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Team 7: Applying Automated Red Teaming in an Urban Ops Scenario

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INTRODUCTION

With rapid urbanisation, troops today will have to operate in an increasingly complex and urbanised environment. Together with a more potent enemy capability, the troops will have to be highly armour protected even at the lowest level (company size) in order to minimise the casualty rate. The fighting force will need to be a combined force to achieve a swift and decisive result in an urbanised terrain. This study explored the Coy level urban fighting force packages operating in a built up area.

AIM

To present the results on the relative performance of each proposed Coy level urban fighting force structure.

OBJECTIVES OF THE STUDY

The objectives of this study were to determine the performance of the various proposed Coy level urban fighting force structures to open and clear an axis through a built up area.

The Auto Red Teaming (ART)[2] framework developed by DSO National Laboratories was used to identify the key parameters that would affect the outcome of the urban war fighting scenario.

DESIGN OF EXPERIMENT

Blue Urban Fighting Force Structure. In this study, three Coy force structures were studied. The three structures would be analysed with two different armour platform (medium and heavy) for IFV/NLOS. The structures proposed were namely Tank heavy company, Balanced company and NLOS heavy company. The compositions of each structure were shown in Table 1.

The three force structures represented a wide spectrum of possible combinations of Tank platoons and NLOS sections within a company size force. Engineer elements were left out in this study as no obstacles were modelled in the scenario. The study assumed that an NLOS section was a reasonable trade-off with a Tank platoon.

Structure	Tank Heavy	Balance	NLOS Heavy
HQ	2 tanks	2 tanks	1 tank
Tank platoon (4 tanks each)	3	2	1
AI platoon (3x IFVs each)	1	1	1
NLOS section (2x NLOS + 1x UAV each)	1	2	3
Total	14 x tanks 3 x IFVs 2 x NLOS 1 x UAV	10 x tanks 3 x IFVs 4 x NLOS 2 x UAV	5 x tanks 3 x IFVs 6 x NLOS 3 x UAV

Table 1: Composition of Coy Level Urban Fighting Force

DESCRIPTION OF SCENARIO

In this scenario, the terrain profile in the area of operations comprised of mainly High Density built up area. No neutral or civilian exist in the AO as they were not modeled in this study. The primary task for the Blue forces was to clear an axis to open a path for follow up forces. The secondary task for the Blue forces was to attract enemy fires and inflict as much damages as possible to the enemy forces.

The Blue force behaviour modeled in this scenario was defined as follows:

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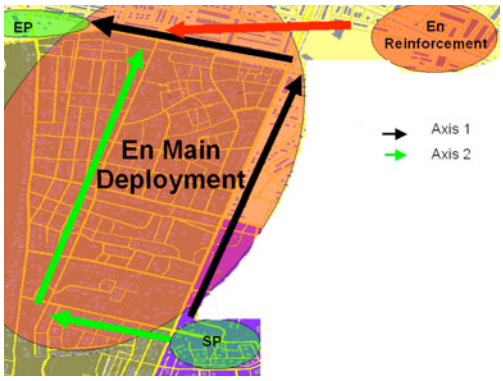
2 ART is a technique to uncover system vulnerabilities or to find exploitable gaps in operational concepts, with the overall goal of reducing surprises, improving and ensuring the robustness of the Blue ops concepts.

a. The Blue tanks will manoeuvre along the pre-defined axes and will engage the Red forces when detected or being fired upon, the tanks will resume their movement along the intended axes after the engagement.
b. The Blue IFVs and NLOS will slow down when the Blue UAV or tanks detected the Red forces. The NLOS will engage according to their pre-defined target engagement priorities. Upon no further detections of enemy, they will resume their movement along the intended axes.



The AO would be defended by an enemy Armoured Cbt Tm (Company size) with the support of a RPG platoon and reinforced by another Amoured Cbt Tm. The Red force profile modeled in this scenario is illustrated in detail as follows:

a. Composition:

Types	Ambushed	Reinforcement
Red Tank	4	4
Red IFV	8	8
RPG gunners	18	0
Mobile ATGM vehicle	2	2

Table 2: Red Force composition.

b. Red Course of Action:
Tanks, IFVs, ATGM vehicles and RPG gunners pre-deployed in the area of operation will launch surprise attacks on the approaching Blue force, with the order of engagement defined by their priority targets of engagement. The RPGs and ATGMs will embark on "Hit and Run" tactics, springing surprise attacks from their ambush positions and move to new positions to spring the next phase of surprise attacks. The tactic was designed to trap, delay and kill the Blue vehicles while the mobile Armour Cbt Tm rushed in to interdict from the sides.

MEASURES OF EFFECTIVENESS (MOE)

The MOEs were:

a. Blue Attrition – attrition of each component of Blue Force (At least 80% survivability)
b. Red Attrition – attrition of each component of Red Force (At least 50% attrition)

KEY PARAMETERS AND ASSUMPTIONS

The following were important assumptions made in the scenario:

a. Perfect communication networks existed for both the Blue and the Red forces. Hence the effects of imperfect comms were not represented or examined in this study.
b. UAV did not have the capability to detect RPG in ambush position (inside buildings).
c. Red forces in ambush positions had the benefit of firing the first shot before they can be detected.
d. No dismounting of AI Platoon from IFV vehicles was modeled.

The following platform classes were modeled:

Platform Type	Class of Protection
Blue Tank	Heavy
Blue NLOS	Medium or Heavy
Blue IFV	Medium or Heavy
Red Tank	Heavy
Red IFV	Medium

Table 3: Platforms and their Protection Levels.

It was assumed that the platforms have a priority of engagement as follows:

Shooter	Targeting Priority				
	1	2	3	4	5
Blue Tank	Red Tank	Red ATGM	Red RPG	Red IFV	-
Blue NLOS (Medium Class)	Red Tank	Red IFV	Red RPG	Red ATGM	-
Blue NLOS (Heavy Class)	Red Tank	Red ATGM	Red RPG	Red IFV	-
Blue IFV (Medium Class)	Red IFV	Red RPG	Red ATGM	-	-
Blue IFV (Heavy Class)	Red ATGM	Red RPG	Red IFV	-	-
Red Tank	Blue Tank	Blue NLOS	Blue IFV	-	-
Red IFV	Blue NLOS (Medium Class)	Blue IFV (Medium Class)	-	-	-

Red RPG	Blue NLOS (Medium Class)	Blue IFV (Medium Class)	Blue Tank	Blue NLOS (Heavy Class)	Blue IFV (Heavy Class)

Table 4: Platforms and their Targeting Priorities.

PRELIMINARY STUDY ON FACTORS OF INTEREST

Sensitivity analysis was carried out for the list of factors over the following set of values:

a. Level of Protection for Blue IFV/NLOS:
   - Medium Class, Heavy Class
b. No. of Red Reinforcement.
   - Tank and IFV

The data for the sensitivity analysis was generated using the Data Farming technique.

RESULTS AND ANALYSIS

As explained under the section of "Design of Experiment", this part of the study examined the performance and survivability of each force structure when tasked to conduct the battles depicted in the earlier paragraph. For each force structure, two variants of the IFV/NLOS platforms were examined, namely the Medium Class and Heavy Class types.

The results for the force structures equipped with the medium class IFV/NLOS platforms were presented in Table 5.

Table 5 shows the results of the 03 x proposed Urban Fighting structures equipped with medium class IFV/NLOS platforms. The results showed that the three structures all achieved comparable Red reinforcement attrition levels. Most of the Red reinforcement were attrited as the reinforcement were the first to be spotted and engaged by the Blue forces. For the Red ambush force, the Red IFV faced a relatively high attrition rate (80 %) by the Tank company structure while the other two structures only manage to achieve around a 50 % attrition rate. On the other hand, the Tank heavy company structure achieved the lowest attrition rate for the Red RPG compared to the other two structures. These results shown that the Tank heavy company structure is more capable in fighting a mobile force and less efficient against a static force.

On analysis of the Blue attrition figures, the number of platforms killed across the three proposed structures was approximately similar (between 5 to 9 vehicles). None of the three structures meet the 80% survivability benchmark. The attrition of NLOS and IFV platforms were noticeably low under the Tank heavy company structure, with the Blue tanks taking the highest attrition at 4 Tanks. The Balanced and NLOS heavy company structures show an inverse result whereby the attrition of the Blue tank is low but high for the IFV and NLOS. For these two structures the Blue tank attrition rate is between 2 to 3 while the IFV and NLOS faced high attrition rate between 2 to 3 (IFV) and 3 to 4 (NLOS).

This implied that the decrease of 1x Tank Platoon from the Tank company structure to the Balanced company structure and subsequently to the NLOS company structure had caused a transfer of enemy's concentration of firepower from Blue tanks to Blue IFVs and Blue NLOS. This transfer of enemy's firepower had resulted in a proportionate decrease in the number of Blue tanks killed, but had caused a greater than proportionate increase in the number of IFVs and NLOS killed.

Platforms	**Tank Heavy**			**Balanced**			**NLOS Heavy**		
	Qty	**No. Killed**	**% Killed**	**Qty**	**No. Killed**	**% Killed**	**Qty**	**No. Killed**	**% Killed**
Blue Tank	14	4.05	28.9	10	2.86	28.6	5	2.21	44.2
Blue NLOS	2	0.96	48.0	4	3.36	84.0	6	3.91	65.2
Blue IFV	3	0.43	14.3	3	2.62	87.3	3	2.69	89.7
Total Blue	19	5.44	28.6	17	8.84	52.0	14	8.81	62.9
Red Ambush									
Red Tank	4	3.55	88.8	4	3.14	78.5	4	2.81	70.3
Red APC	8	6.41	80.1	8	3.93	49.1	8	4.4	55.0
Red ATGM	2	1.92	96.0	2	1.82	91.0	2	1.62	81.0
Red RPG	18	5.55	30.8	18	10.38	57.7	18	7.9	43.9
Red Reinforcement									
Red Tank	4	4	100.0	4	3.99	99.8	4	3.99	99.8
Red APC	8	8	100.0	8	7.82	97.8	8	7.89	98.6
Total Red	44	29.43	66.9	44	31.08	70.6	44	28.61	65.0

Table 5 - MOEs for Blue structures with medium class IFV/NLOS platforms.

Platforms	Tank Heavy			Balanced			NLOS Heavy		
	Qty	No. Killed	% Killed	Qty	No. Killed	% Killed	Qty	No. Killed	% Killed
Blue Tank	14	3.63	25.9	10	1.65	16.5	5	1.61	32.2
Blue NLOS	2	0.04	2.0	4	0.54	13.5	6	1.06	17.7
Blue IFV	3	0.1	3.3	3	0.91	30.3	3	0.93	31.0
Total Blue	19	3.77	19.8	17	3.1	18.2	14	3.6	25.7
Red Ambush									
Red Tank	4	3.58	89.5	4	3.38	84.5	4	2.98	74.5
Red APC	8	6.08	76.0	8	4.44	55.5	8	5.36	67.0
Red ATGM	2	1.9	95.0	2	1.88	94.0	2	1.72	86.0
Red RPG	18	12.51	69.5	18	9.24	51.3	18	9.57	53.2
Red Reinforcement									
Red Tank	4	4	100.0	4	3.99	99.8	4	2.97	74.3
Red APC	8	8	100.0	8	7.79	97.4	8	8	100
Total Red	44	36.07	82.0	44	30.72	69.8	44	30.6	69.5

Table 6 - MOEs for Blue structures with heavy class IFV/NLOS platforms.

The results for the force structures equipped with the heavy class IFV/NLOS platforms are presented in Tables 6.

Table 6 shows the results of the proposed Urban Fighting structures equipped with heavy class IFV/NLOS platforms. The results showed that the Balanced and NLOS heavy company structures achieved comparable Red reinforcement attrition levels while the Tank company structure had a significantly higher Red attrition rate. The Tank heavy company structure achieved the highest attrition rate for the Red RPG compared to the other 2 structures. These could be due to the increase defense capability of the IFV/NLOS which enable them to survive the Red RPG attacks and thus create the opportunity for the Blue tanks to engage the Red RPG while they are exposed. All three structures meet the 50% attrition rate inflicted on the Red forces.

The overall Blue attrition rates were similar across the 3 structures but only Tank heavy and Balance structure meet the 80% survivability condition. This means that these two structures are the only structures that meet the MOEs requirement with the Tank heavy structure fairing better on the attrition on Red forces.

Sensitivity Analysis of Red Reinforcement Forces

Sensitivity analysis was performed on the number of tanks and IFV in the Red reinforcement forces to determine their impact on the Blue's survivability. The results are presented in Figure 1 to 6.

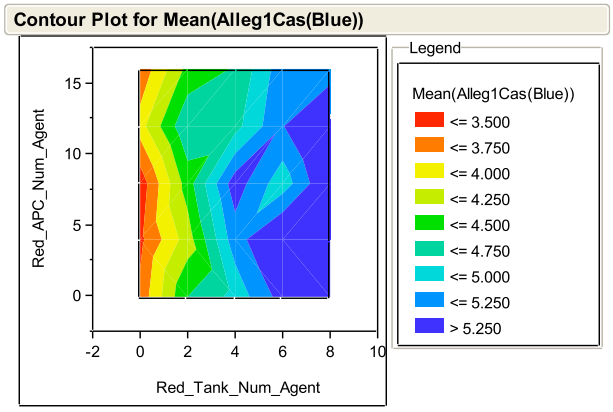


Figure 1: Tank structure with medium class IFV/NLOS platforms.

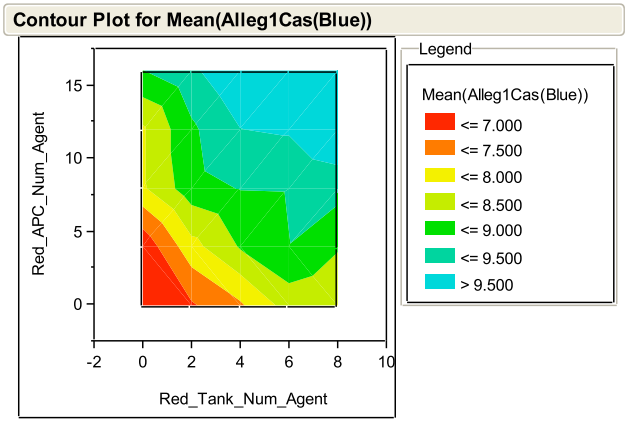


Figure 2: Balanced structure with medium class IFV/NLOS platforms.

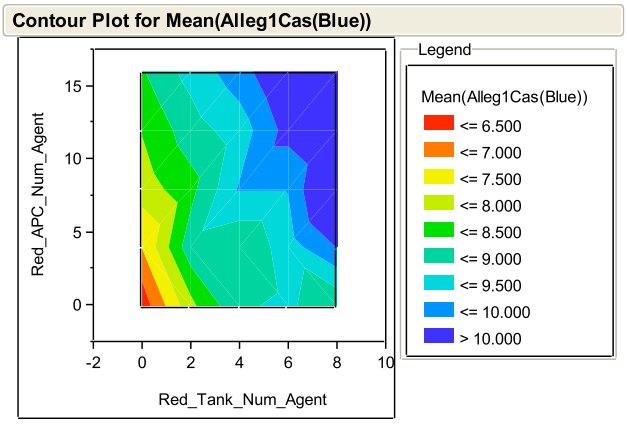


Figure 3: NLOS structure with medium class IFV/NLOS platforms.

Based on the Figures 1, 2 and 3, for the medium class IFV/NLOS studies, the Blue attrition increased when the Red reinforcement increased. However it is also noted that for the Tank heavy company structure, an increased in Red IFV does not contribute to the attrition rate of the Blue forces. This could be attributed to the inability of the Red IFV to inflict any damage to the forward forces of Blue tanks.

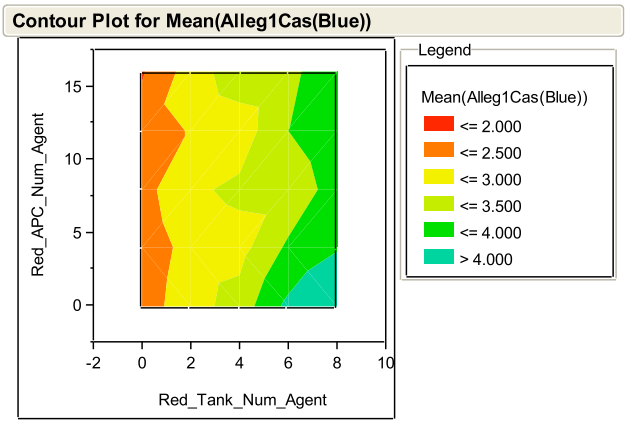


Figure 4: Tank structure with heavy class IFV/NLOS platforms.

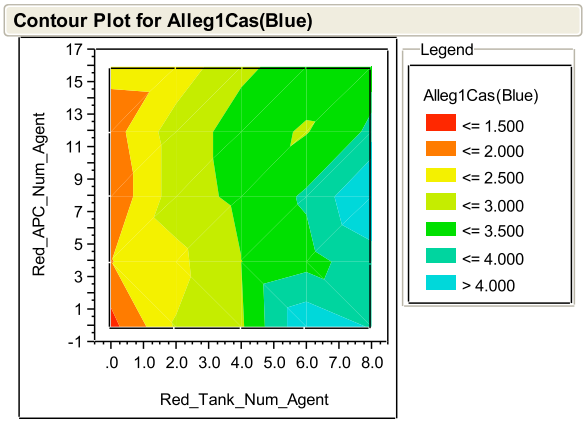


Figure 5: Balanced structure with heavy class IFV/NLOS platforms.

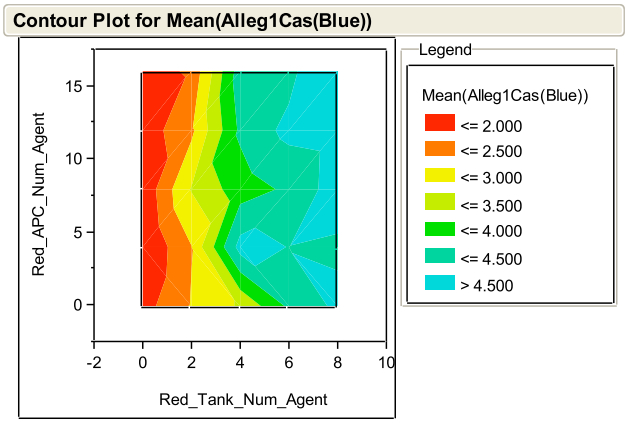


Figure 6: NLOS structure with heavy class IFV/NLOS platforms.

Figures 4, 5 and 6 depicts the effect of Red reinforcement on the attrition rate of Blue forces with heavy armoured IFV/NLOS. It clearly showed that an increase in Red IFV quantity has no significant effect on the Blue forces and this is due to the inability of the Red IFV to inflict any damage to the heavy armoured Blue IFV/NLOS.

Automated Red Teaming (ART) Framework

The intent of this study was to explore how intangibles could lead Red to break Blue. The scenarios used in this study were the 3 proposed structures with medium class IFV/NLOS platforms. We short listed the parameters in Table 7:

Red Farming Parameters	Min	Max
Red Reinforcement Tank Individual Aggression	-100	100
Red Reinforcement Tank Squad Aggressiveness	-100	100
Red Reinforcement Tank Response To Injured Red	-100	100
Red Reinforcement Tank Clustering	-100	100
Red Reinforcement Tank Squad Cohesion	-100	100
Red Reinforcement IFV Individual Aggression	-100	100
Red Reinforcement IFV Squad Aggressiveness	-100	100
Red Reinforcement IFV Response To Injured Red	-100	100
Red Reinforcement IFV Clustering	-100	100
Red Reinforcement IFV Squad Cohesion	-100	100
Red Ambush Tank Individual Aggression	-100	100
Red Ambush Tank Squad Aggressiveness	-100	100
Red Ambush Tank Response To Injured Red	-100	100
Red Ambush Tank Clustering	-100	100
Red Ambush Tank Squad Cohesion	-100	100
Red Ambush IFV Individual Aggression	-100	100
Red Ambush IFV Squad Aggressiveness	-100	100
Red Ambush IFV Response To Injured Red	-100	100
Red Ambush IFV Clustering	-100	100
Red Ambush IFV Squad Cohesion	-100	100
Red Ambush IFV Stealthiness	0	99

Table 7: Red Parameters for ART.

A negative value for the parameter denotes an aversion to the particular attribute. For instance, -100 for clustering means the agents prefer to spread out rather than sticking as a group. A neutral value, 0, would mean that the agent is indifferent. For stealth, the value ranges between 0 and 100, however, 100 was not taken as it would mean the unit is completely invisible.

The Measures of Effectiveness (MOEs) to be collected for analysis were:

a. Maximize Blue Attrition.
b. Minimize Red Attrition.

The data were then analyzed using the Clustering and Outlier Analysis for Data Mining (COADM)1 tool developed by DSO National Laboratories to identify the parameters associated with the best Red cluster, i.e. the cluster with the lowest Red attrition and highest Blue attrition. Below is a summary of the results in Table 8:

Red Farming Parameters	Tank		Balanced		NLOS	
	Mean	Var (+/-)	Mean	Var (+/-)	Mean	Var (+/-)
Red Reinforcement Tank Individual Aggression	-80.18	55.209	-76.97	0.504	29.51	0.189
Red Reinforcement Tank Squad Aggressiveness	-92.02	43.763	63.52	25.021	-13.74	0.33
Red Reinforcement Tank Response To Injured Red	-32.36	26.372	-59.71	8.132	-26.48	0.002
Red Reinforcement Tank Clustering	-77.11	1.285	-91.5	7.565	-86.2	14.901
Red Reinforcement Tank Squad Cohesion	-24.02	15.976	-28.57	8.198	-94.12	0.208
Red Reinforcement IFV Individual Aggression	2.64	29.89	62.8	17.784	45.92	0.901
Red Reinforcement IFV Squad Aggressiveness	3.4	24.593	65.38	36.251	92.1	0.332
Red Reinforcement IFV Response To Injured Red	-5.3	29.807	23.08	22.677	43.02	0.315
Red Reinforcement IFV Clustering	17.98	35.456	-75.54	3.324	-41.76	0.582
Red Reinforcement IFV Squad Cohesion	-87.7	0	-2.04	14.523	-3.07	11.006
Red Ambush Tank Individual Aggression	10.42	11.581	-85.02	1.418	-17.99	0.21
Red Ambush Tank Squad Aggressiveness	-82.12	35.319	10.21	0.925	87.83	0.375
Red Ambush Tank Response To Injured Red	75.22	38.811	26.41	26.874	56.93	0.155
Red Ambush Tank Clustering	37.99	41.54	-35.69	33.238	-50.11	1.412
Red Ambush Tank Squad Cohesion	-15.64	9.038	-48.91	5.362	-0.99	0.468
Red Ambush IFV Individual Aggression	28.64	86.719	17.55	11.594	35.5	0.332
Red Ambush IFV Squad Aggressiveness	47.52	27.774	98.75	28.474	-55.17	0.302
Red Ambush IFV Response To Injured Red	-24.1	39.793	11.21	0.525	88.16	0.465
Red Ambush IFV Clustering	43.64	42.42	-35.41	64.993	-59.38	0.233
Red Ambush IFV Squad Cohesion	94.39	0	-49.43	2.009	-21	0.692
Red Ambush IFV Stealthiness	97.02	0	92.29	1.326	94.8	0.51

Table 8: Results of Red Teaming Runs.

The above results indicated that an effective Red force against the Blue Tank structure would be for the Red reinforcement tanks not to cluster during movement and the Red reinforcement IFVs not to move cohesively. The Red ambush IFVs need to move in a cohesive and stealthy manner to avoid the forward deployed Blue tanks.

The above results indicated that an effective Red force against the Blue Balanced structure would be for the Red reinforcement force not to cluster during movement to avoid Blue fire support. The Red reinforcement and ambush tanks also need to be less aggressive individually. The Red ambush IFVs need to be highly stealthy and less cohesive to avoid the Blue tanks.

The above results indicated that an effective Red force against the Blue NLOS structure would be for the Red

1 CODAM is a data mining software package that is capable of visualizing complex data set and it keeps track of information which greatly facilitates the data mining process.

reinforcement force to be more aggressive individually and not to cluster during movement to avoid Blue fire support. The Red ambush tanks need to be more aggressive as a squad and with a propensity to move towards fellow injured Red. The Red ambush IFVs need to be highly stealthy, less cohesive to avoid the Blue tanks and with a propensity to move towards fellow injured Red.

	Tank		Balanced		NLOS	
	Base Case	ART	Base Case	ART	Base Case	ART
Blue Force						
Mean Attrition & Percentage	5.44 (28.6)	6.74 (35.5)	8.84 (52.0)	11.08 (65.2)	8.81 (62.9)	12.06 (86.1)
Red Force						
Mean Attrition & Percentage	29.43 (66.9)	23.4 (53.2)	31.08 (70.6)	25.92 (58.9)	28.61 (65.0)	21.98 (50.0)

Table 9: Comparison between Base Case Run and Red Teaming Results.

The Red Force recommended by ART has shown to achieve higher Blue attrition and lower their own attrition. By applying ART, we have effectively found gaps in performance of Blue's plan which would otherwise not be so easily identified.

Based on the indications of the red teaming results, the Blue should be prepared to face a possibly challenging Red Force and hence improve their capability and plans to counter the following red characteristics:

a. Stealth. Using better or more sophisticated sensors to identify stealthy Red agents hiding within buildings, can greatly aid in survivability of Blue. This is to ensure that the Red Force would not be elusive.
b. Cohesion. In order to counter the dispersion of the Red defending forces, it is important to derive plans to force the defence to cluster or co-locate at known positions to Blue. Carefully planted support fire and deceptive tactics can help Blue achieve this effect.
c. Aggression. Behavioural techniques to reduce aggression can also reduce Red's effectiveness. For instant, using a show of force (shock and awe) to intimidate the enemy.

With the results obtained, we have demonstrated the ability of using ART to search for associated parameter values that improved red force performance. In understanding what constitutes a potent Red Force, the Blue then has the ability to refine their plans and capability to ensure a more favourable and robust outcome when engaging an unpredictable Red Force.

SUMMARY OF FINDINGS

Blue structures with medium class IFV/NLOS platforms

Platforms	Tank Heavy			Balanced			NLOS Heavy		
	#	No. Killed	% Killed	#	No. Killed	% Killed	#	No. Killed	% Killed
Total Blue	19	5.44	28.6	17	8.84	52.0	14	8.81	62.9
Total Red	44	29.43	66.9	44	31.08	70.6	44	28.61	65.0

Blue structures with heavy class IFV/NLOS platforms

Platforms	Tank Heavy			Balanced			NLOS Heavy		
	#	No. Killed	% Killed	#	No. Killed	% Killed	#	No. Killed	% Killed
Total Blue	19	3.77	19.8	17	3.1	18.2	14	3.6	25.7
Total Red	44	36.07	82.0	44	30.72	69.8	44	30.6	69.5

Table 10: Summary For The Force Options

The study indicated that up-armouring of IFV/NLOS from the medium to the heavy class is probably required given the threats they would face in the urban environment. Both the Tank Heavy and Balanced company with the heavy armoured IFV/NLOS met the criteria of at least 80% survivability rate (Redcon 1) and are plausible force structures for urban fight. However, the Tank Heavy company is recommended as it inflicted more damage to the Red forces as compare to the Balanced structure.

Based on the ART findings, the Blue force should employ effective sensors to seek and destroy the Red ambushed forces. Carefully planned fire would be required to prevent the Red from scattering and behavioural techniques such as a show of force (shock and awe) could be used to curb the Red forces aggressiveness.

CONCLUSIONS

The findings presented in this paper highlighted some of the key issues for a force to fight in built up areas and can perhaps provide a useful basis for the future studies to be conducted.

It is important to keep in mind that the results were preliminary as many unique features of urban operations were, unfortunately, not possible to model here. To draw more conclusive answers and refine the options, it is recommended that further experimentation be conducted using other modeling and simulation tools, as well as to focus on the other potential operational tasks (such as obstacle clearance under hostile fire) of the Combat Team as part of the urban fighting mission.