Temasek Defence Systems Institute



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Effects of Sensing Capability on Ground Platforms' Survivability During Ground Force Maneuver Operations.

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PROBLEM DEFINITION

The conventional approach of increasing passive armor thickness on ground platforms may not be the way ahead as advancements in weaponry are going at a faster pace than armor protection development. Adding to the difficulty, most existing platforms are reaching their weight limits, making it technically not feasible and not cost effective to keep adding passive armor thickness. Therefore, there is a need to identify other approaches to improve ground platforms' survivability while developments in armor protection are still in progress.

MODELING & SIMULATION

The measures of effectiveness were:

- 1. Percentage of Blue Casualties
- 2. Probability of Mission Success
- 3. Time to Complete mission



SYSTEMS ENGINEERING APPROACH

The author modified Winston W. Royce's Waterfall Systems Engineering process model, developed in 1970, and tailored it to guide the study of this thesis. This model is iterative, and each phase of the model can provide feedback to any of its preceding phases.

OPERATIONAL ANALYSIS

Maneuver, as defined in the US Joint Capability Area Refinement Paper 2010, is the ability to move to a position of advantage in all environments in order to generate or enable the generation of effects in all domains and the information environment.

A hypothetical scenario is designed to maneuver three teams of Blue forces, each comprising a platoon of Abrams MBT, Bradley IFV, and Stryker ICV from base camp to a designated location 20km away. It is anticipated that there are adversaries (Red forces) in ambush along the movement route. Each team was dispatched at intervals of ten minutes, and the formation of each team was in the following order: MBT followed by IFV and lastly ICV. Fifteen minutes prior to moving out, two units of Raven UAVs were deployed for aerial surveillance, and the maneuver force was supported by 155mm artillery.



CONCEPTUAL DESIGN

Tailored Systems Engineering Waterfall Process Model



Hypothetical Ground Force Maneuver Operations



FACTORS STUDIED

- Sensor classification probability at maximum sensor classification range for:
 - Main Battle Tank (MBT)
 - Infantry fighting Vehicle (IFV)
 - Infantry Carrier Vehicle (ICV)
 - Unmanned Aerial Vehicle (UAV)
- UAV Speed •

MANA Scenario modeled

The Map Aware Non-Uniform Automata (MANA) Agent-based simulation software was used to create a hypothetical Ground Force Maneuver Operation Scenario for this exploration.

DESIGN OF EXPERIMENTS

The Nearly Orthogonal Latin Hypercube, which generated 33 nearly orthogonal design points, is used for the design of experiments methodology used.

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Scatter Plot Matrix

UAV Speed (kph)				
	UAV class Prob @ Max Class Rng			
		MBT Sensor class Prob @ Max Class Rng		
			IFV Sensor class Prob @ Max Class Rng	
				ICV Sensor class Prob @ Max Class Rng
30 40 50 60 70 80	0.450.55 0.65 0.75 0.85	0.450.55 0.65 0.75 0.85	0.450.55 0.65 0.75 0.85	0.450.55 0.65 0.75 0.85

- Space filling property
 - No large empty spaces
 - NOLH sampled well

RESULTS AND ANALYSIS

Both regression and partition tree models created can explain approximately 77% of the response variations. In order of importance, the significant factors identified were IFV sensor classification probability, MBT sensor classification probability, and UAV speed.

■ Response Mean(Blue Cas %)		
⊿ Actual by Predicted Plot	Summary of Fit	
	RSquare	0.769195

t Prune				Number					
	RSquare	RMSE	N	of Splits	AICc				
	0.777	0.0214673	33	4	-144.64				
						1			

FUNCTIONAL ANALYSIS

Functional decomposition was the analysis method used to identify the high-level critical functions that are required to be performed by the system to achieve the objectives.

SCOPE OF STUDY

The systems engineering process identified some alternatives to improve survivability, and this thesis focus on studying the effectives of sensing capability by analysing the effects of various platform's sensor classification probability at maximum sensor classification range.

Function Function Function Function 1.1 2.1 3.1 4.1 Navigate Route Detect Objects Avoid Adversaries' Detection Function Function Function Function Function Function Function Function Function Function Function Function 1.2 Classify Objects 3.2 Defeat Incoming Munitions Function Function Function Function Function Function Function	6 Monitor Area of Operations	5 Communicate Information	4 Attack Adversaries	3 Protect Crew	2 Sense Adversaries	1 Move Assets
Function Function 1.2 2.2 Drive Platforms Classify Objects Function Function Function Function Function Function 1.3 (2.3)	6.1 Display Map	5.1 Transmit Information	4.1 Employ Weaponry	3.1 Avoid Adversaries' Detection	2.1 Detect Objects	1.1 Navigate Route
Function Function Function Function	6.2 Update Map	5.2 Receive Information	4.2 Track Adversaries	3.2 Defeat Incoming Munitions	2.2 Classify Objects	1.2 Drive Platforms
Transport Identify Prevent Armor	Function	Function	Function	3.3 Prevent Armor	2.3 Identify	Function

Functional Decomposition for Maneuver Ground Forces



Potential Scope of Analysis on Survivability Improvement



Results of Regression Analysis



Results of Partition Tree Analysis

ion Probability @ Max Range

-0.0140

-0.0309

0.000

-0.0038

BENEFITS

When actual information such as hit probabilities and effective ranges are used, the model can provide decision makers with quantitative figures as references for specification definition.

FUTURE WORKS

The thesis, which focuses on ground platforms' survivability in ground force maneuver operations, is made in conjunction with two other theses that explore offensive and defensive operations, respectively, in an urban environment. It is envisage that when all three these are studied together, more insights could be uncovered.

