DRAFT - Public Release Pending

Reading the Mind of the Enemy: Predictive Analysis and Command Effectiveness

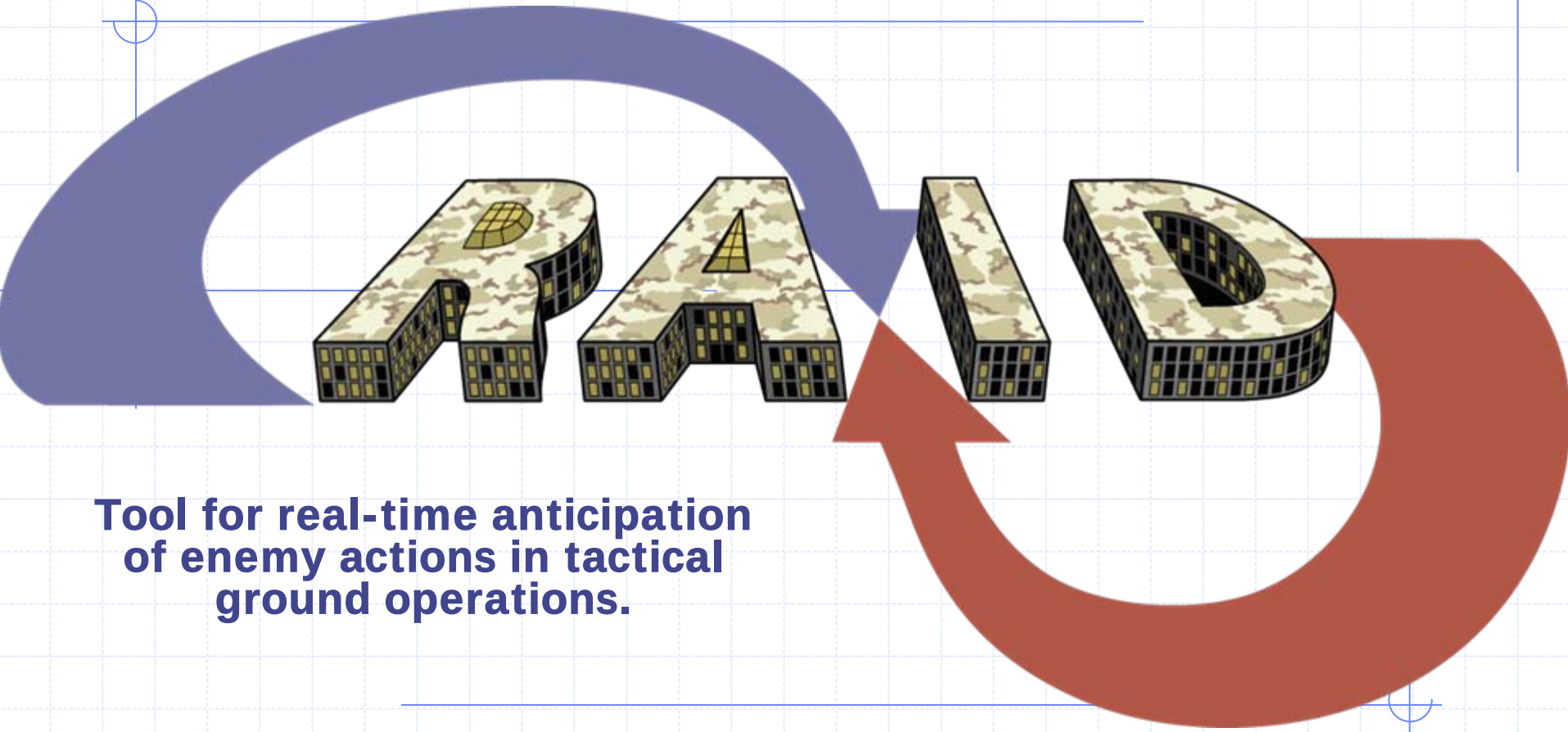
Presented to
the
2006 CCRTS

The State of the Art and
The State of the Practice

June 2006

RAID

Real-time Adversarial Intelligence & Decision making



Tool for real-time anticipation of enemy actions in tactical ground operations.

Program Manager: Dr. Alexander Kott
DARPA / Information Exploitation Office (IXO)

RAID estimates the future of the battle from the available prior/current situational information

Operational Challenge

In-execution predictive analysis of enemy probable actions in urban operations

Program Objectives

Leverage novel approximate game-theoretic and deception-sensitive algorithms to provide real-time alternatives to tactical commander

Technical Challenges

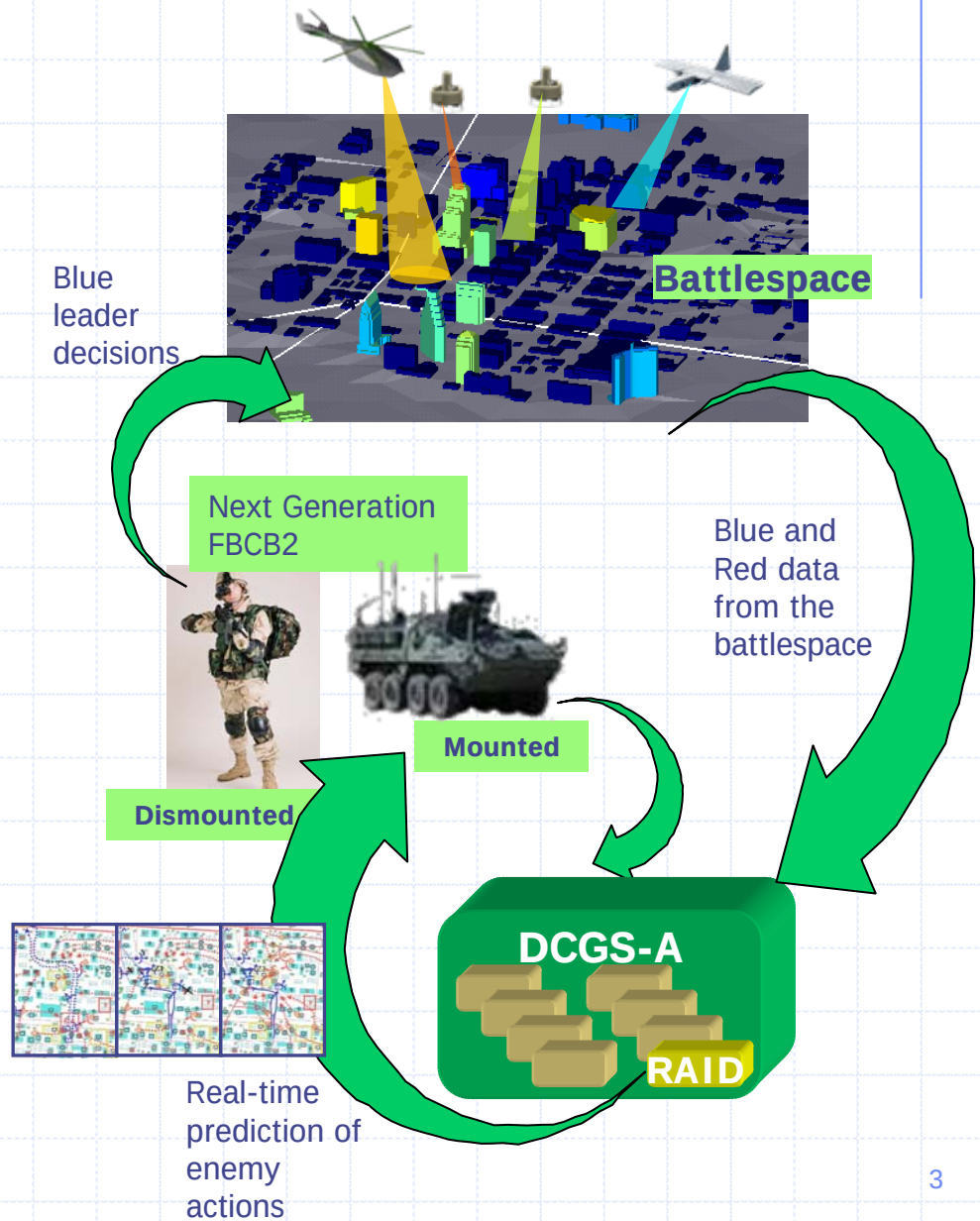
Adversarial Reasoning: continuously identify and update predictions of likely enemy actions

Deception Reasoning: continuously detect likely deceptions in the available battlefield information

Realistic Evaluation

Human-in-the-loop OneSAF-based wargames compare humans and RAID

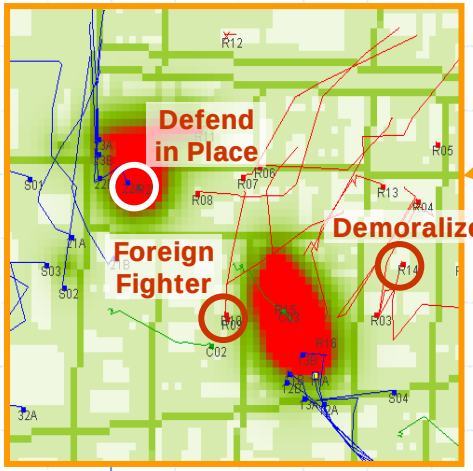
Transition: Army DCGS-A



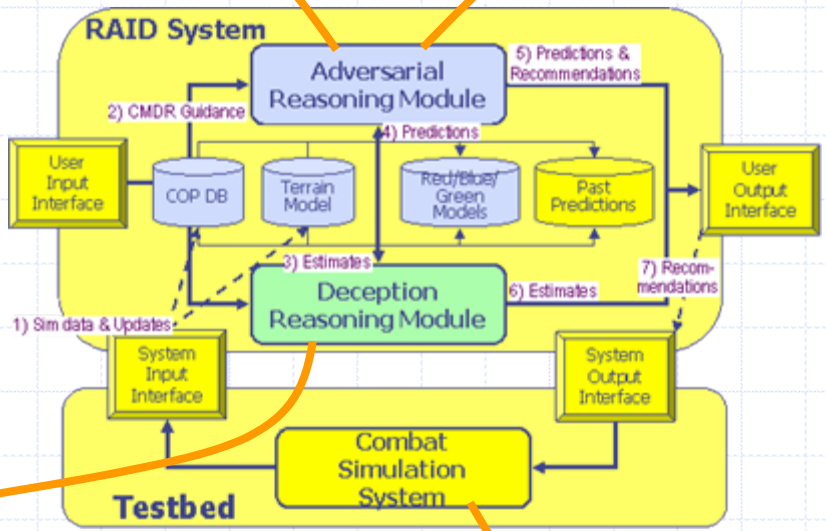
Experiment Goals by Phase

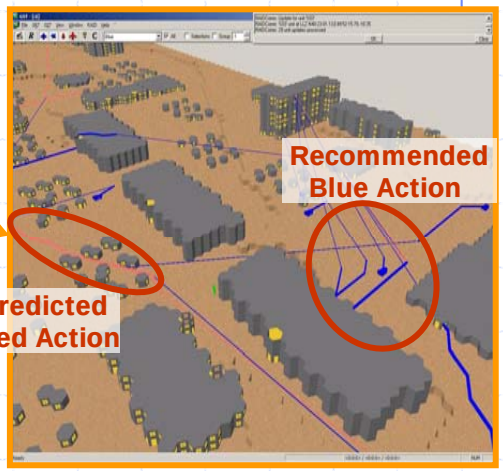
	Phase 1	Phase 1	Phase 2	Phase 3
Objective	**Anticipation and Counteraction**	**Initial Experiment Results**	**Deception and Concealment**	**Robustization and Transition**
Power – scale of the adversarial problem solvable by RAID	10**8,000	10**11,000	10**20,000	10**60,000
Speed – time to provide predictions to the user	300 sec	~300 sec max ~127 sec avg	120 sec	30 sec
Look Ahead Into the Future	At least 30 Min	30 Min	At least 60 Min	At least 5 Hrs
Key Goal	RAID assisted small staff scores as high as large unassisted staff	RAID scored higher w/81% confidence	RAID assisted small staff scores as high as large unassisted staff	RAID assisted small staff scores as high as large unassisted staff

The current RAID system comprises deception detection, enemy cognitive estimates, action-reaction reasoning, and OneSAF-based testbed

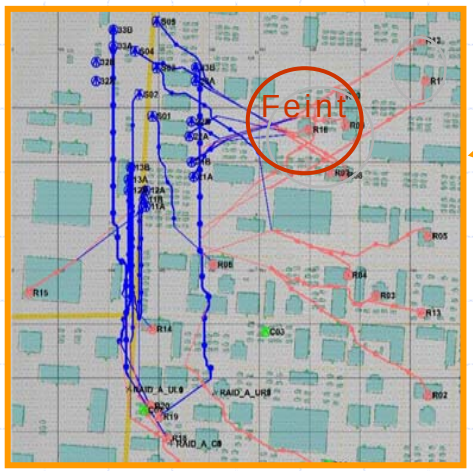


Cognitive modeling infers the enemy's desires, goals, and morale from his behaviors.

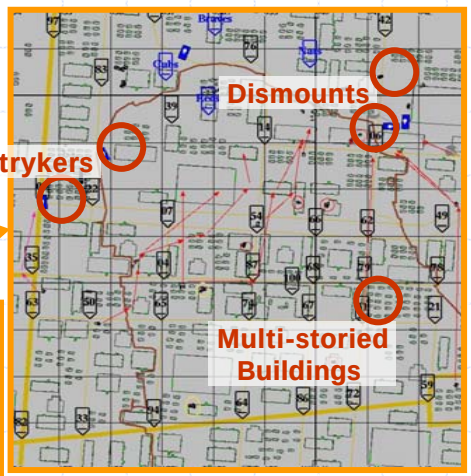




Game-theoretic action-reaction reasoning determines the enemy's most dangerous future movements and fire engagements.



Deception reasoning identifies feints and diversions.

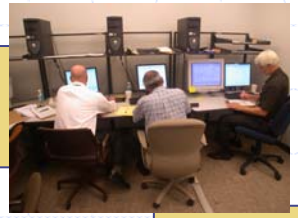


Urban-capable version of OneSAF provides a realistic experimental environment.

The experimental concepts pitches Blue cell and RAID against a free-play aggressive Red force

Blue Cell
CMDR + 4 staff
w/o RAID

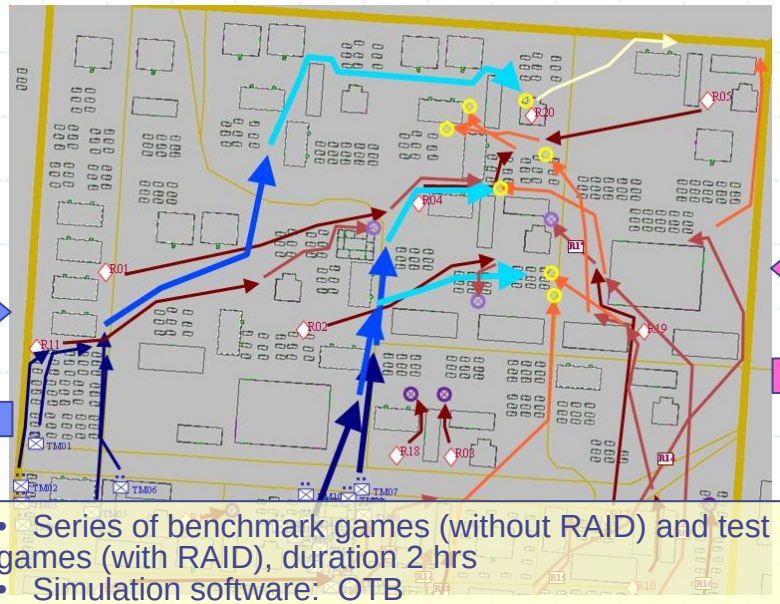
Control Cell (3 personnel)
enforces realism and integrity of the wargame



Experiment
Switch

Commands

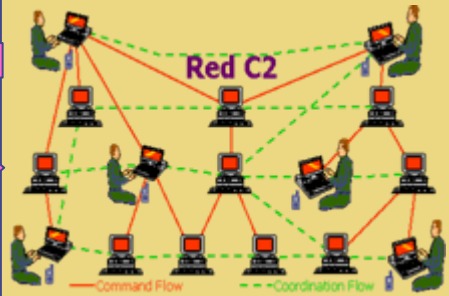
Situation



Commands

Situation

Red Cell
5-8 personnel



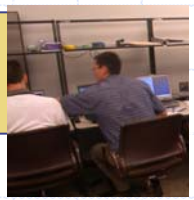
Commands
agile and
aggressive
Red Force

Blue Cell
CMDR + RAID

RAID

- Series of benchmark games (without RAID) and test games (with RAID), duration 2 hrs
- Simulation software: OTB
- 3 mission types: point attack, zone attack, point defense
- Wargame scores: mission completion; enemy destroyed; friendly losses and distance.

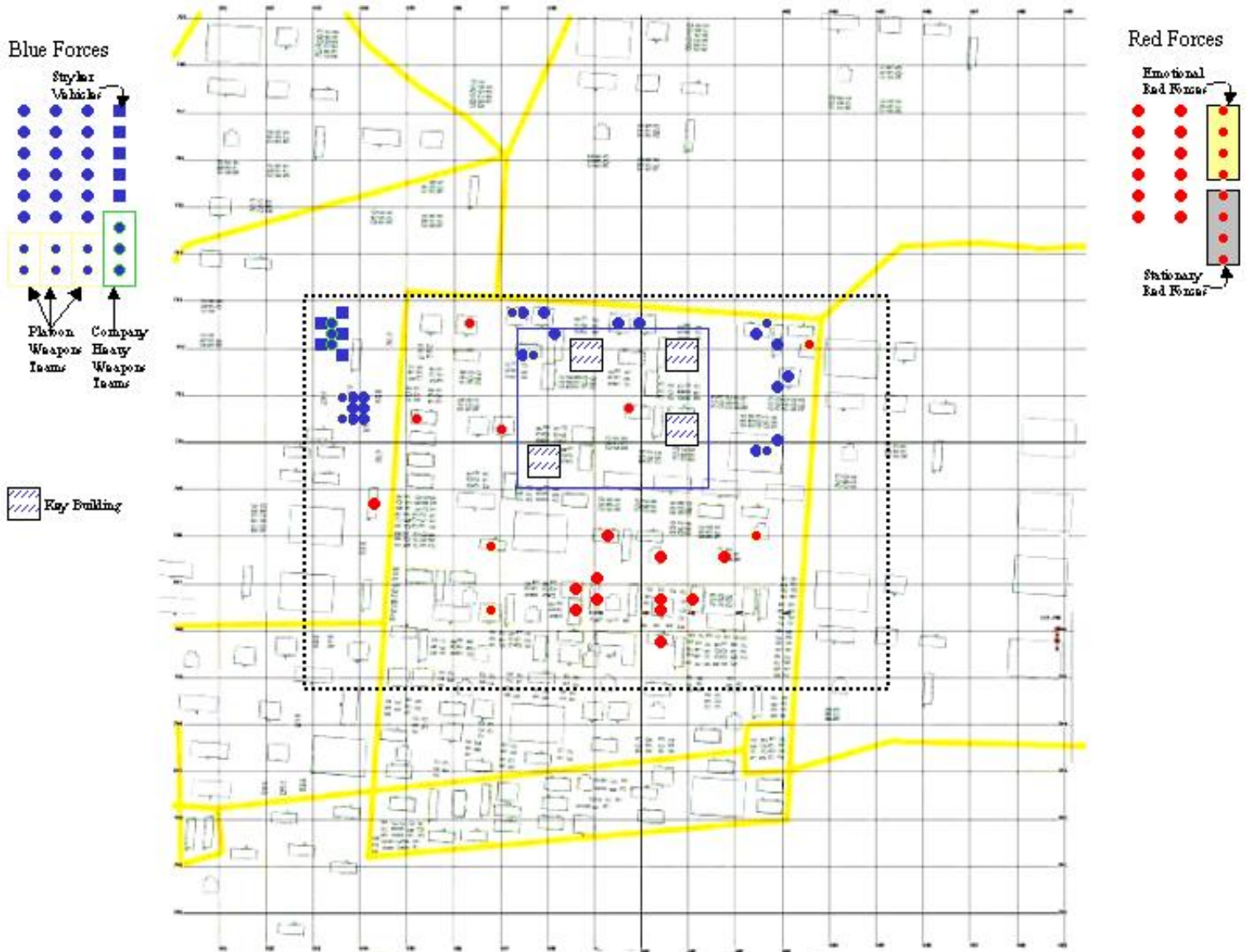
Data collection and analysis cell (2 personnel)
computes scores and predictive accuracy w/ and w/o RAID



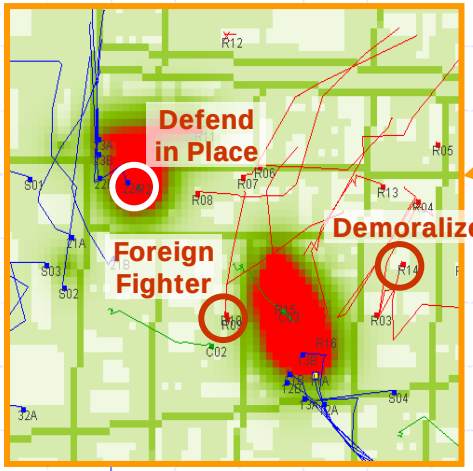
Experimental evaluation of RAID uses a range of scenarios

- Scenarios focused on urban terrain, largely dismounted Blue force, and insurgent-like irregular dismounted OPFOR
- The scenarios are inspired by Mogadishu, Najaf, Faluja…
- Situations / missions include, among others:
  - Defense of friendly Government's facilities
  - Rescue of a downed aircrew
  - Capture of an insurgent leader
  - Rescue of hostages
  - Reaction to an attack on a friendly patrol

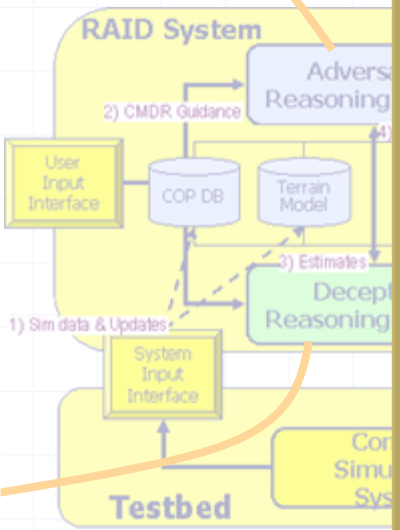
A sample scenario: Blue hasty defense of friendly Government's facilities attacked by insurgents



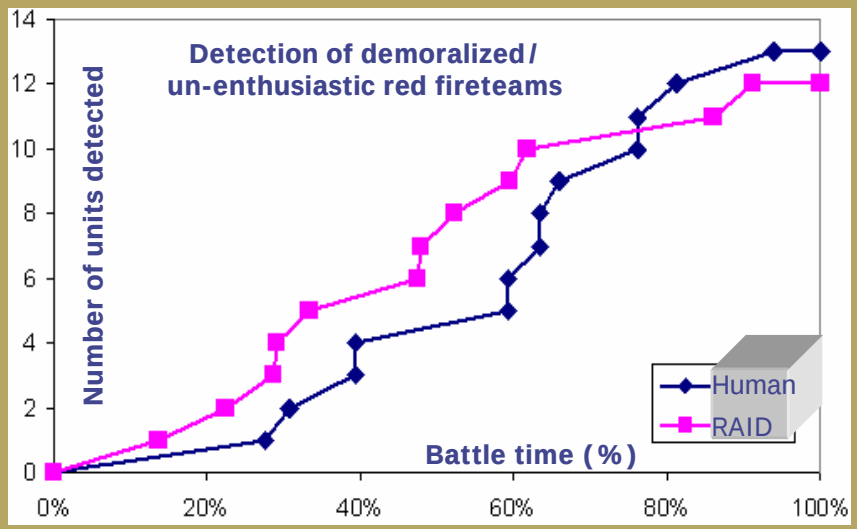
Estimation of Enemy Goals and Attitudes



Cognitive modeling infers the enemy's desires, goals, and morale from his behaviors.



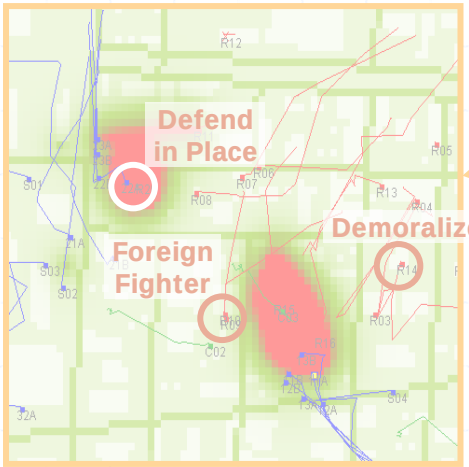
Deception reasoning identifies feints and diversions.



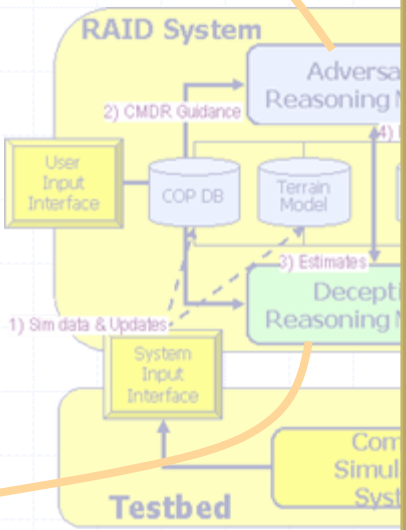
- The "play" of the Red cell included several units that were either particularly aggressive or unwilling fighters
- RAID typically recognized the "unwilling" about 10-15 minutes earlier than the human staff

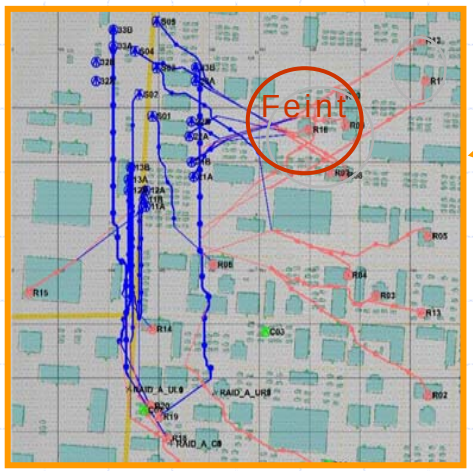
SAF provides a realistic experimental environment.

Identification of Enemy Deceptions

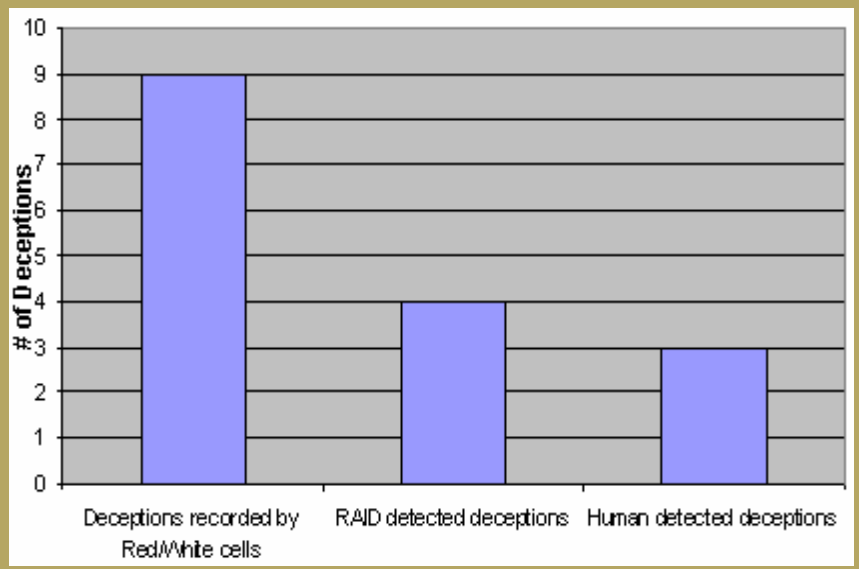


Cognitive modeling infers the enemy's desires, goals, and morale from his behaviors.

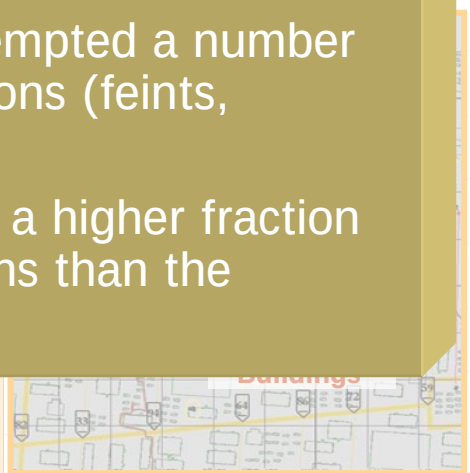




Deception reasoning identifies feints and diversions.

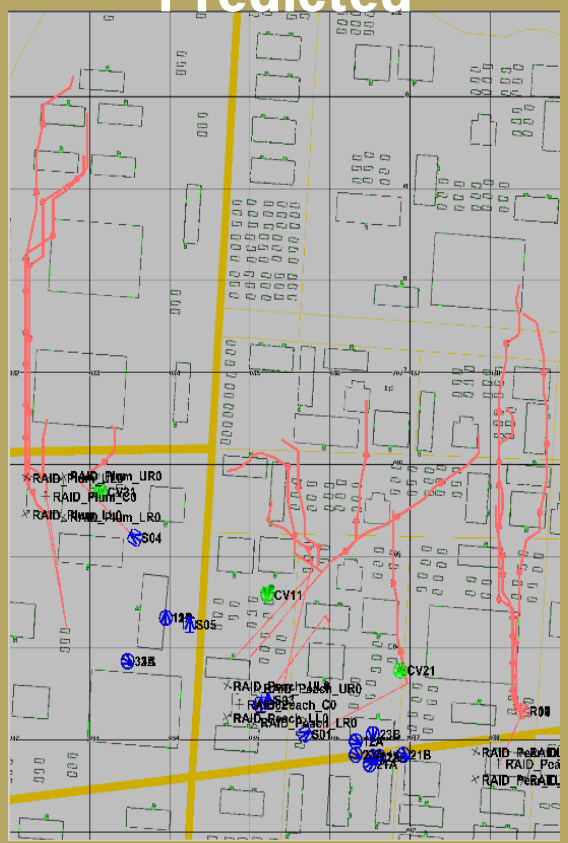


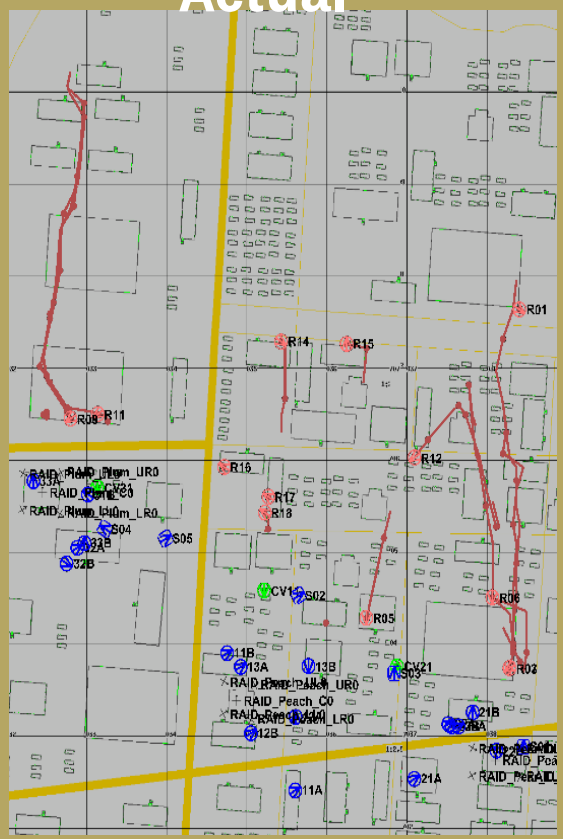
- The Red cell attempted a number of deceptive actions (feints, distractions)
- RAID recognized a higher fraction of such deceptions than the human staff



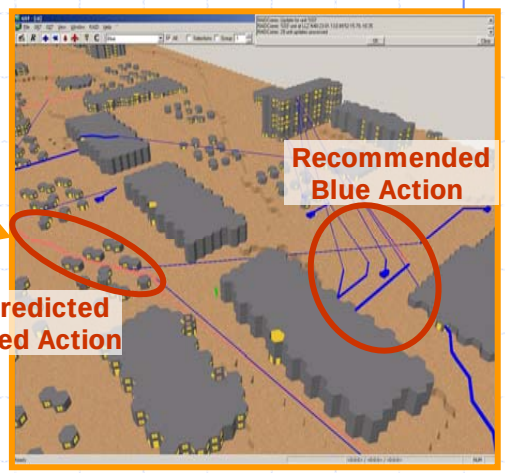
Urban-capable version of OneSAF provides a realistic experimental environment.

Anticipation of Enemy Movements

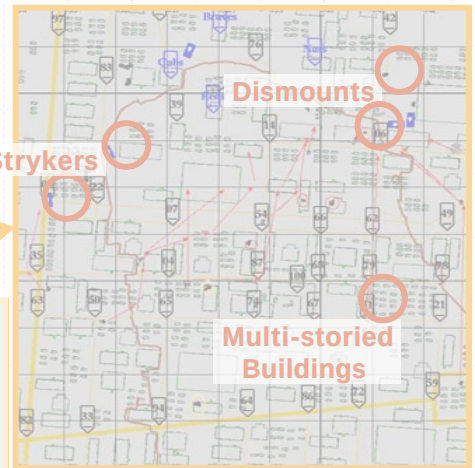




In most cases the strong correlation of predicted and actual Red actions is visually noticeable



Game-theoretic action-reaction reasoning determines the enemy's most dangerous future movements and fire engagements.

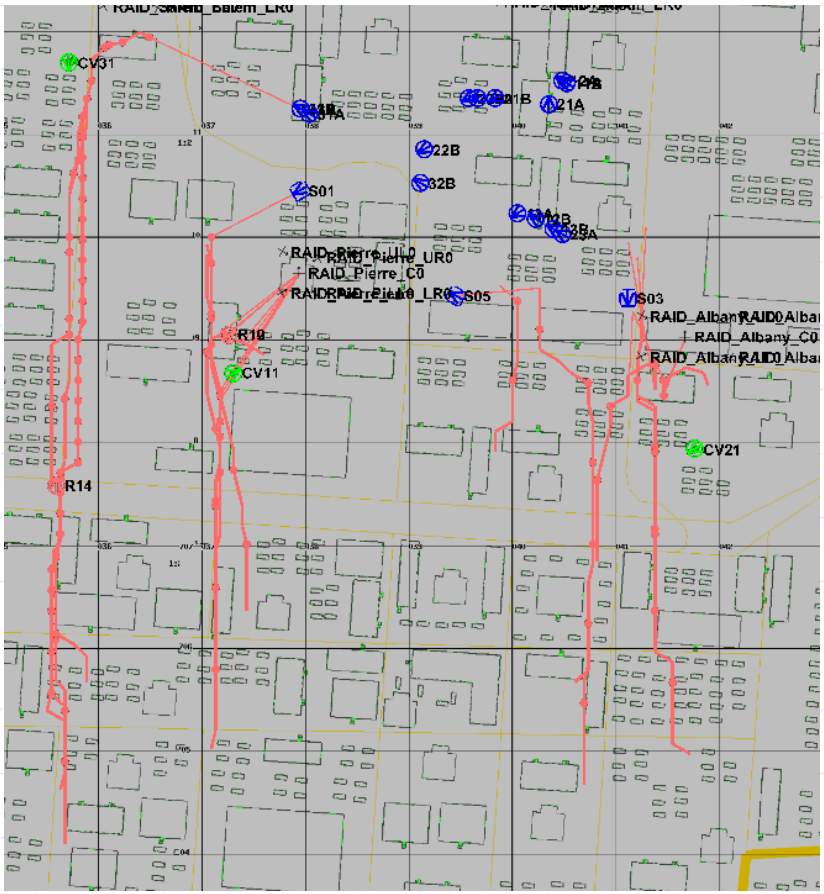


Urban-capable version of OneSAF provides a realistic experimental environment.

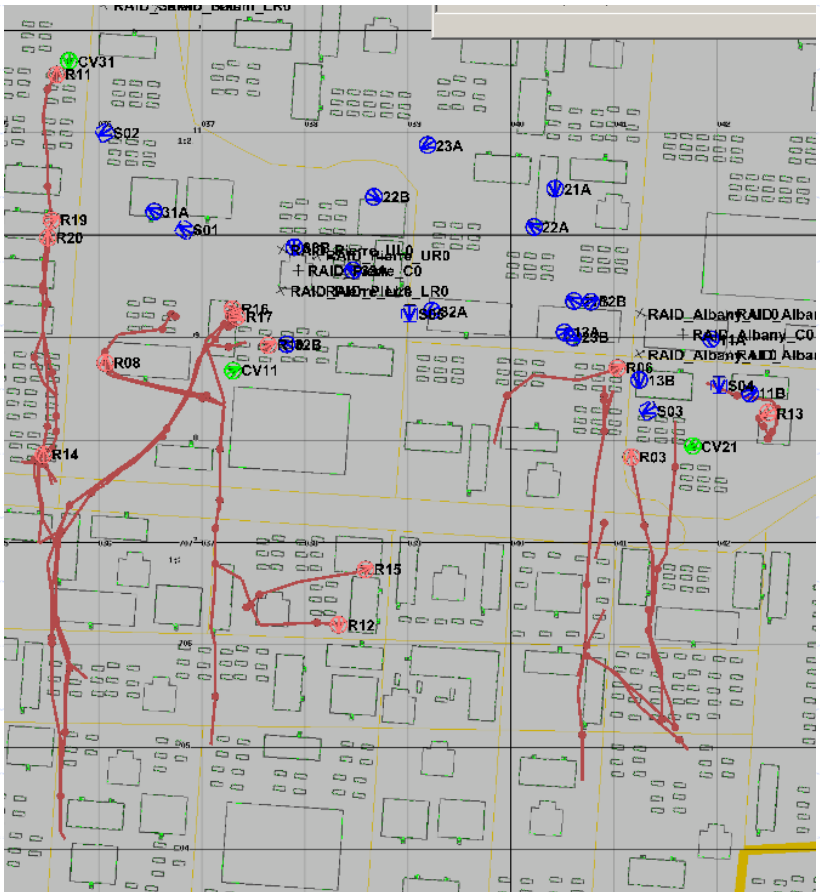
Deception reasoning identifies feints and diversions.

Anticipation of Enemy Movements
Here is another example of correlation

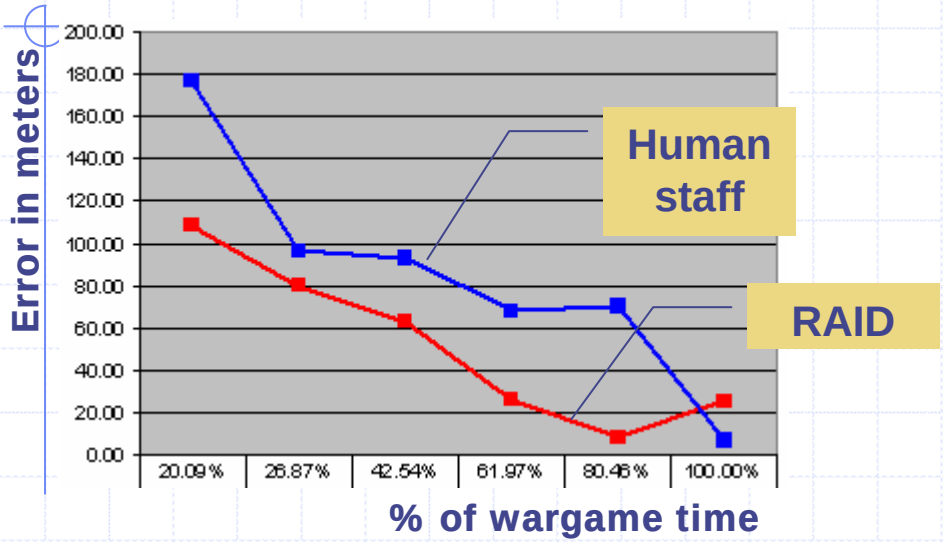
Predicted

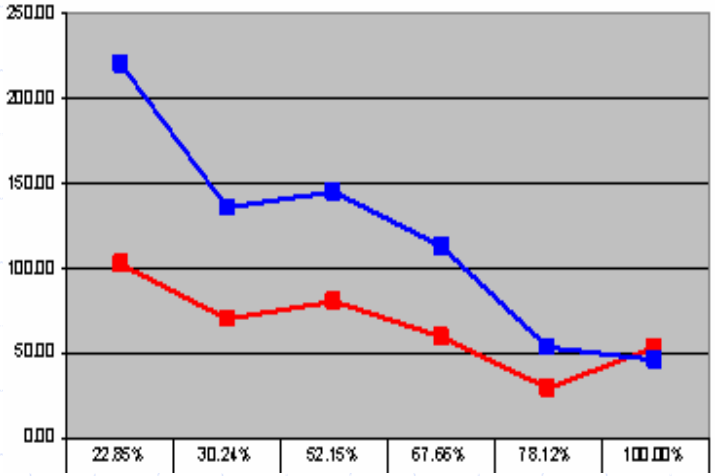


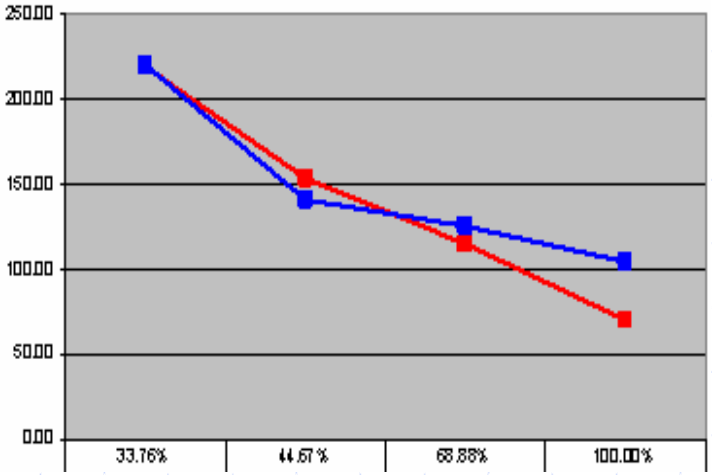
Actual

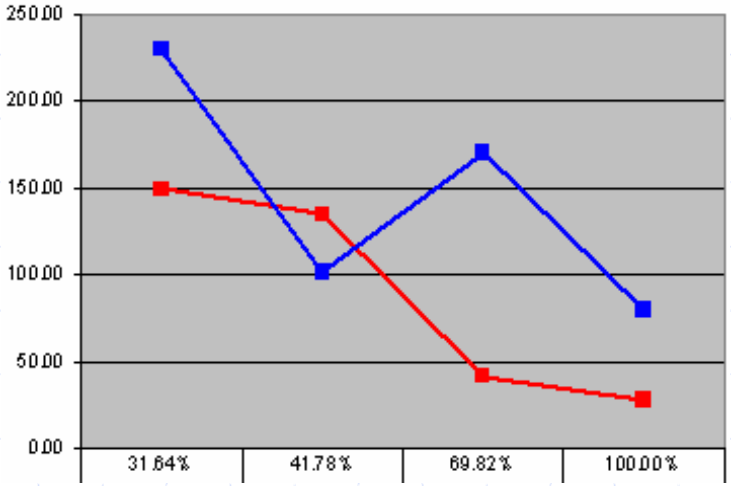


The location prediction accuracy of RAID (average error in predicted locations of Red units) compared favorably with human staff's

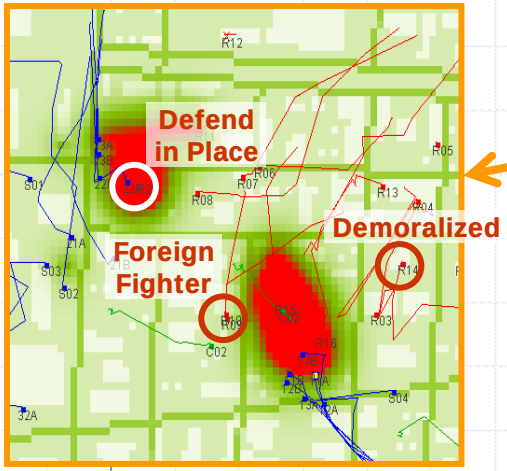






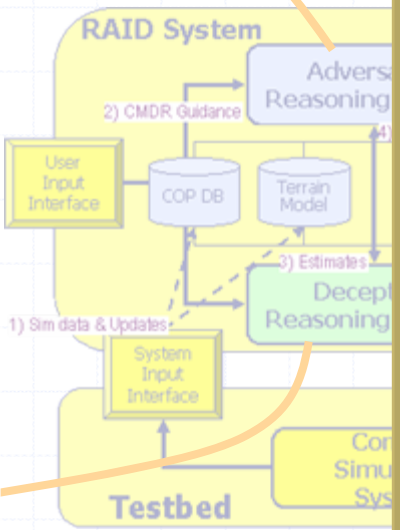


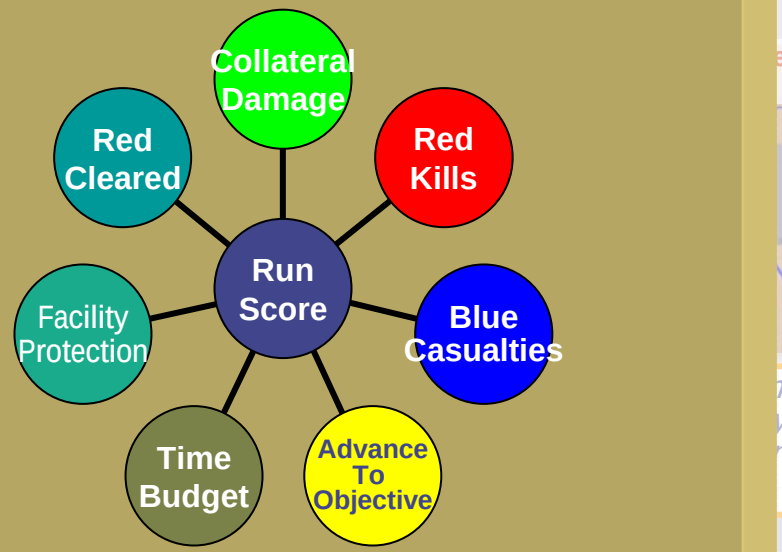
Overall Battle Outcome



Cognitive modeling infers the enemy's desires, goals, and morale from his behaviors.

Deception reasoning identifies feints and diversions.





- These are the weighted parameters that were used to calculate the operational scores.
- Parameters and weights were vetted through a panel of subject matter experts

provides a realistic experimental environment.

These are the actual conditions of the most recent experiment

	Phase 1	Phase 2	Phase 3
Thrust	Action-reaction-counteraction	C…	…stness, transition
Experiment Design	10 benchmark, 10 test games, compare scores	Add: compare accuracy of predictive estimates	… setup, integrated with FCBC2, ASAS-L / DCGS-A
Location Exp 1 Exp 2	System Integrator Site (Orlando FL) System Integrator Site (Orlando FL)	Arm… (Orlando FL) A… olk LA)	
Terrain	Digital McKenna MOUT site (Ft Benning GA)	Digital Jakarta (JFCOM data), 1,800,000 buildings	Digital (Exp 1), Physical (Exp 2) JRTC MOUT site (Ft Polk LA)
OPFOR	Up to 20 teams of 3 fighters each w/ small arms, RPGs	U… …ormed	
BLUFOR	Company-sized force w/ 5 armored vehicles	Add air support (4 helicopters)	Add CAS (10 2-ship sorties), joint … fires, air mobility
Terrain Representation	Buildings and floors, aggregated interiors	Ad… basements, internal passages	… corridors of mobility, overpass, fences, walls, urban clutter
Intel Capabilities	Full state known to both sides	Observations by troops	Add UGS and UAV sensors
Organization	Flat organization of fixed small teams with single command node	C…	Dynamic reorganization and reattachment (10 events)
Communications	Implicit idealized instant broadcast	Comms and info processing delays	Differentiated nets with realistic delays and sporadic loss
Casualty Mgmt	Implicit immediate evacuation	Treatment, delayed evacuation	Add explicit medevac actions
Logistics	Implicit continuous resupply	Run out of ammo, delays in resupply	Explicit resupply actions
Civilians	Random presence and reactions	Ci…	Blue actions to manage civilians
Concealment, Deception	Feint movements and attacks	Conce… stealthy moves	Decoys, civilians do diversions
Timing	Game 2 hours, slower than real	Ea… real time	Game lasts 4-6 hrs, real time
Look ahead into future	At least 30 min	At…	At least 5 hours
Problem Complexity	over 10**8,000	ov…	…0
Solution speed	Within 300 sec	Within 120 sec	Within 30 sec
Key Gate	RAID-assisted small staff scores as high as large unassisted	R… high as large unassisted	… scores as high as large unassisted

9 Benchmark and 9 Test Games

Much larger, digital Baku ~1000 bldgs

20 fire teams of 3, w/ RPGs and AK-47s

18 fire teams of 4, plus 5 Strykers

BLUFOR w/ 3 platoons

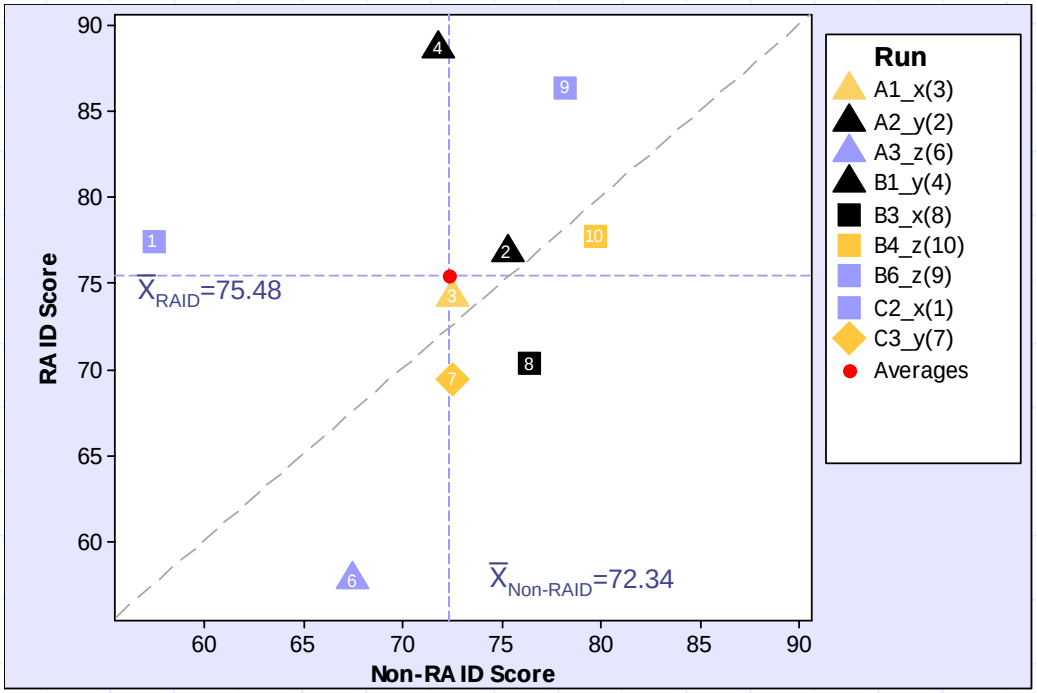
Real time w/ pauses

10**10,700

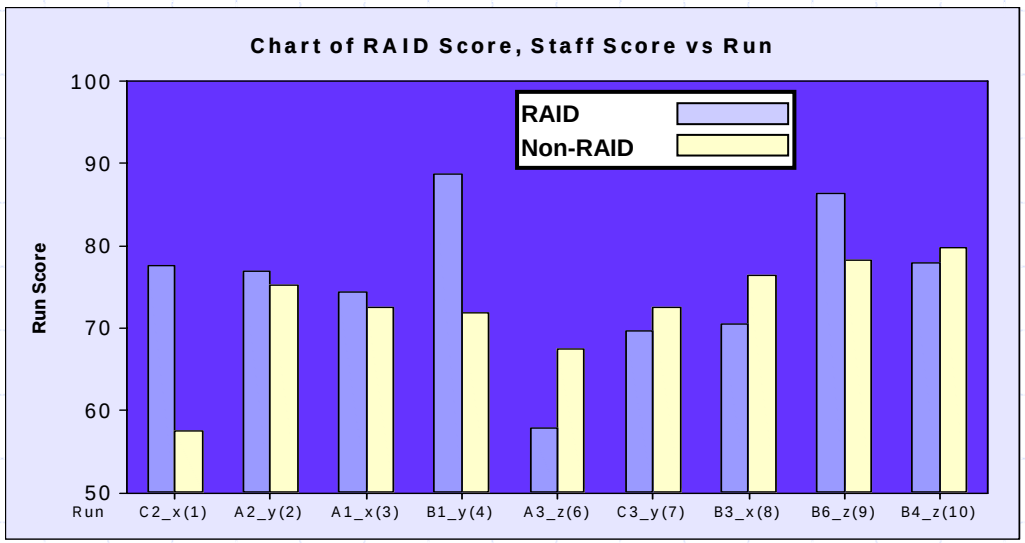
~300 sec max w/ ~120 sec avg

RAID outperformed staff in 5 of 9 cases

Experiments show that RAID-supported commander noticeably outperforms the staff-supported one



Pair	RAID Score	Non-RAID Score	Difference
A1_x(3)	74.300	72.500	1.80
A2_y(2)	76.890	75.240	1.65
A3_z(6)	57.840	67.440	-9.60
B1_y(4)	88.650	71.750	16.90
B3_x(8)	70.390	76.350	-5.96
B4_z(10)	77.810	79.710	-1.90
B6_z(9)	86.390	78.170	8.22
C2_x(1)	77.500	57.380	20.12
C3_y(7)	69.530	72.520	-2.99
$\overline{X}$	75.48	72.34	3.138
σ	9.205	6.718	10.097



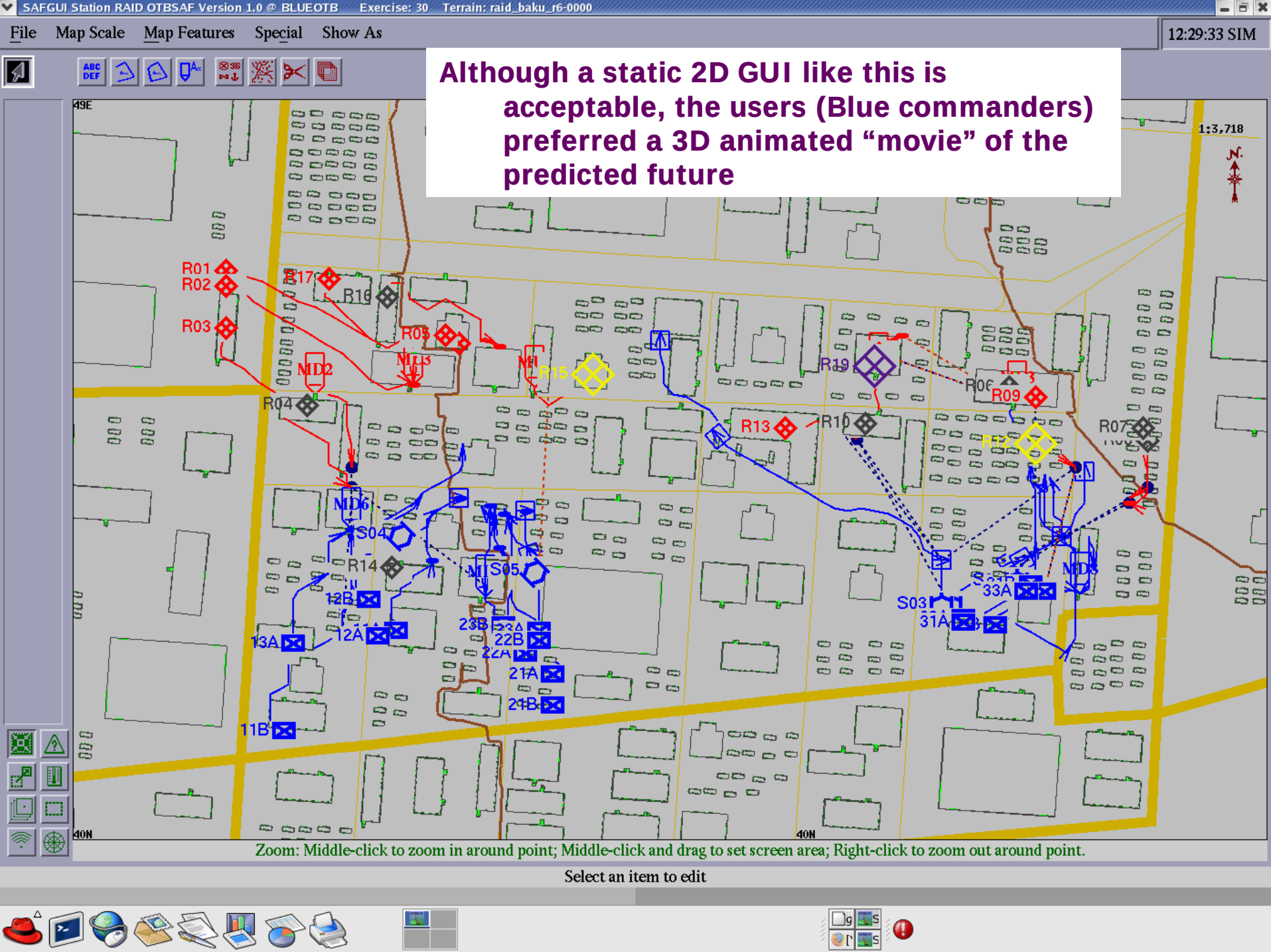
# of valid Run Pairs = 9

Mean diff = 3.138

StDev = 10.097

Difference Data can be treated as Normal

Results Significance: 81.0%

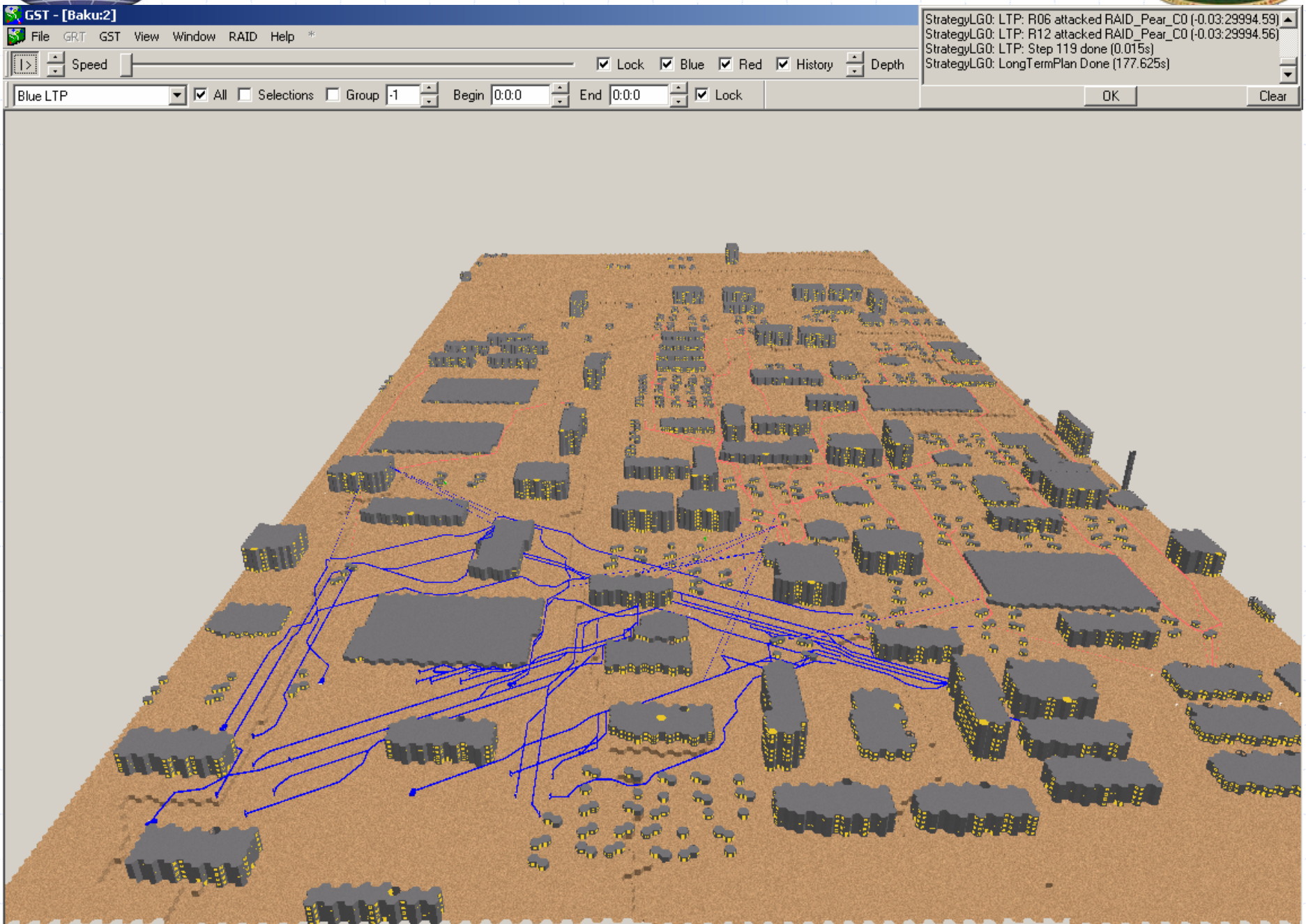


Although a static 2D GUI like this is acceptable, the users (Blue commanders) preferred a 3D animated "movie" of the predicted future

The content of the next slide (movie)

- Blue is in hasty defense of friendly Government facilities against an attack by insurgents
- Red is converging on, and attacking the facilities
- The “movie” on the next slide is the RAID-generated prediction of how the battle will unfold in the next 15 minutes
- Such predictions are generated on the Blue Cmdr’s request, typically every 5-15 minutes
- The movie begins with a 3D view of the anticipated Blue and Red movements and engagements
- Note the extensive use of roofs and windows, and coordination of various units
- Then the movie shows 2D view of the predictions and also compares them with what the Red force (Red cell) actually did in the free-play wargame. Note a strong correlation between the predicted and actual movements and positions of the Red fireteams.

If the movie does not start automatically, go to the avi file and start it directly


GST - [Baku:2]
File GRT GST View Window RAID Help
Speed
Lock Blue Red History Depth
Blue LTP
All Selections Group -1 Begin 0:0:0 End 0:0:0 Lock
StrategyLG0: LTP: R06 attacked RAID_Pear_C0 (-0.03:29994.59)
StrategyLG0: LTP: R12 attacked RAID_Pear_C0 (-0.03:29994.56)
StrategyLG0: LTP: Step 119 done (0.015s)
StrategyLG0: LongTermPlan Done (177.625s)
OK
Clear

Having met the Gates of Phase 1… here is what we plan to do in the following phases

Experimental Conditions and Gates as Planned

	Phase 1	Phase 2	Phase 3
Thrust	Action-reaction-counteraction	Concealment and deception	Breadth, robustness, transition
Intel Capabilities	Full state known to both sides	Observations by troops	Add UGS and UAV sensors
Concealment, Deception	Feint movements and attacks	Concealment, stealthy moves	Decoys, civilians do diversions
Terrain complexity, scale	Digital McKenna MOUT site (Ft Benning GA)	Larger terrain, basements, breached openings	Digital (Exp 1), Physical (Exp 2) JRTC MOUT site (Ft Polk LA)
OPFOR	Up to 20 teams of 3 fi w/ small arms, RPGs	Up to 30 teams of 3-7. Add sniper 5 rifles, 5 HMGs, 5 MANPADS	200 fighters, dynamically formed teams. Add 10 mortars.
BLUFOR	Company-sized armored vehic	Add air support (4 helicopters)	Add CAS (10 2-ship sorties), joint close support fires, air mobility
Operational realism	No explicit l asualty managem	Limited ammo, delayed re-supply, delayed evacuation of casualties	Explicit management and execution of re-supply and casualty management
Scale of the adversarial problem	8,000	10**20,000	10**60,000
Time to provide predictions to user	< 300 sec	120 sec	30 sec
Personnel to operate the system	< 2	1	0.5
Accuracy of preds vs. humans	N/A	At least 1.0	At least 1.0
Wargame score vs. humans	At least 1.0	At least 1.0	At least 1.0

Complete

Reading the Mind of the Enemy: Predictive Analysis and Command Effectiveness