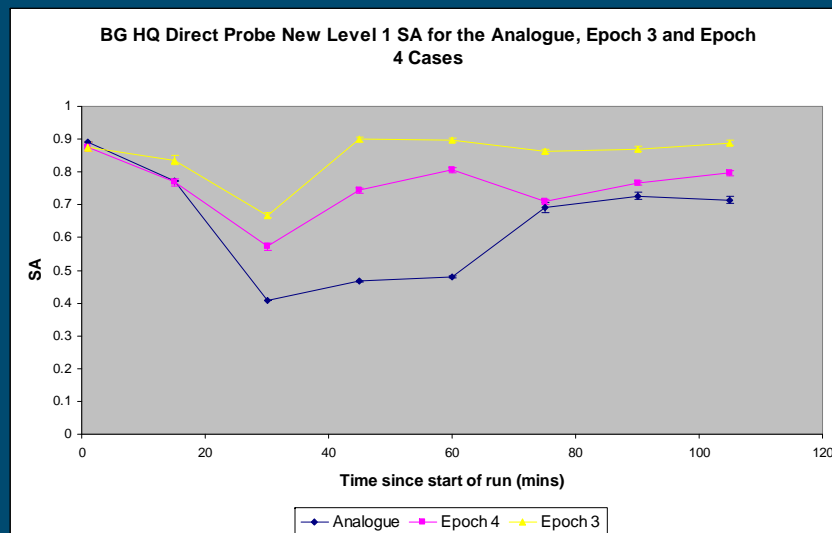


- Direct probe values systematically higher than COSAQ
- Higher COSAQ at start reflects pre-scenario player briefings
- Increase in COSAQ between 30-45 minutes is seen in direct probe measure
- Marginal drop in direct probe measure after 45 minutes consistent with COSAQ
- Trends in direct probe measure similar to those in COSAQ

Comparing Direct Probe – All Cases

Improved SA for Epoch 3 compared with Epoch 4 not expected but was due to difficulties managing game variables

- Level 1 SA is better in both the digitised cases than the analogue
- Shape of curves consistent with key events in cases



Analogue case approaches digitised cases

- Initially: due to ISTAR sweep and 'flush' of information to lower levels
- Around 75 minutes: in the close battle

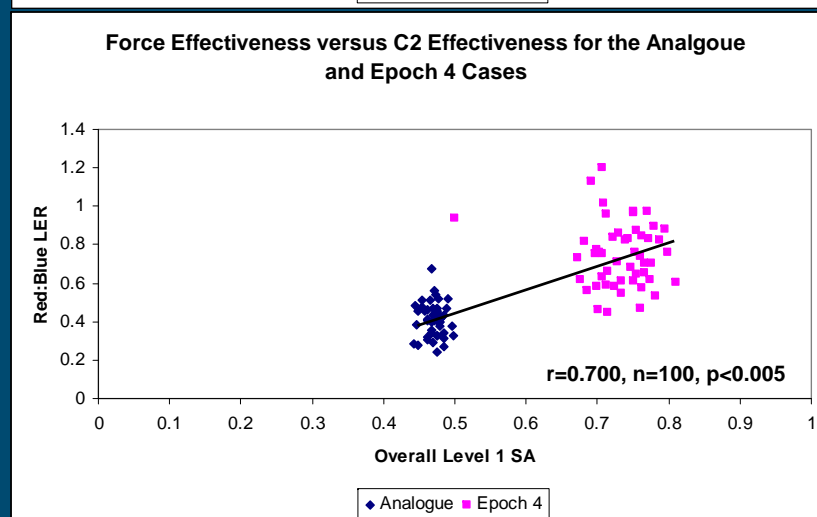
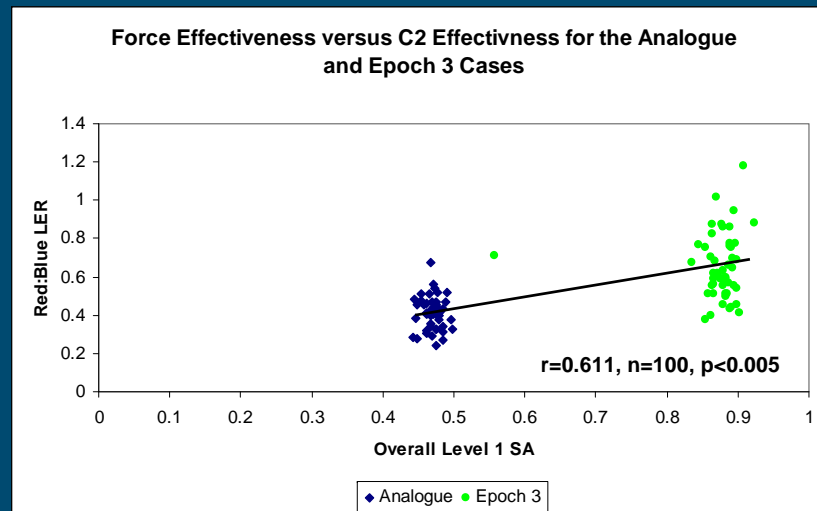
Detailed Results

Correlations – All Cases

Work to date indicates that there is a relationship between FE and C2E and that digitisation leads to significant improvement in both FE and C2E

These results show that, although FE is improved through the production of a digitised CIS and that force effectiveness improves, there is a greater variation in force effectiveness in the digitised cases when compared to the analogue

There is also a larger variation in Overall Level 1 SA in the Epoch 4 cases when compared to the Epoch 3 and analogue cases



Phase 3 Way Forward

Background traffic IERs represented explicitly in WISE

Explicit model of communications now represented within WISE:

- Representation of communications systems and fixed and mobile networks;
- Representation of physical propagation constraints using the Global Information System Electronic Planning Tool (GISEPPT);
- Throughput delays for messages

Improvements to calculation of situation awareness measures for Level 2 and 3

Constructive simulation only experimentation currently underway to repeat phase 2 assessment

Summary

A direct probe method for measuring situation awareness has been developed

The new analytical method is able to differentiate between changes in CIS options

The application of the method was successful however experimental control was challenging

Improvements have been made to the method, are currently being tested with the aim to report them at the next ICCRTS

Points of contact

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