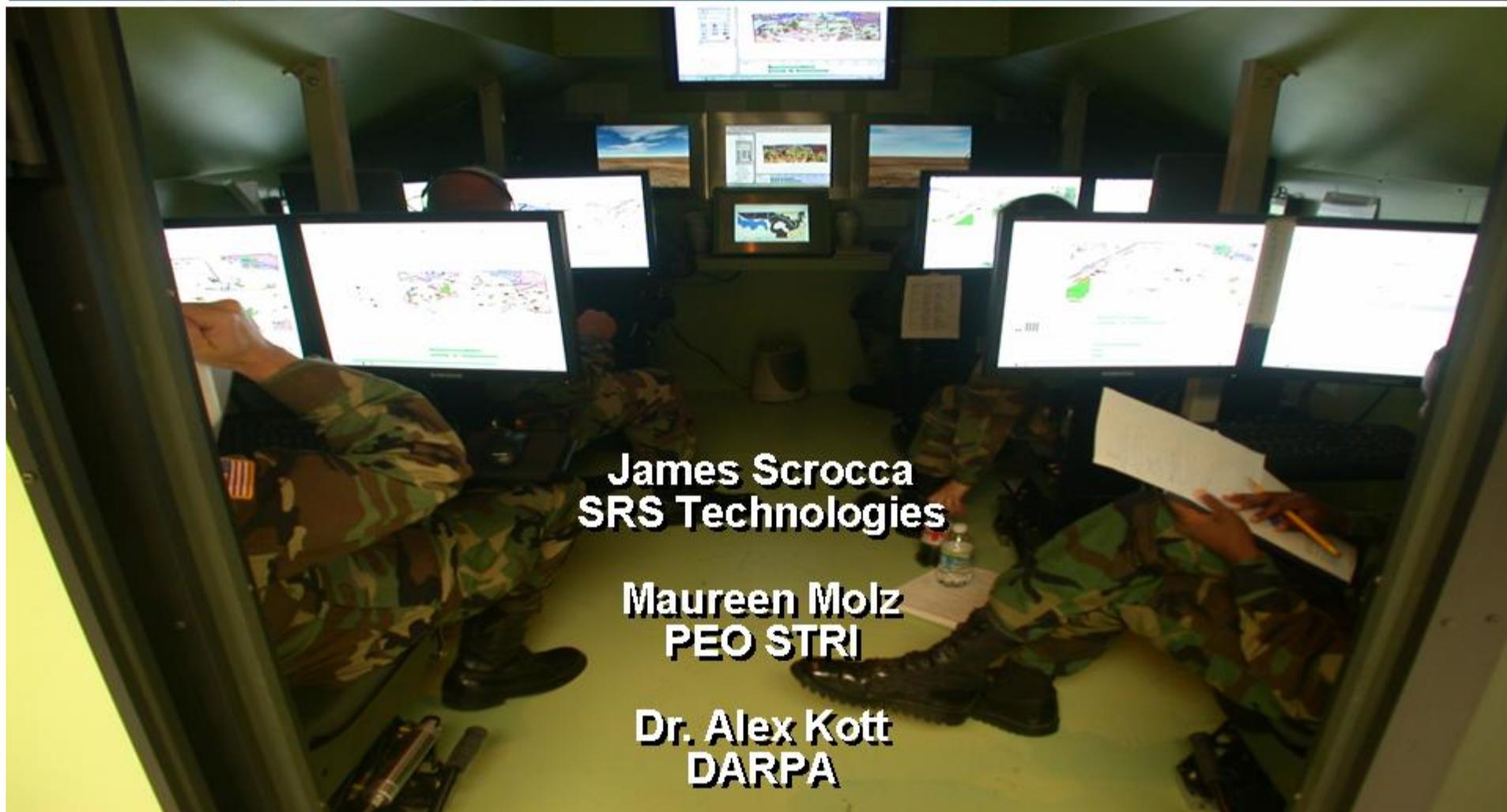


# Collaborative Awareness: Experiments with Tools for Battle Command



**James Scrocca**  
**SRS Technologies**

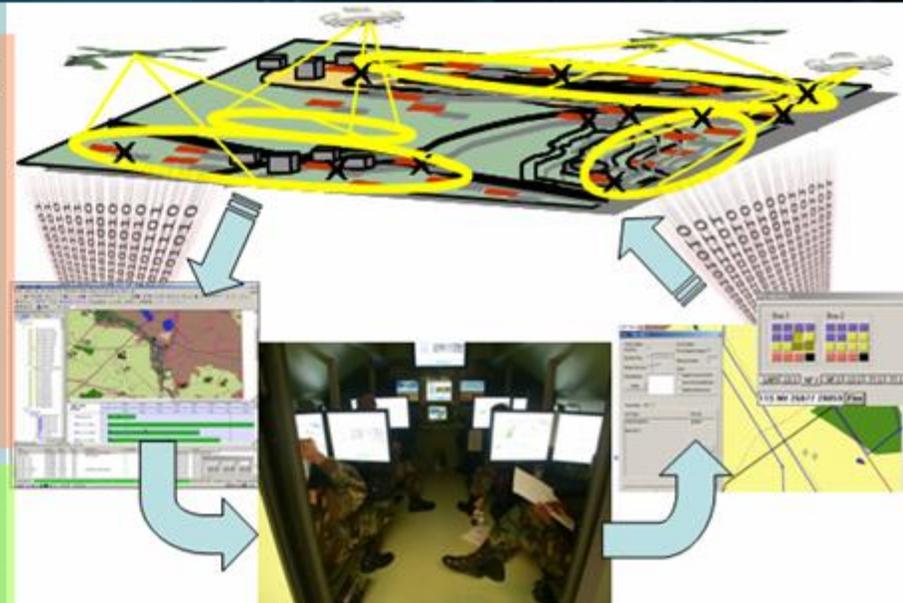
**Maureen Molz**  
**PEO STRI**

**Dr. Alex Kott**  
**DARPA**

Approved for Public Release, Distribution Unlimited

# Multicell and Dismounted C2 Program

- **Problem:** Current C2 system cannot support the information load and cognitive demands of future network-centric forces
- **FCS ORD KPP#2:** “The FCS Network must enable Battle Command and provide Situation Awareness to the manned platform and the dismounted soldier level”
- **Solution:** New human-machine system translates high-rate inflow of battlespace data into high-agility battle commands
  - **Integration and awareness tools** continuously and autonomously fuse data into high-quality shared situation portrait
  - **Execution tools** support human-controlled automation of intel, maneuver, fires, BDA
  - **Unified interface** enables rapid multi-functional command by small staff

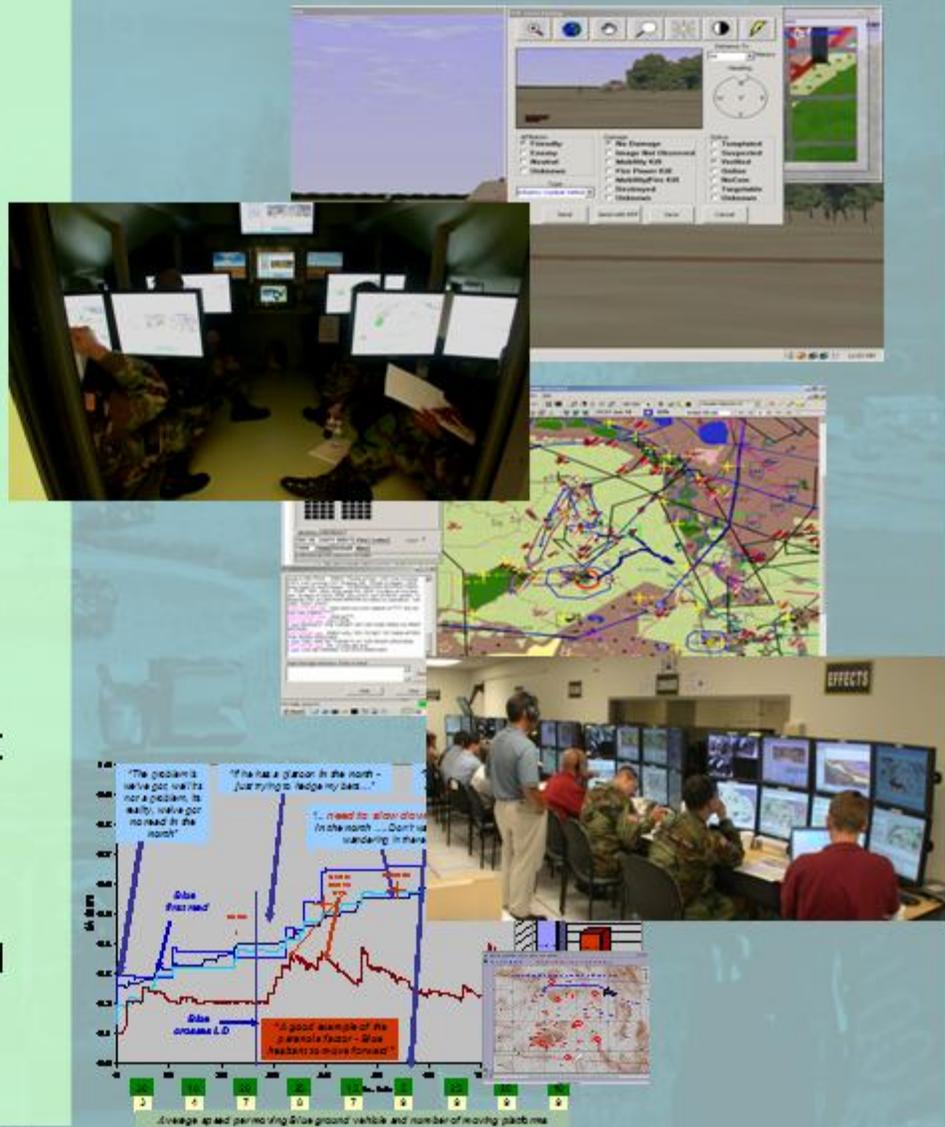


Evaluation by ARI: ABCS vs MDC2	ABCS	MDC2
Soldiers' rating which functions easier to learn	9%	74%
Soldiers' rating which functions easier to use	0%	91%

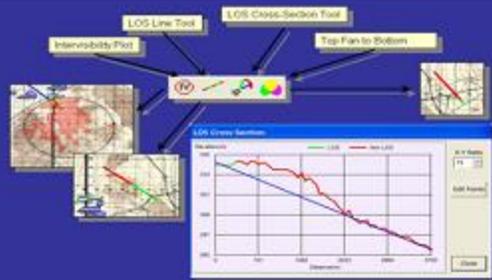
**New Battle Command Tools for Bn and Below**

# Program Elements: Breakthroughs in Experimental SA Analysis Lead to New Battle Command Tools

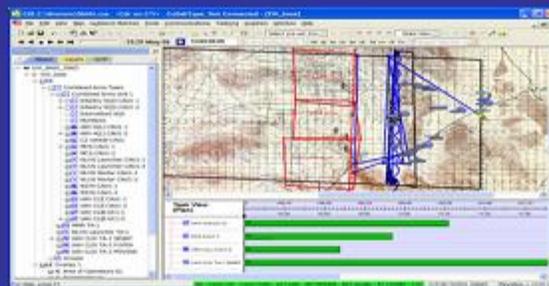
- Integrated Battle Command Support Environment (BCSE):
  - CSE: Commanders Support Environment
  - SSE: Soldier Support Environment
  - PSE: Platform Support Environment
- Integrated Federation Test Bed
  - SEM: Sensor Effects Model
    - I2WD SAR Image Generator
    - NVESD DVO/IR Image Generator
  - OTB: OneSAF Test Bed (enhanced)
  - SVS: Soldier Virtual Simulator
    - Full immersive stand-up simulators
    - Desktop stations
- Extensive System Experimentation to Test Prototype
  - Detailed System Performance Data and Analysis
  - Detailed Cognitive Performance Data and Analysis



# Battle Command Execution Tools



Line-of-Sight Tools Enhancing Commander's battlefield visibility and awareness



Situational Awareness (SA) capabilities enhancing the Commander's Quality of First

Attack Guidance Matrix

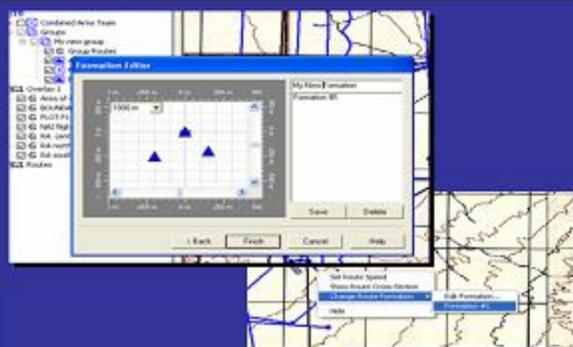


Quick Fire Capability

Visualize Fires



Each capability allows the Commander to automatically control networked fires and effect high payoff targets quickly



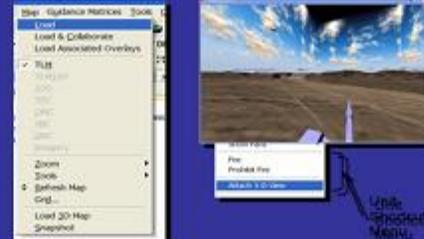
Maneuver Tasking and Group Formation for Control of Subordinate Assets



Commander utilizing CSE in the C2V Prototype



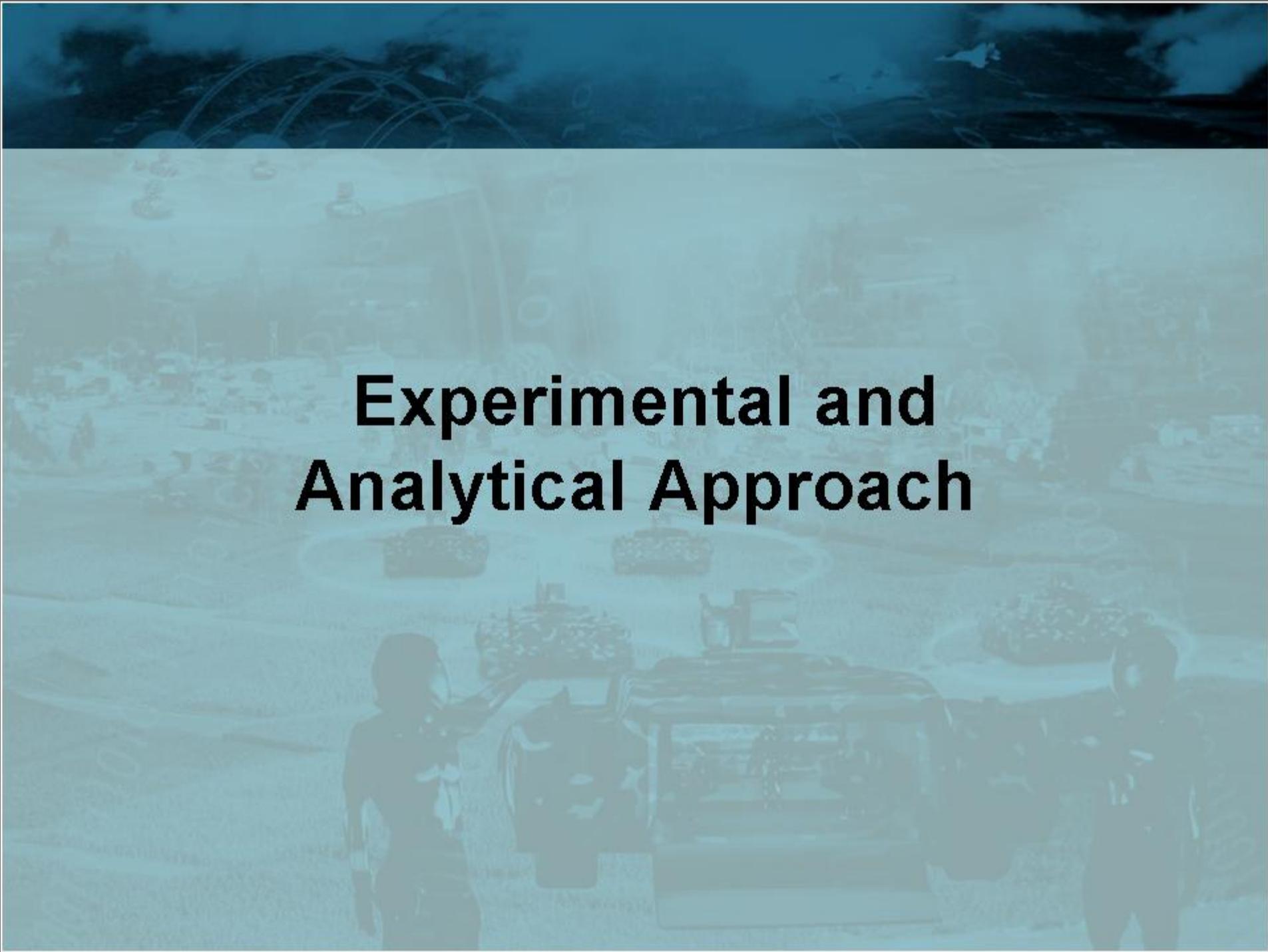
Individual and Customizable Graphic Control Measures (GCM) and Task Organization (TORG) Capabilities



Multiple views of the Battlefield in both 2D and 3D



Human Target Recognition and BDA via Unit Viewer



# Experimental and Analytical Approach

# Experimental Execution Process



BLUEFOR Individual/Collective Training



White Cell Control



Intel Officer re-tasking UAV



OPFOR Training



After Action Review



Dismount Cave



Post Run Focus Group



C2V in the fight!



Data Collection/Analysis



VIP Control



Observer Station for C2V

# Experimental Objectives

- **Continue Exploring Battle Command**

Spirally develop a multi-echelon, knowledge-based reasoning enhanced, C2 prototype model of a “net-centric” battle command system. Through experimental investigations that measure the effectiveness of its integrated battle command functions, inform the future force “Quality of Firsts” providing Commanders the decisive edge.

Current Arch.

Exp 7 Jan '06 – M&D C2 “ . . . Continue to investigate networked battle command for the Combined Arms Team (CAT)” To be Completed

Exp 6 Jun '05 – M&D C2 “ . . . investigate networked battle command for the Combined Arms Team (CAT) facilitating decision making and mission success across multiple echelons”

Improved Arch.

Exp 5 Oct '04 – M&D C2 “ . . . investigate challenges associated with integrating the dismounted Soldier into a networked Battle Command System”

Exp 4a Oct '03 – Unit Cell “Improved See/Move/Strike/Sustain” – Phase II

Exp 4 Mar '03 – Unit Cell “Improved See/Move/Strike/Sustain” – Phase I

Initial Arch.

Exp 3 Sep '02 – Unit Cell “Improved See/Move/Strike & Sustain”

Exp 2 May'02 – Unit Cell “See/Move & Strike”

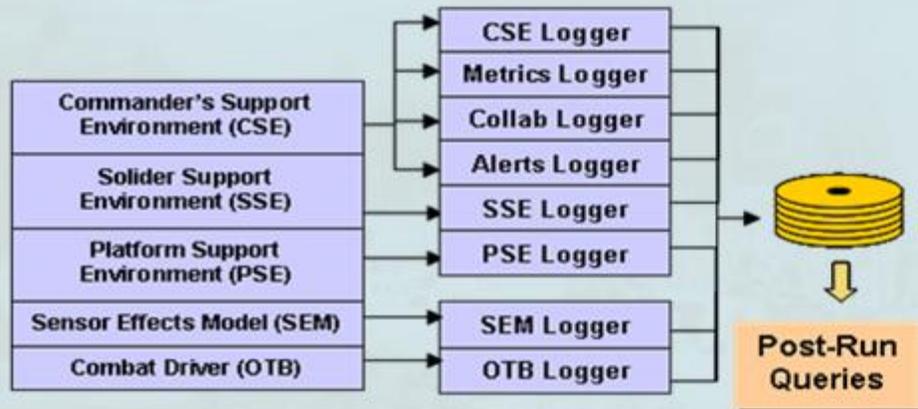
Exp 1 Dec '01 – Unit Cell “ See and Move”

M&D C2  
Building on  
DARPA  
FCS C2

# Data Collection Methodology

## • M&D C2 Data Collection & Analysis

### Automated Data Collection



### Player Input



Video tapes

After Action Reviews

Audio logs

Survey/Questionnaire

### Observer Data Collection

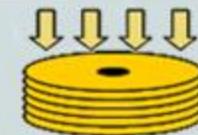


Ability to eavesdrop or talk among observers



OTB Ground Truth

Multiple Screens for BFA monitoring across teams & echelons



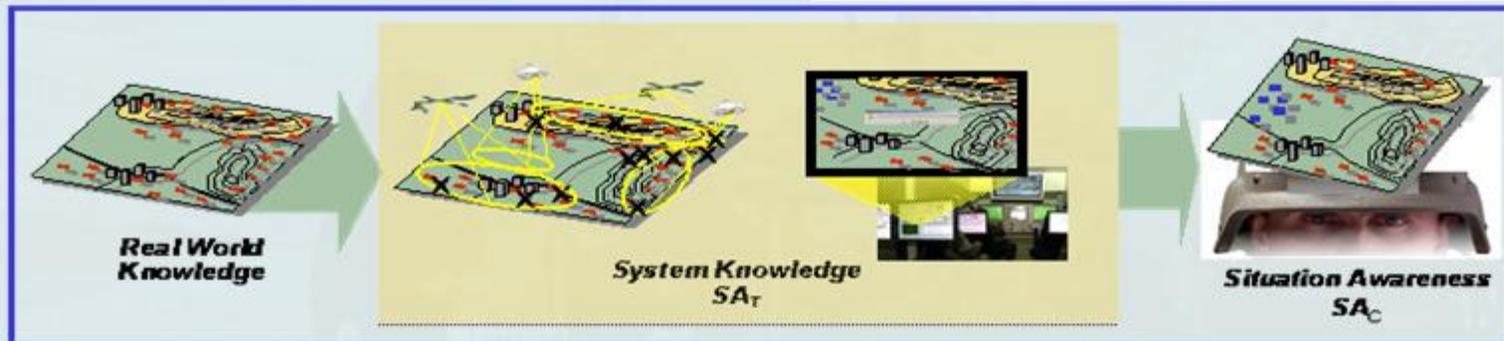
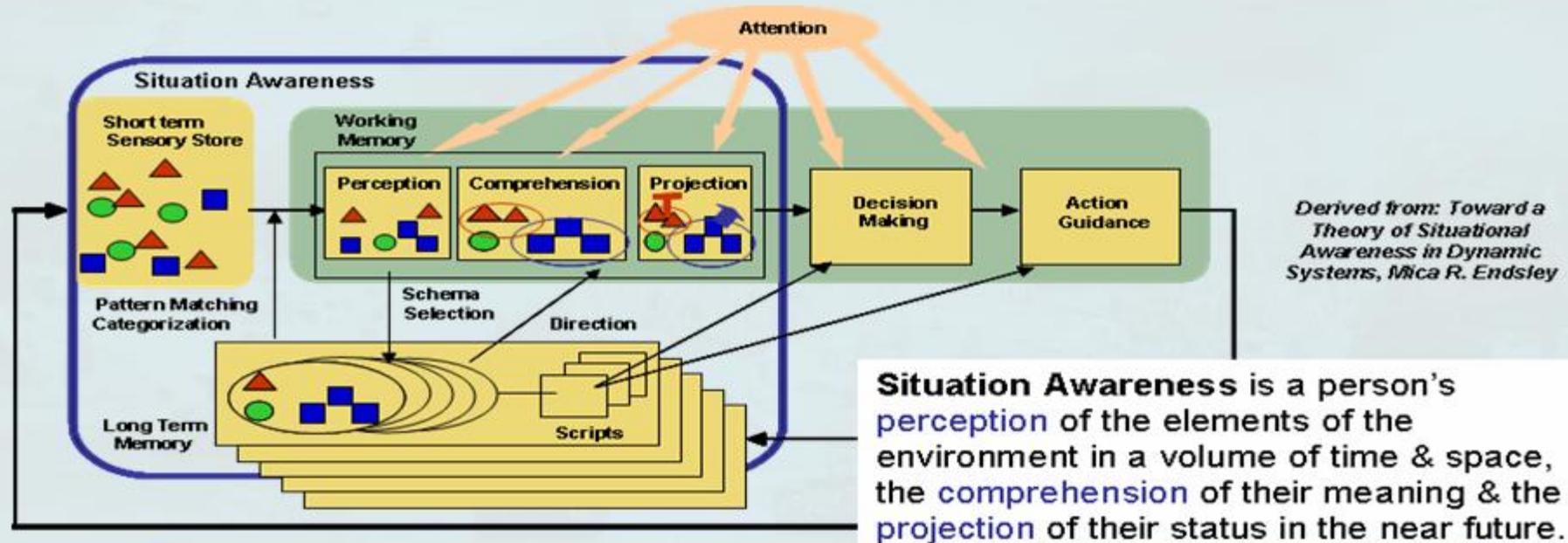
Post Run Queries

• Comprehensive

• Multi-faceted

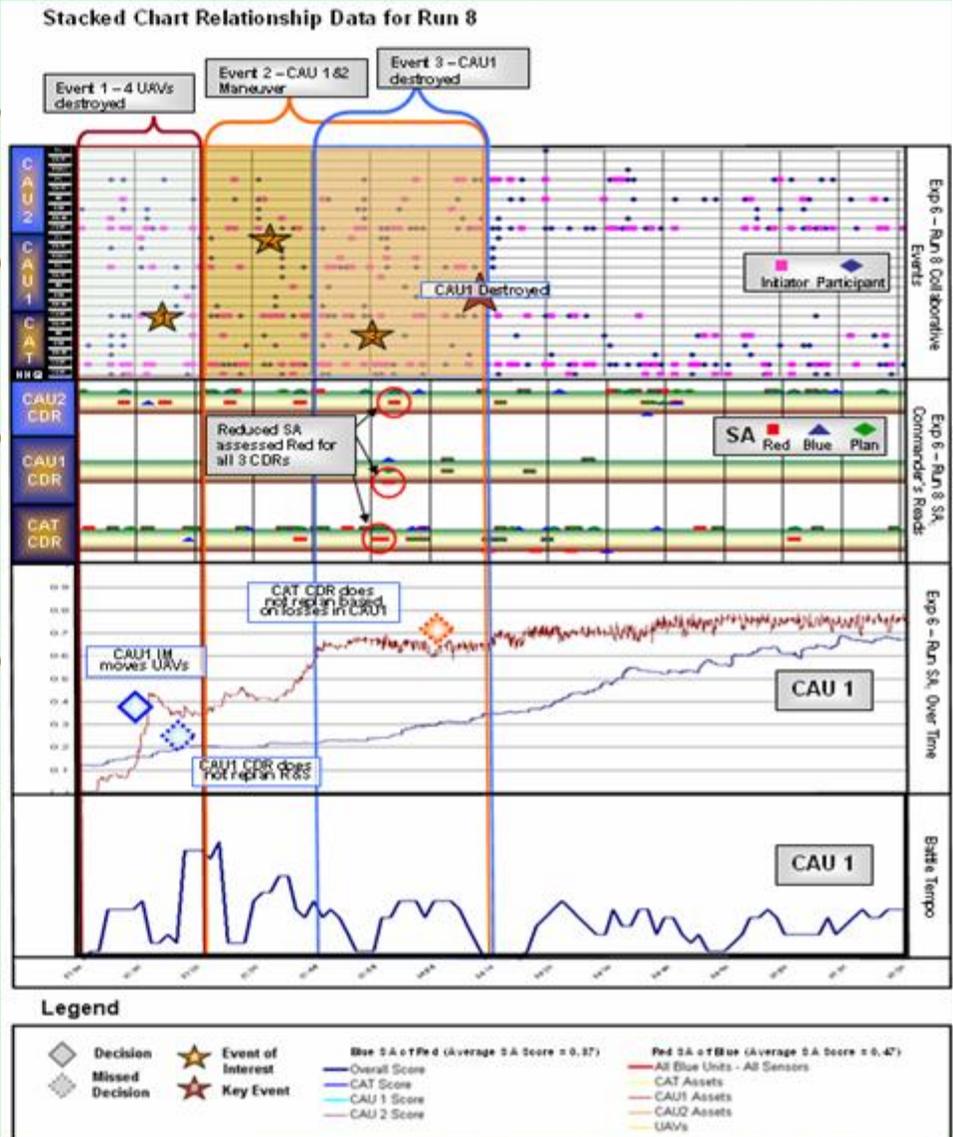
• Driven by the EEA

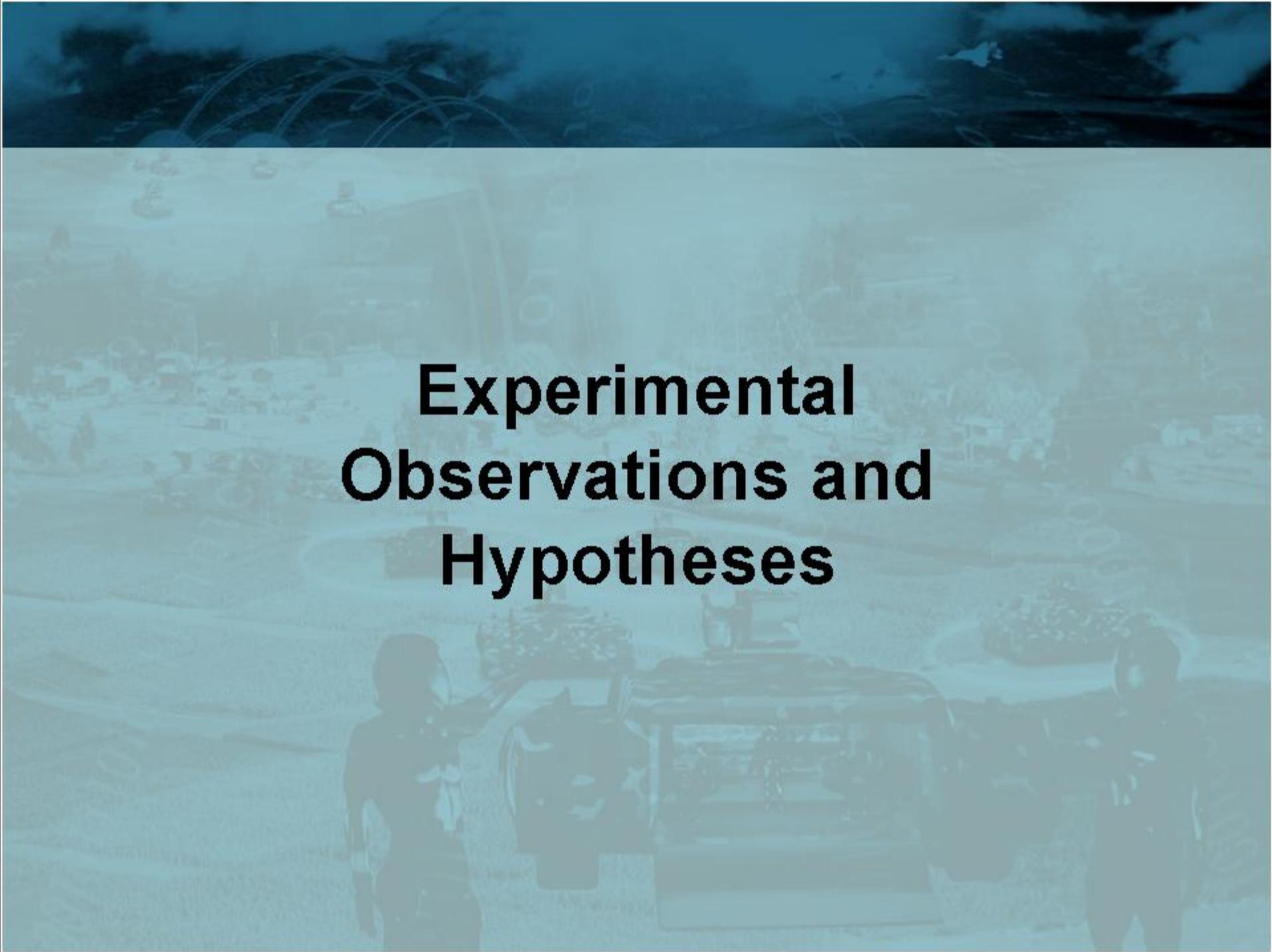
# Exploring Situational Awareness



# Analysis of Collaborative Cognitive Processes

- Identification of events of interest for process tracing.
- Observations regarding collaborations that occurred among the operators and commanders.
- Analyst assessments of the level of understanding ( $SA_c$ ) communicated by commanders in collaborations and directed reads.
- System Knowledge score ( $SA_t$ )\* by echelon – Blue of Red and Red of Blue.
- An assessment of the battle tempo of the force based upon the actions being taken to fight the battle over time.





**Experimental  
Observations and  
Hypotheses**

# Situational Awareness has Critical Impact

## Insight:

**Difference** between Red and Blue **System Knowledge ( $SA_T$ )** was a **key predictor** of battle outcome.

$$SA_T = \text{System Knowledge} \\ = f(\text{location, acquisition, state, priority})$$

## Notes:

- Limiting Red's ability to see was critical. Red  $SA_T$  routinely increased during the close fight.
- As the detection of HPT increased, so did the potential for favorable battle outcomes.
- Every Run had periods of rapid, gradual or no growth in  $SA_T$ .



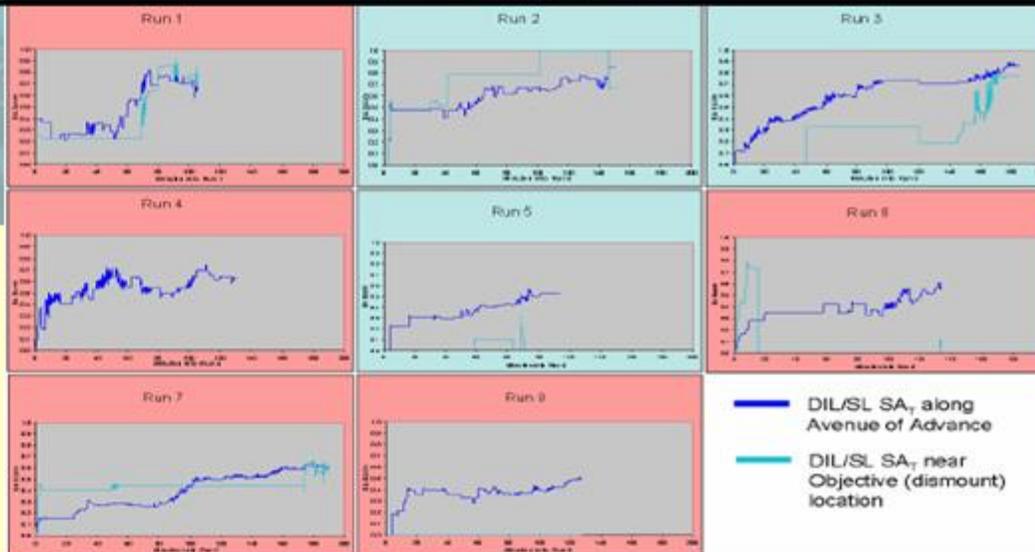
*"...FCS equipped organizations must understand and act in the battlespace ... rapidly and accurately while denying the same capability to the enemy."  
FCS ORD para 1.1.5*

## Insight:

The number of **undetected lethal threat systems** that are positioned along the **avenue of approach** is a **predictor** of battle outcome .

## Supporting Data:

- In runs where blue was victorious there was an average of 10 MDTs identified in the analysis – of these 1 was undetected during the run.
- In runs where red was victorious, there was an average of about 17 MDTs with 4 undetected.



# Counter Recon Fight Can Determine Situational Awareness

## Insight:

When either force is able to *gain initial information advantage* (higher  $SA_t$ ), the opponent is unlikely to recover .

## Supporting Data:

In Runs 4 and 6, Red's mission was to exfiltrate from Azerbaijan to Iran, and was less focused on conducting the counter reconnaissance fight. These Runs were assessed as "Advantage Blue."



## Supporting Data:

In Runs 5 and 8, Red's ability to obtain early intelligence of the Blue Force by positioning their forward reconnaissance element proved to be a decisive component in the battle.



# More Concern, Attention to Information

## Insight:

*Information Acquisition* emerged as the focus of *Commander's concern*. Commander focused on *managing sensor assets*, delegated other tasks.

## Supporting Data:

- Over 50% of all decisions were made to acquire information.
- “Seeing” was considered the hardest task.
- “Firing” was considered the easiest task.

	Automatable	Adjustment	Complex	Total
Move	3	37	4	44
See	32	49	0	81
Strike	8	35	5	48
Total	43	121	9	173

### Decision Focus and Content

- *Move* - the movement of organic assets (25%).
- *See* - the development of the intel picture (47%).
- *Strike* - the application of effects (28%).

- All articulated choices were recorded as decisions.
- 173 decisions were observed over 8 record runs.
- Of 32 Automatable-See decisions:
  - 13 involve sensor allocation and positioning.
  - 5 involve changes to sensor mode (MTI/SAR).
  - 11 involve cross-cueing different sensors.
  - 3 involve micro UAV use to enhance BDA.

### Decision Types

- *Automatable* – all variables known or can be calculated, something a computer can do (25%).
- *Adjustment* – mostly known variables within the plan context, requires human judgment (70%).
- *Complex* – requires definition of options, criteria and decision process (5%).

## Insight:

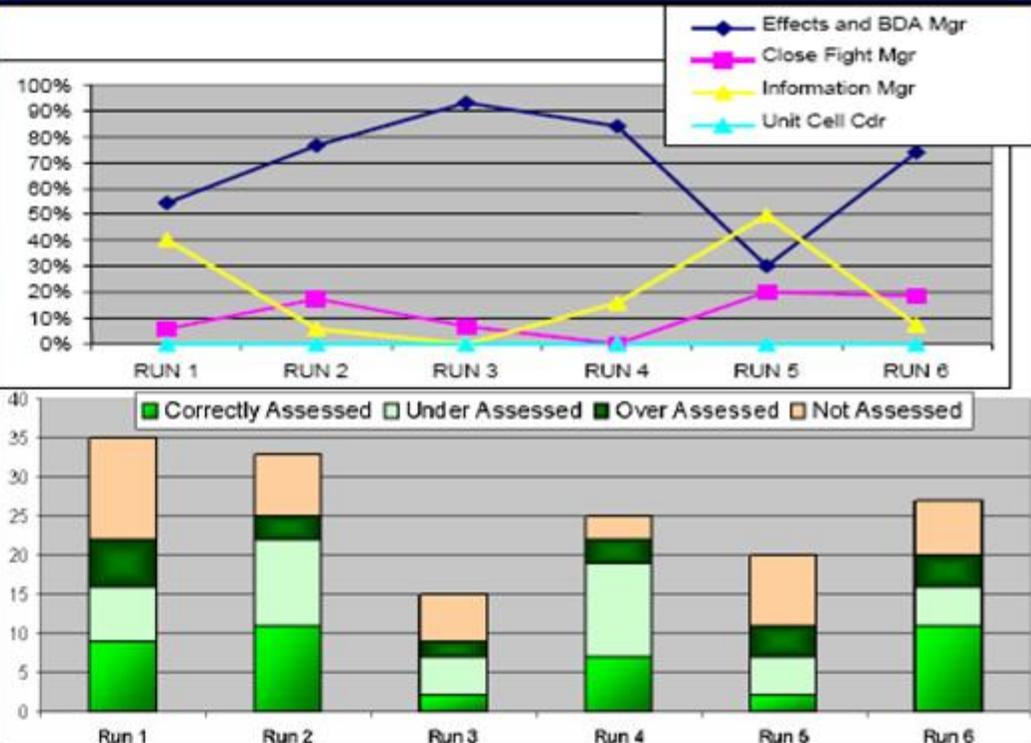
*Command Staff* found that *BDA* has grown as a *critical and most demanding* task and a *key detriment to SA*.

## Notes:

- Difficulties in assessing the ‘state’ of engaged targets significantly degraded the level of SA<sub>T</sub>.
- Without effective BDA, the forces slow down and engage targets multiple times – inefficient use of assets.

## Supporting Data:

- Less than 30% of attempted assessments were correct.
- 40-50% of all missions are re-engagements.



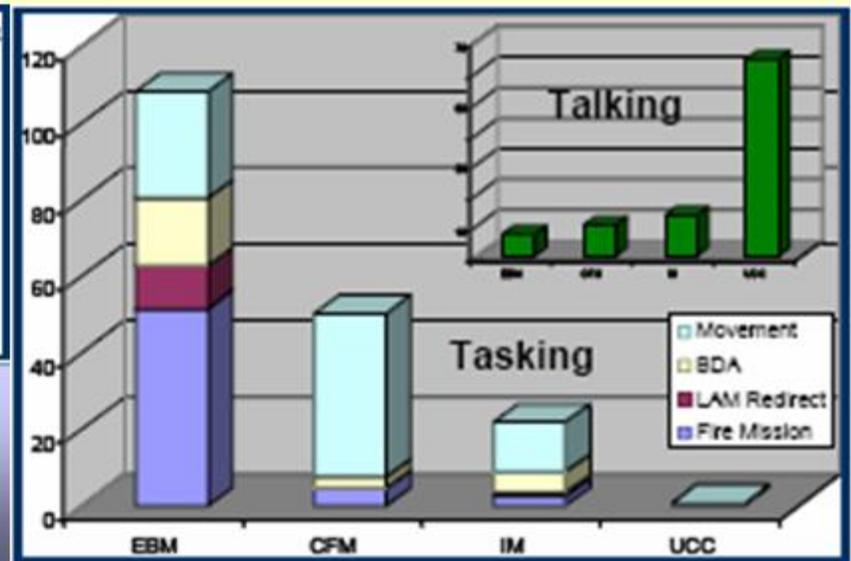
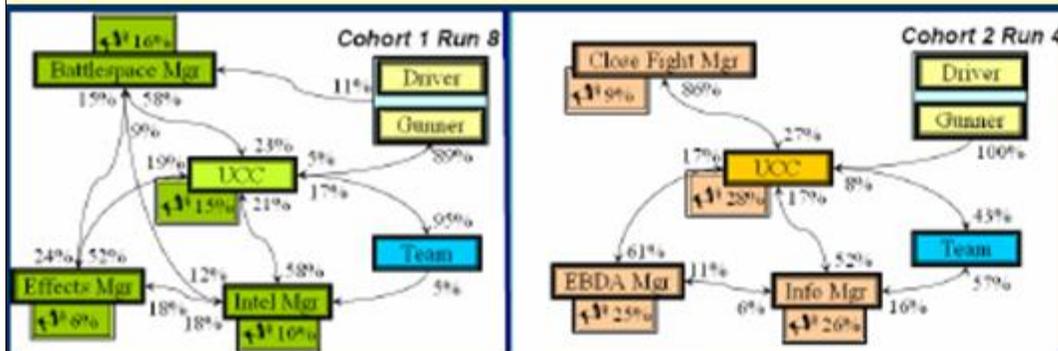
# Flexible Re-Organization is Well Supported

## Insights:

- **BCSE** allowed the *staff to be multi-functional* and *share* all available *information and functions*.
- **BCSE** allowed the *staff to self-organize* their respective *roles, functions and communication patterns* as mission and personnel characteristics required.

## Notes:

- There are noticeable differences in the decision-making organization and processes of each Commander and staff.
- The number and focus of the decisions made as well as the patterns of dialogue and collaboration vary.



BCSE is able to accommodate the differences in the decision-making approaches of various commanders and staff members and enable each to execute the assigned tactical mission.

# Seeing is Far From Understanding

## Insights:

- **Command staff** has a *hard time believing* the available *correct information*.
- **Commanders** do not appreciate the lack of SA. They *overestimate their SA*, partly because the CSE lulls them into false security - "I can see it all."

$SA_C = \text{Situational Awareness Cognitive Component}$   
 $= \text{Human Understanding of } SA_T$

## Supporting Data:

- Limited correlation between  $SA_T$  and  $SA_C$  – assessment of available information skewed by "belief persistence".
- Commander assessment of available information was correct approximately 60% of the time.

Time	UCC's Statement	Read Element	Assessment
12:55	"I'm not seeing much change in the situation at this time. Still believe the enemy was trying to show some force in the north sector and the choke point to deter my movement there. Still seeing minimal in the southern corridor and the central corridor looks pretty clear except for those two forward elements that we engaged. I believe the enemy is still defending deep."	a. not much change b. show force in the north to deter Blue movement c. minimal force in the southern corridor d. enemy defending deep	Correct Correct Incorrect Incorrect
23:09	"I'm still think the enemy is deep."	a. no change	Incorrect
24:57	"I'm thinking he is buying it [deception] because he's moving forward in that southern sector. He may be buying it and he may not be."	a. Red moving forward	Incorrect - movement is neutral LAVs, not Red
41:48	"The read hasn't changed much..." Team Cdr: "Do you still believe he is defending deep?" UCC: "Affirmative."	a. no change	Incorrect
57:30	"I think he's probably figured out that we're moving by now."	a. Red knows Blue is moving in the central corridor	Correct

## Insight:

*Seeing-understanding gaps* often manifested in *poor synchronization of information and movements*.

## Notes:

- Experiments shown frequent commander's over- and under-estimates even with extensive info available
- Over-estimate of threat results in unnecessarily slowing down the force to acquire more information
- Under-estimate of threat causes the force enter into the LOS fight without sufficient information making blue more vulnerable.



# Collaboration Can be Extensive and Effective

## Insights:

- Experiment # 6 demonstrated consistently very high level of task and asset sharing between and across echelons
- Staff members created “Special Interest Groups” and engaged in extensive cooperative tasking and assets usage

## Supporting Data:

Functional Group	Run	Observations made	Collaboration for Assets (Calls for Fire)	Other Collaborations
Fires - (EM)	4	26	12	14
	5	33	9	24
	7	24	9	15
	8	23	8	15
			106	38
			35.85%	64.15%

Functional Group	Run	Observations made	Collaboration for Assets (Requests for Coverage)	Collaboration of Information	Other Collaborations
Sensors - (IM)	4	49	5	24	20
	5	36	6	10	20
	6	36	7	14	15
	7	16	1	5	10
	8	29	3	13	13
		166	22	66	78
			13.25%	39.76%	46.99%

## Insight:

- Implicit or tacit collaboration can be extremely effective

## Supporting Observation:

- Observed for numerous runs - CAU2 Effects Manager developed a technique for utilizing other echelon's LAMs when CAU2's munitions were running low:
  - By using tools within the BCSE, the CAU2 EM would monitor the fuel status of LAMs within CAU2's Area of Interest.
  - When a LAM was running low on fuel, the EM would send a request to the owner to use the LAM on a specified target with her AOR.

# Collaboration Can Also be Detrimental

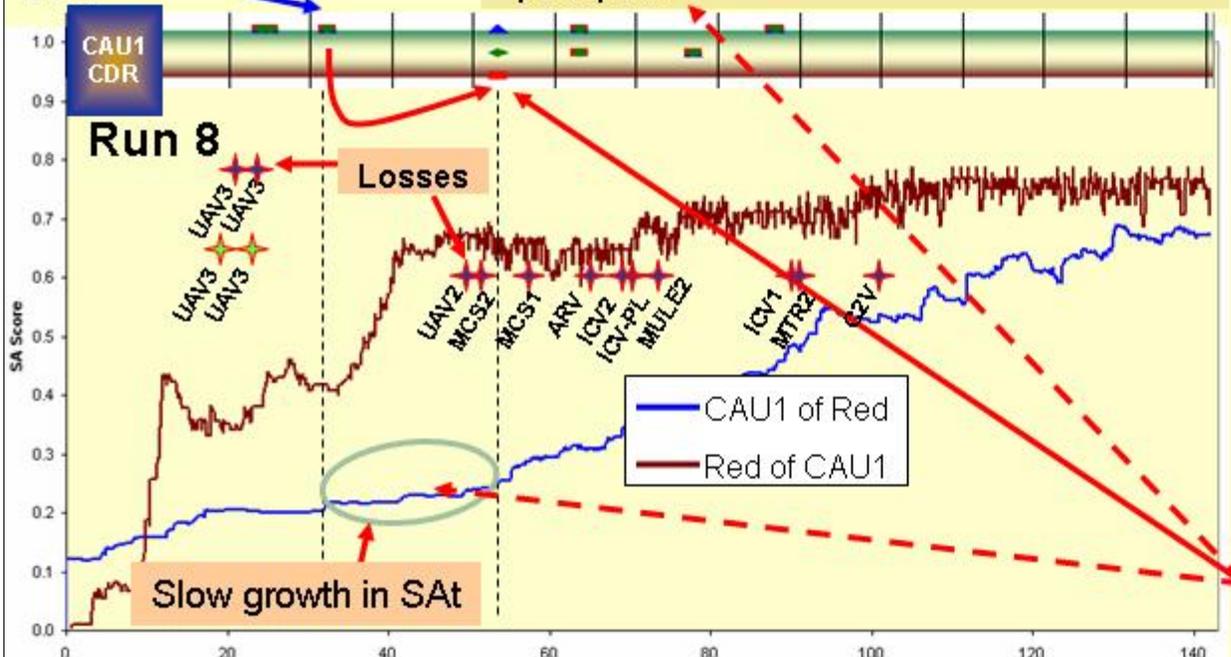
CAU1 CDR was walking into a massacre, yet other echelons never paid attention or raised a concern. Collaboration can reinforce an incorrect perception by apparent acquiescence by other decision makers. Information gaps are not appreciated by individual CDRs, and collaboration does not help to alleviate that.

- Out of 7 episodes of Exp6 analyzed, 3 produced improved SA, 2 – distracted the DM from the more critical focus, 2 – led the DMs to reinforce the wrong bias

**H + 32: Panther 6 and Tiger 6 collaborate on understanding of Red plan. Panther 6 assessment was, "Enemy is executing Most Dangerous COA"**

## Confirmation Bias via Collaboration

**H + 38: Cheetah 6 – "... enemy is further North by Northeast than anticipated. I suspect his intent is to defend heavy forward."** This was an incorrect perception



## Collaboration Misdirecting Attention

**H + 44: Tiger 6 – "... chief you got to hold that guy in the North – PURGA! Purga in the South."**

**Tiger 16 – "6 be advised, lots of vehicles Town 17, lots of vehicles."**

**Tiger 6 – "Roger, what about Town 25? (Preliminary Objective) ...**

**"Where is Town 17?"**

**(Western flank, off of Tiger 6 display)**

## Unnecessary Collaborations

**H + 45: Tiger 6 – "... you're taking arty, keep moving boys."**

**Panther 6 – "You're taking indirect Tiger."**

**Tiger 16 – "6, be advised t here's indirect around you, I don't know if you can see it or not."**

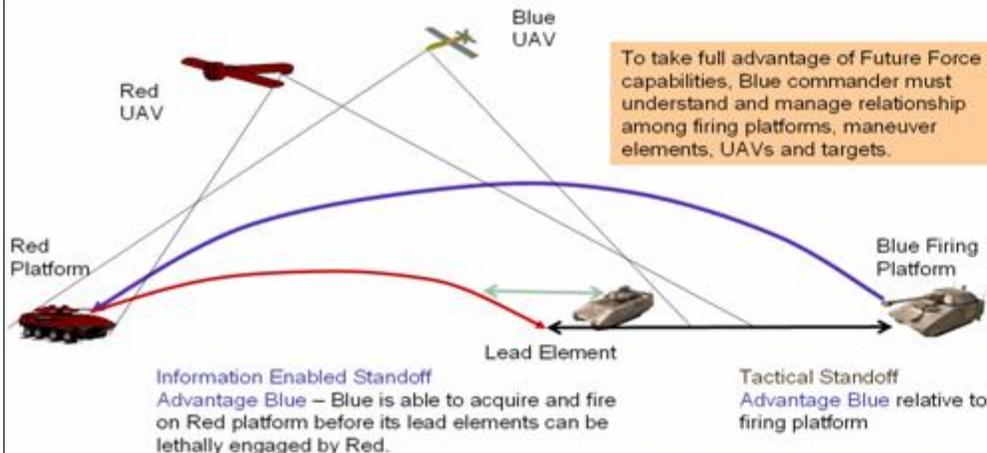
## Lost Understanding

**H + 52: Tiger 6 – "... I'm not seeing any counter attacking forces moving towards us. I think the majority of his (Red) forces are in the Cheetah sector."**

# Information Standoff is Difficult to Control

## Insight:

- Blue maintains *information and tactical standoff* by *detecting and engaging* enemy targets before entering Red's lethal range.
- Commanders must *orchestrate* the synchronization of *maneuver and sensor platforms* to maintain *information and tactical standoff* with their lead elements.



## Supporting Data:

- The distance to the nearest Blue ground platform when Red units were engaged gives an indication of the relative standoff when Red is being engaged.
- 82% of the detected Draegas in Run 8 were first engaged when Blue had a platform within 8 km. A clear indication that standoff had not been maintained.
- About the same percentage of Red platforms detected in each run; difference is the distance at which identifications and engagements are made

We see an emerging concept in which commanders may need to consider additional factors to take full advantage of the tactical standoff afforded by Future Force fires.

**% of Platforms First Engaged with Blue ground element within lethal radius of Red**

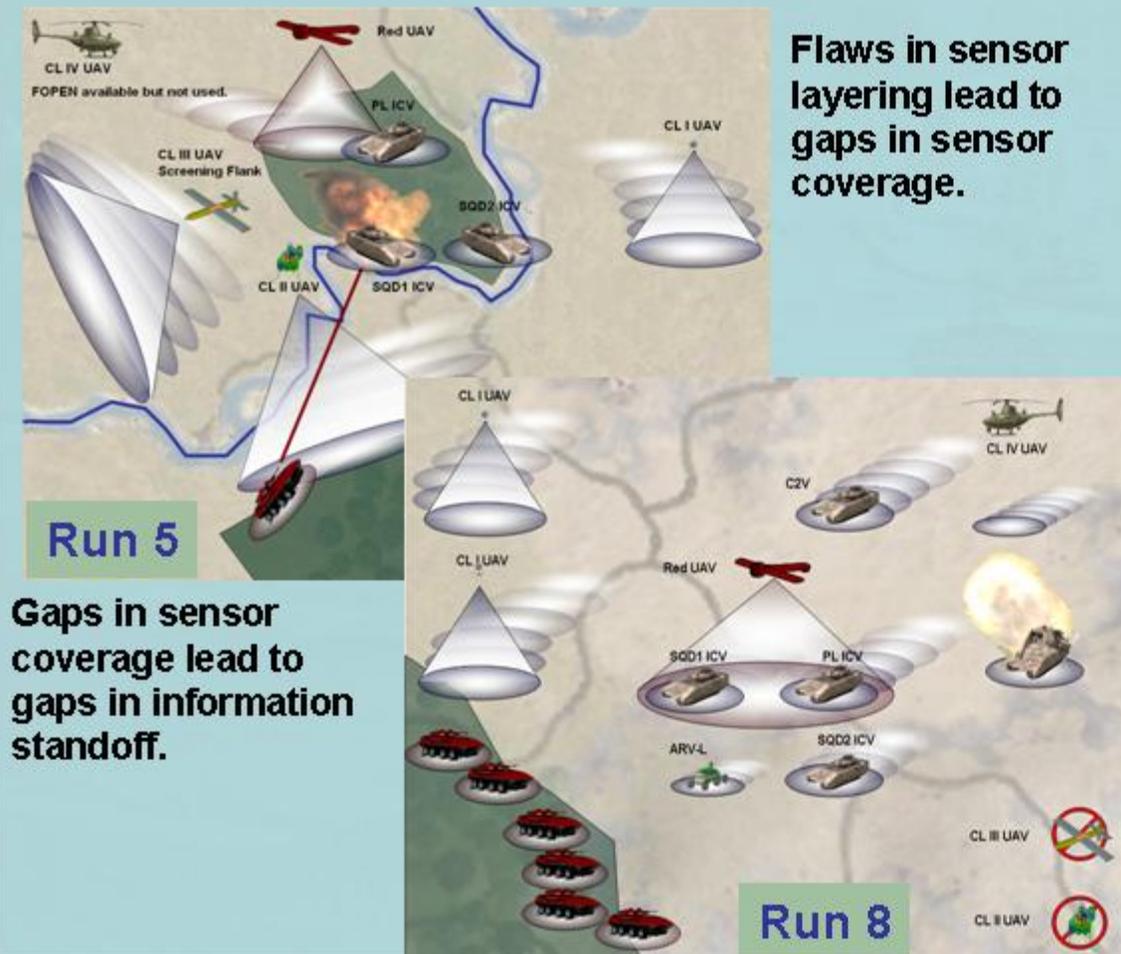
Type of Red Platform	Max Lethal Range(m)	% of Platforms First Engaged with Blue ground element within lethal radius of Red				
		Run 8	Run 7	Run 6	Run 5	Run 4
NONA	8,850	60%	75%	29%	50%	17%
DRAEGA	8,000	82%	29%	7%	39%	18%
GARM	8,000	29%	100%	14%	22%	7%
OREL	8,000	50%	0%	25%	100%	0%
<b>All Included Systems</b>		<b>58%</b>	<b>61%</b>	<b>15%</b>	<b>36%</b>	<b>11%</b>
<b>Advantage</b>		<b>Red</b>	<b>Red</b>	<b>Blue</b>	<b>Draw</b>	<b>Blue</b>
<b>% of Red Platforms Detected</b>		<b>59%</b>	<b>28%</b>	<b>52%</b>	<b>56%</b>	<b>55%</b>

“Future Force fires support tactical maneuver by achieving greater destruction at standoff.” – TRADOC Pam 525-3-90 O&O, p4-66.

# It is Hard to Know What We Know and Don't Know

## Insights:

Commander and staff had difficulties tracking the extent and timing of the sensor coverage available in different part of the battlefield. They did not know what they had seen and what they had not.



Flaws in sensor layering lead to gaps in sensor coverage.

Gaps in sensor coverage lead to gaps in information standoff.

**Note:** Critical gaps in sensor coverage were commonly unnoticed by commanders. The gaps enable Red to obtain positions of advantage and engage Blue.

**Recommendation:** The Commander must maintain *appreciation of sensor coverage* in order to maintain his SA Advantage and needs functionality regarding:

- Sensor management for planning and execution
- Linkage of tasks to be accomplished to platform availability
- History of sensor coverage

Observers recommended tools to support visualization of coverage, latency, etc.

“UA also must force the enemy to see last... defeating his ground reconnaissance and... stay inside the enemy’s decision cycle.”  
-TRADOC Pam 525-3-90 O&O, p4-5