Cognitive Impact of a C4ISR Tactical Network

14th ICCRTS

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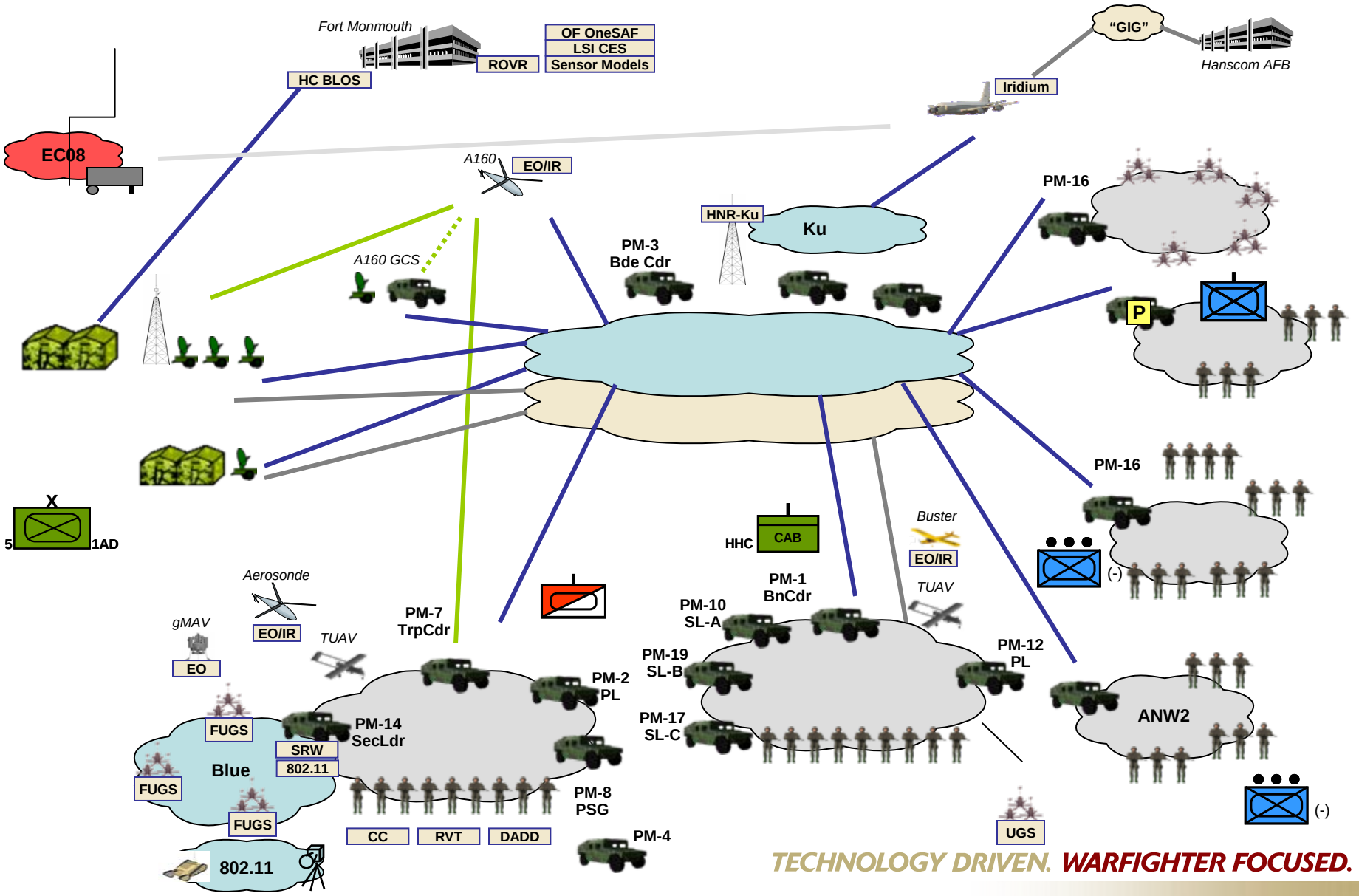
Fundamental Issues

- How well does the *network* enable the flow of data & information throughout the entire experimental force?
- What *battle command interface functionality* & decision aids are essential at company & platoon echelons (e.g., at TOC, vehicle, and dismount)?
- How is the quality of information available at the platoon level impacted by:
  - the *suite of sensors,*
  - the *fusion processes, and*
  - the *implemented information management protocols?*
- How does the information made available through the implemented C4ISR architecture impact the *decision making and mission execution* at the experimental platoon level?
  - Decision Accuracy
  - Decision Timeliness
  - Workload, Situation Awareness, Trust in Network

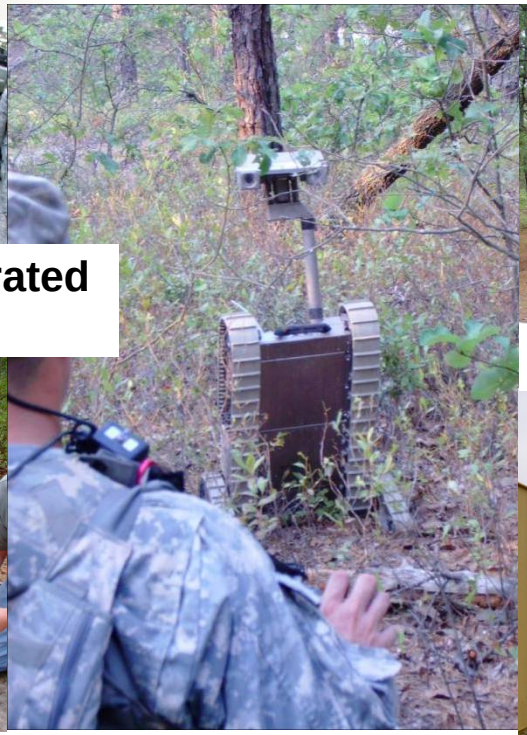
E08 Integrated C4ISR Architecture



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Field Study Setting

Manned and Unmanned Systems integrated in a network architecture



Urban and forested terrain

Day and Night missions

Live but scripted OPFOR

Instrumented vehicle fleet

Procedures

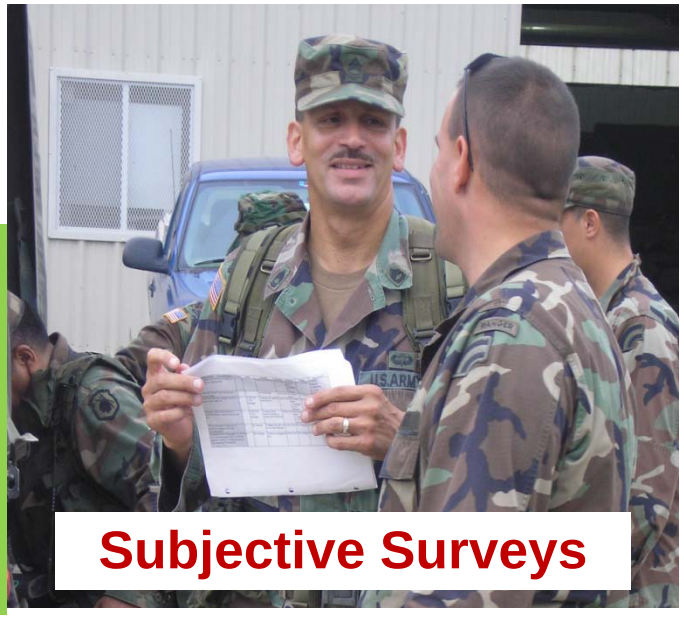
- Two platoons
  - FCS surrogate
  - Spin Out (SO) (legacy +)
- Live (scripted) OPFOR
- Priority Intelligence Requirements (PIR) sent during missions formed the basis for objective ratings of accuracy and timeliness
- Dependent Measures
  - Workload (NASA TLX)
  - Situation Awareness (MARS)
  - Trust in Network (new survey)
- Independent Performance Measures
  - Decision Accuracy
  - Decision Timeliness

Comprehensive Data Collection

Participant Observation

Triangulation Approach:

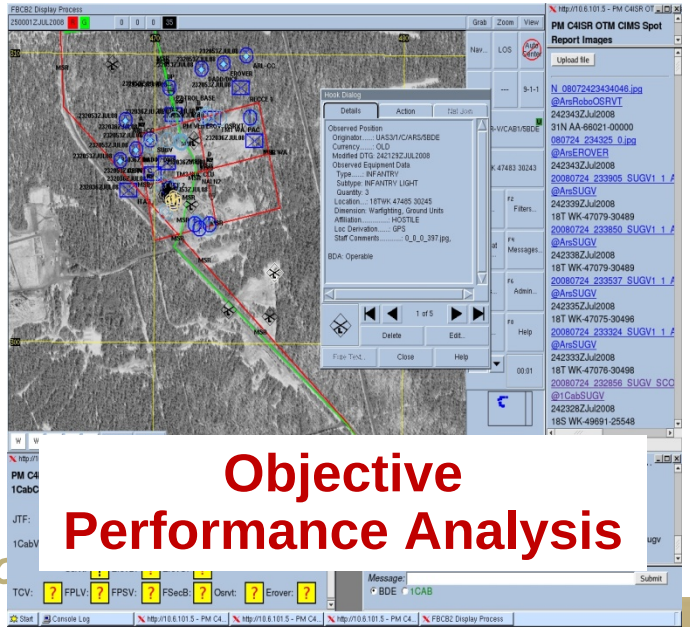
- **Observations/Interviews**
- **Subjective ratings of workload, SA, performance**
- **Objective Analysis of performance**
- **Soldiers completed feedback cards daily**



Subjective Surveys

Field Interviews Day & Night

How does network performance impact information available to Soldiers, and what is the impact of networked information on decision making?



Objective Performance Analysis

Communication Technologies

Spin Out Platoon

- In Vehicles:
  - Enhanced FBCB2
- Dismounted:
  - Warrior Application: display screen w/ BFT, spot reports, texting, collaborative white boarding, integrated w/ FBCB2.
  - Networked Javelin CLU
  - SUGV Packbot (stand alone)
  - UAV remote video terminals

FCS Platoon

- In Vehicles:
  - Enhanced FBCB2
- Dismounted:
  - Black Coral, allowed collaboration with TOC
  - Digital Alert Display Device: wrist-worn texting capability, built-in messages + original. Allowed comms w/i platoon and to higher echelon.
  - SUGV Packbot, integrated
  - UAV remote video terminals

Spin Out Platoon Comments on Dismounted Communications

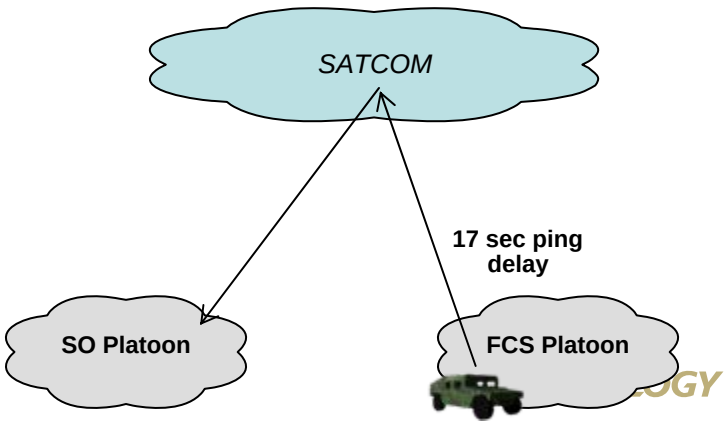
Spin Out Platoon Dismounted Comms Feedback 	• **Good ability** to see where everyone is at times. **Good sending spot reports.** • Device **worked well** today. Transferred to all but one of my leaders • Maps , messaging, spot reports **good** • Device only **used for SA between squads**. • Could not zoom enough to make a difference. • Devices **worked very well**. Free text worked some of the time. Certain people **could receive but not transmit**.– • died 1340 hrs. Way too many soldier icons to determine SA • **Radio communications good between Plt Leader and Bn Cdr** • Dismounted and mounted communications **good at Platoon level**. No company communications. • New map loads work better, **easier to distinguish positions** • Warrior Apps **worked great** - was able to stay behind cover while recording target house.

FCS Platoon Comments on Dismounted Communications

Technology	Observation
FCS Platoon Dismounted Comms Feedback 	• System is **hard to use** once you dismount, glare on computer screen makes it **hard to see**, it is **not with battlefield rhythm** and may **cause you to lose SA** • Device booted up then **crashed several times** during operations. Could not send SITREPS. • Device needs to be faster and more responsive. Needs to be able to send images to individuals of choice. Needs to be able to tell who wrote the messages. It **rarely worked to potential**. It was **hard to depend on**. It is **hard to type with the keys. Slow**. Never knew who wrote messages I received. • **2 of 3 devices did not send or receive messages**. The one that did seem to work sent out a spot report which was not displayed on FBCB2. • Device **did not work at all**. **Could not send or receive**. • **Display unserviceable and non-functional**. • I **think I was able to send**. **Did not vibrate for sending messages**. **Did not receive any messages**. Can't see screen at night with Night Vision Goggles. **Never communicated DADD to DADD**. Separate battery pack is **(not good).**

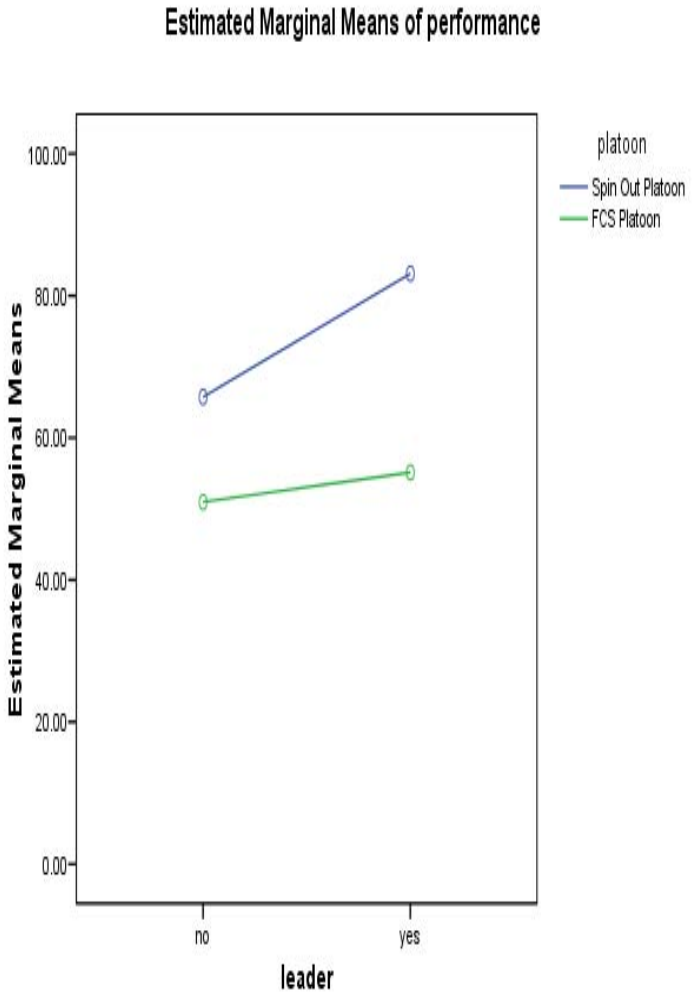
Computer Network Operations

- **Network Intrusion Attacks planned for both platoons**
- **Intrusions simulated delays, drops, and spoofing.**
- **CNO team provided a vehicle to replicate a captured node, was associated with the FCS platoon network.**
- **Attacks on the Spin Out platoon required the CNO team to utilize SATCOM to reach the SO network; this resulted in delays of 17 seconds.**
- **As a result, the CNO team was forced to focus on the FCS platoon only for attacks-original plans called for both platoons to be equally targeted.**



Workload

- **Repeated MANOVA**
  - one W/I factor (day) (no comparison between groups
  - two B/W factors comparing groups
    - platoon [SO or FCS]
    - leader [yes or no]
  - All interaction effects examined
- Significant main effect
  - Effect of platoon significant (*Wilk's* λ F (6,27) = 3.71, *p* =.008.
  - The platoons were significantly different in reported workload
- One dimension of the TLX 'satisfaction with own performance' was significant [F=17.54 (1,32) p<.005]
- Analysis: SO platoon, on average, scored their performance significantly higher (M=74.43) than the FCS platoon (M=53.04). This was true for leaders and non-leaders.



Average Workload Scores Comparing Leaders vs. Non-leaders

Estimates

Measure	leader	Mean	Std. Error
mental	no	43.461	3.871
	yes	52.206	6.743
physical	no	46.902	3.864
	yes	43.819	6.730
temporal	no	47.636	3.838
	yes	52.419	6.684
performance	no	58.356	2.542
	yes	69.113	4.427
effort	no	56.686	3.421
	yes	58.931	5.957
frustration	no	56.789	4.203
	yes	57.200	7.321

Leaders had higher mental workload scores than Scouts

Leaders had lower physical workload scores than Scouts

Leaders felt more time pressure than Scouts

Leaders had higher satisfaction with performance than Scouts

Leaders had higher overall effort scores than Scouts

Leaders and Scouts had nearly identical frustration scores

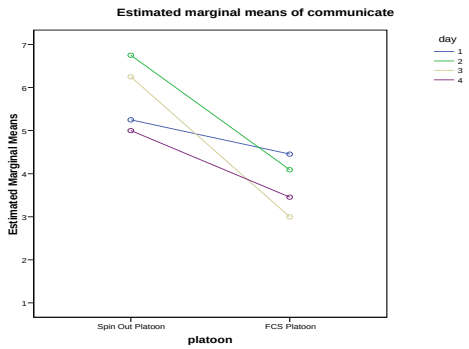
Trust in Networks

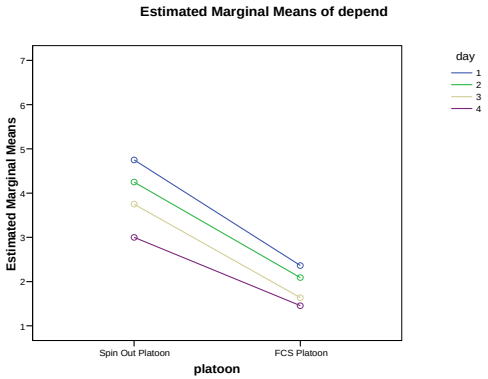
Tests of Between-Subjects Effects

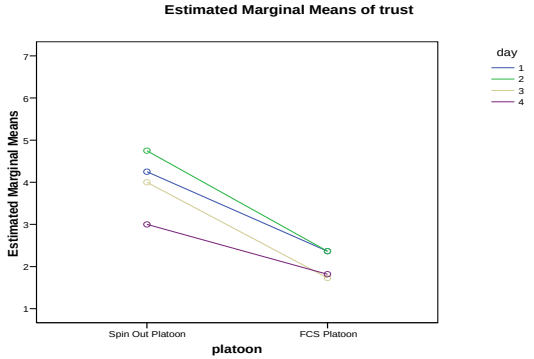
Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	access	440.183	1	440.183	38.213	.000
	communicate	1072.913	1	1072.913	139.218	.000
	depend	397.964	1	397.964	77.951	.000
	trust	432.055	1	432.055	74.844	.000
platoon	access	52.983	1	52.983	4.600	.051
	communicate	49.912	1	49.912	6.476	.024
	depend	49.364	1	49.364	9.669	.008
	trust	43.788	1	43.788	7.585	.016
Error	access	149.750	13	11.519		
	communicate	100.188	13	7.707		
	depend	66.369	13	5.105		
	trust	75.045	13	5.773		

- **SO Platoon rated ability to communicate, dependability, and trust in network significantly higher than FCS platoon.**
- **Why?**
  - **Cyber attacks**
  - **Better intra-squad communication device functionality**

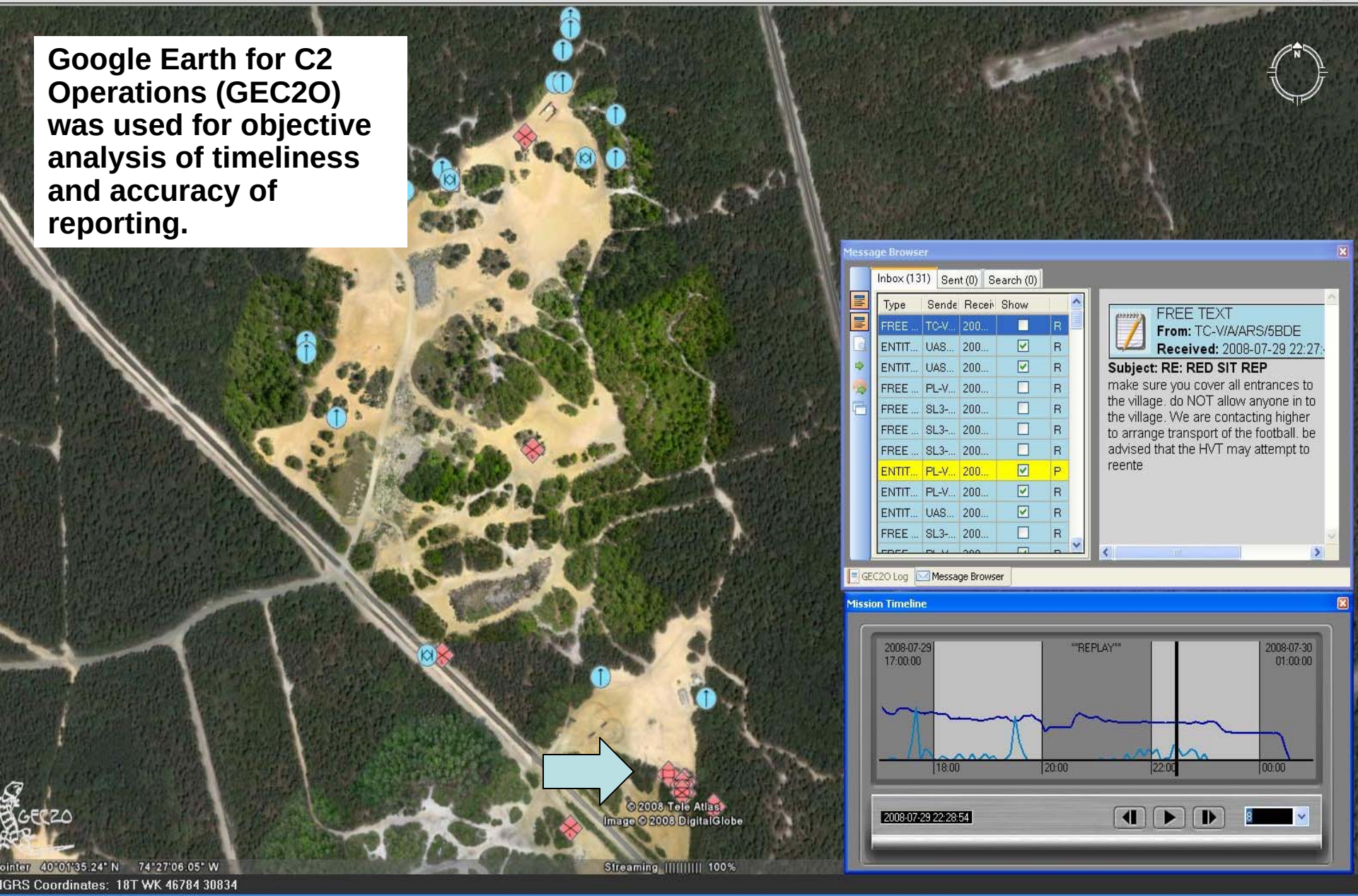






Message Gateway
Running

Google Earth for C2 Operations (GEC2O) was used for objective analysis of timeliness and accuracy of reporting.



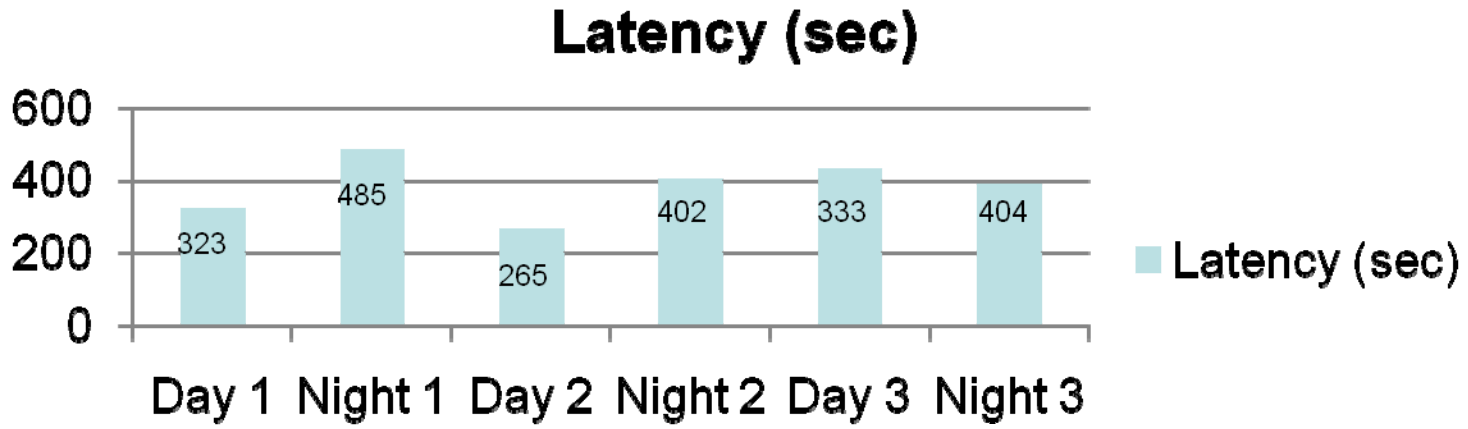
Objective Results of Report Accuracy and Timeliness

Report Accuracy

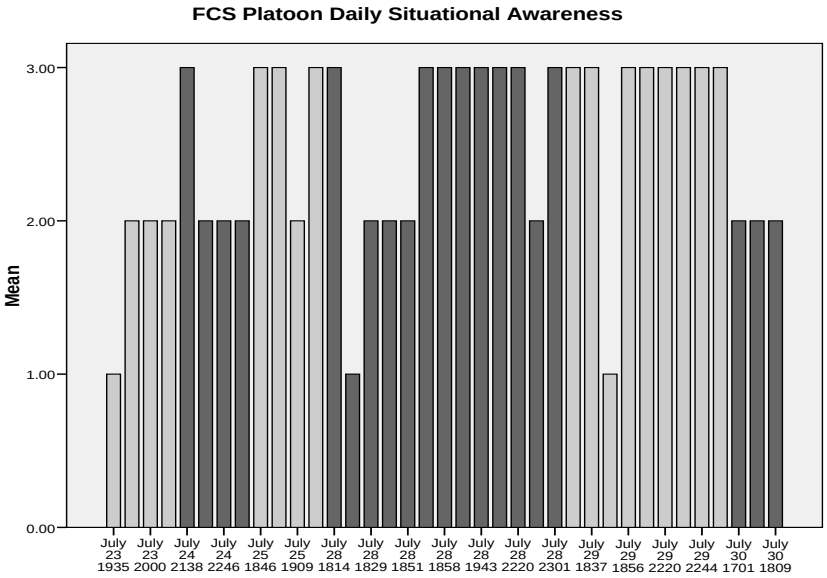
- Reports were within 90% of vehicle and personnel estimates
- Reported target locations were within 20 meters of actual enemy positions

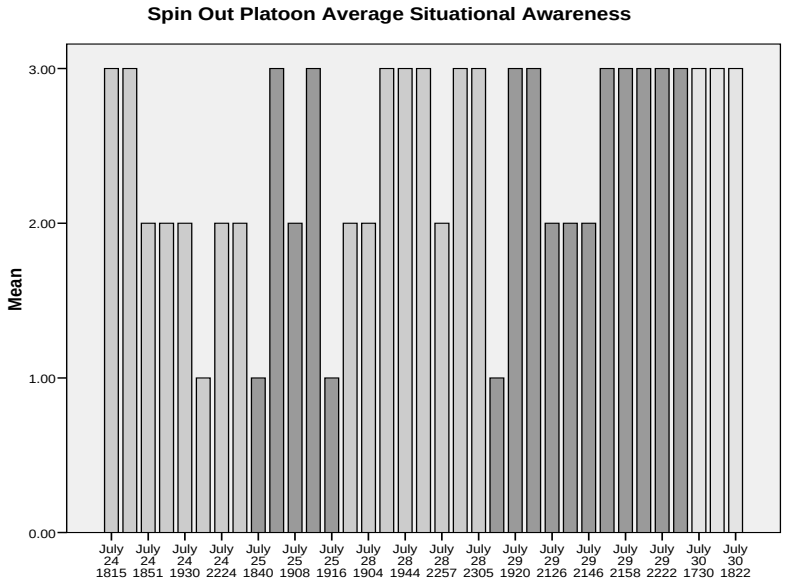
Report Timeliness

- Over 3 days/nights, average latency of messages was 6 min, 11 sec.
- Day missions had slightly shorter latency than night (not significantly different)



Objective Performance Analysis





Shaded bars represent one day's reports

- **SA reports of enemy activity scored by SMEs based on ground truth**
- **Scores were high, medium, or low based on reports of size, activity, location, uniform, time, and equipment**
- **Though SO platoon rated their subjective performance higher than FCS, the FCS platoon scored slightly higher in terms of objective performance (though not a significant difference)**
- **FCS platoon had a 92% rate of high reports compared to 88% for SO**

Recap of Results

- Subjectively, SO Platoon, on average, had higher scores for satisfaction with own performance and higher scores for trust in network communication, dependability, and overall trust.
- Objectively, the FCS platoon had higher ratings for SA as measured by their reports of enemy activity.
- Possible explanations?
  - Communication differences
  - Network Attacks

Adapted from West, Bowman, Rivera (2007) – ASO briefing to ASA(ALT)

Conclusions

- Soldiers' use of technology to see and communicate enhanced SA, at the cost of unacceptable latency.
- Frustration was a major feature associated with use of technology; as battlefield complexity grows we may need specialized experts such as the Robo NCO.
- Workload scores demonstrate the contribution that effective dismounted vehicle communications have on platoon SA.
- This integrated suite of C4ISR technologies, and prototype GEC2O analysis tool, provide solid foundation for further exploration of Soldier use of tactical networks and associated technologies.