Temasek Defence Systems Institute

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

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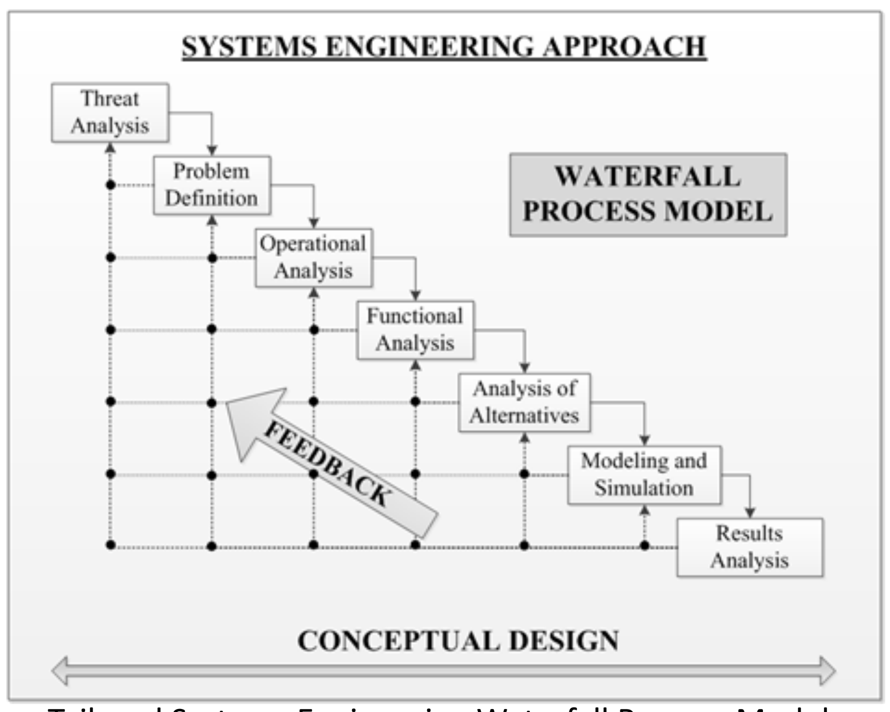
PROBLEM DEFINITION

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.

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.

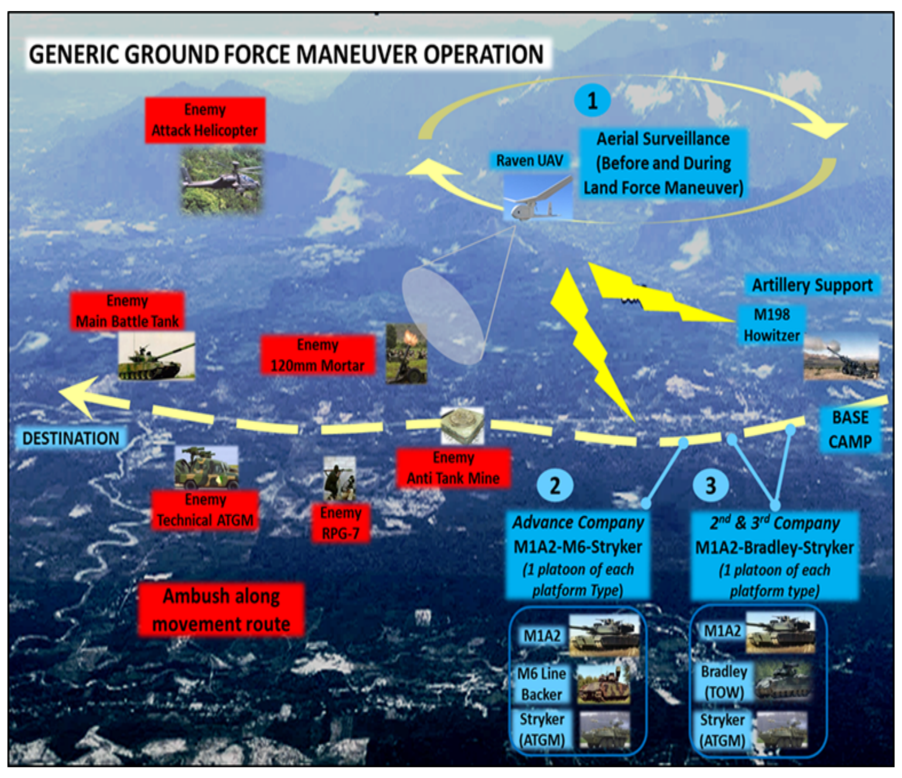


Tailored Systems Engineering Waterfall Process Model

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.

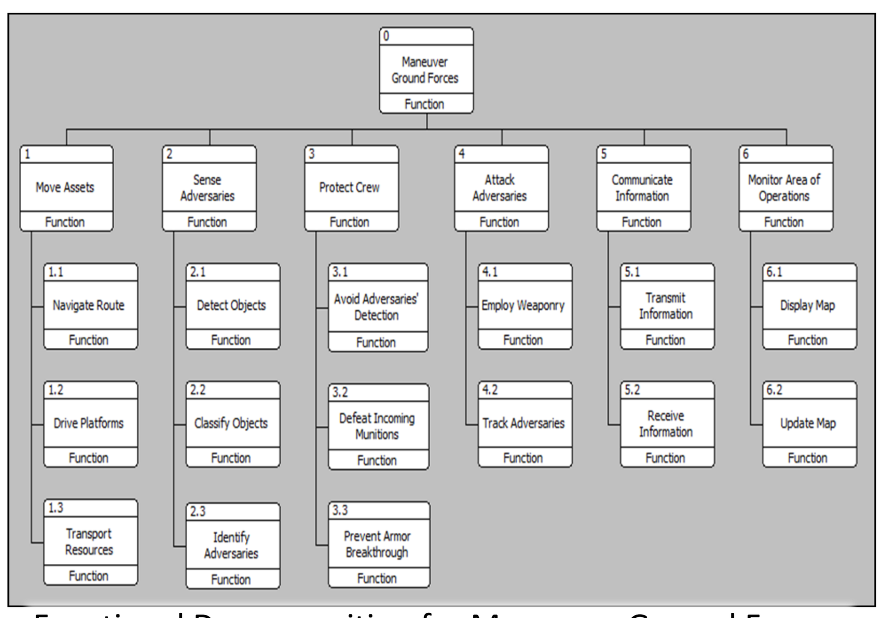
A hypothetical scenario is designed to maneuver three teams of Blue forces, each comprising a platoon of Abrams MBT, Bradley IFV, and Stryker ICV from base camp to a designated location 20km away. It is anticipated that there are adversaries (Red forces) in ambush along the movement route. Each team 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.



Hypothetical Ground Force Maneuver Operations

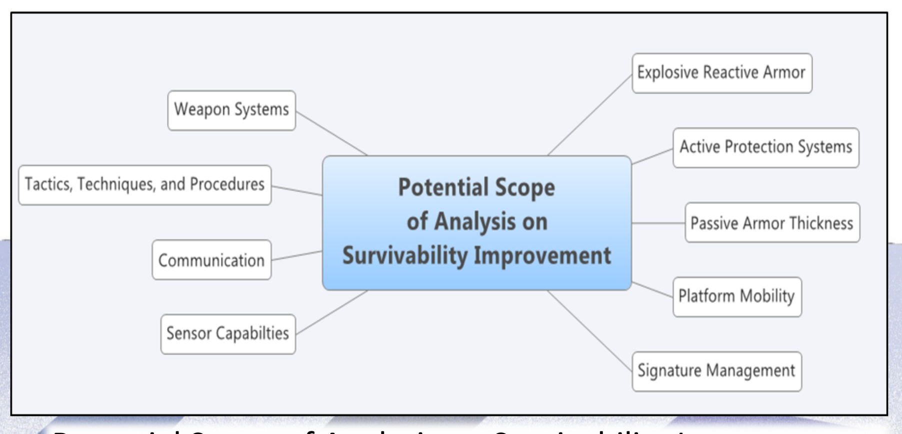
FUNCTIONAL ANALYSIS

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.


Functional Decomposition for Maneuver Ground Forces

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.



Potential Scope of Analysis on Survivability Improvement

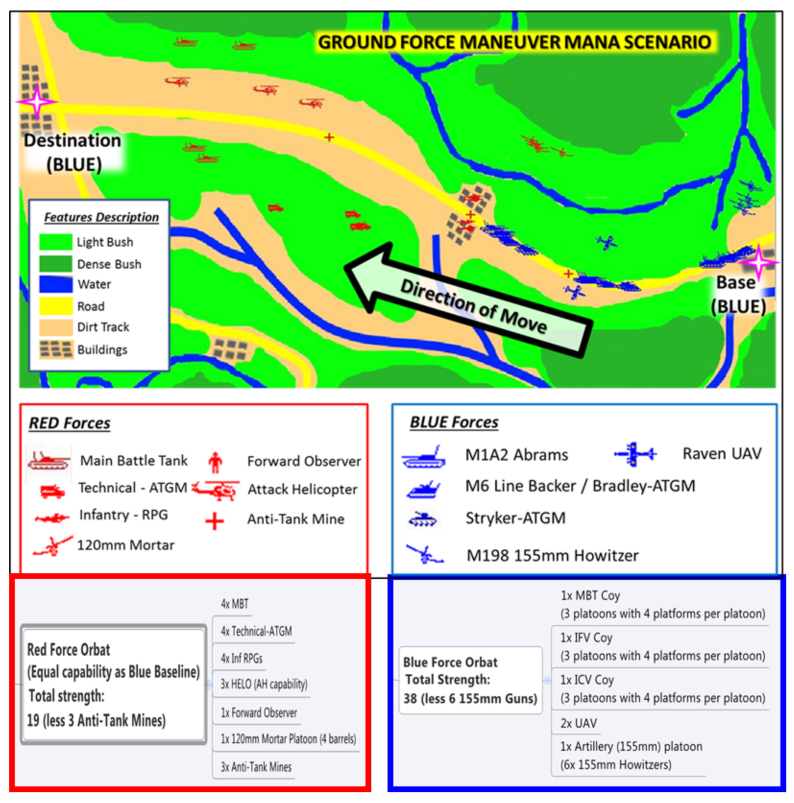
MODELING & SIMULATION

The measures of effectiveness were:

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

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

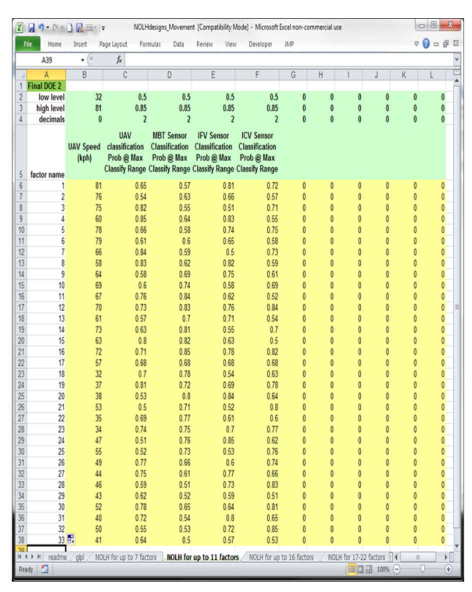


MANA Scenario modeled

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.



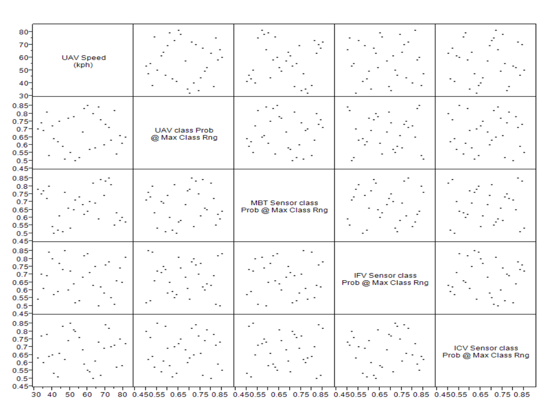
Correlation Matrix

(Pair wise correlation Analysis)

			Sensor Classification Probability @ Max Range			
		UAV Speed (32~81 kph)	UAV (0.5 to 0.85)	MBT (0.5 to 0.85)	IFV (0.5 to 0.85)	ICV (0.5 to 0.85)
	UAV Speed (32~81 kph)	1.0000	0.0076	0.0096	-0.0291	-0.0140
Sensor Classification Probability @ Max Range	UAV (0.5 to 0.85)	0.0076	1.0000	0.0001	-0.0215	-0.0309
	MBT (0.5 to 0.85)	0.0096	0.0001	1.0000	-0.0044	0.0001
	IFV (0.5 to 0.85)	-0.0291	-0.0215	-0.0044	1.0000	-0.0038
	ICV (0.5 to 0.85)	-0.0140	-0.0309	0.0001	-0.0038	1.0000

- Max pairwise correlation is < 0.05.
- NOLH kept the factors nearly orthogonal

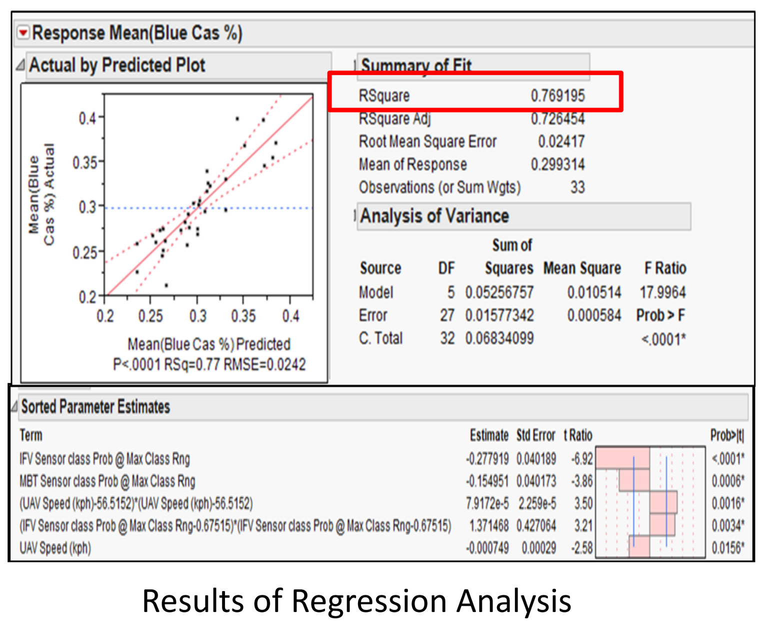
Scatter Plot Matrix

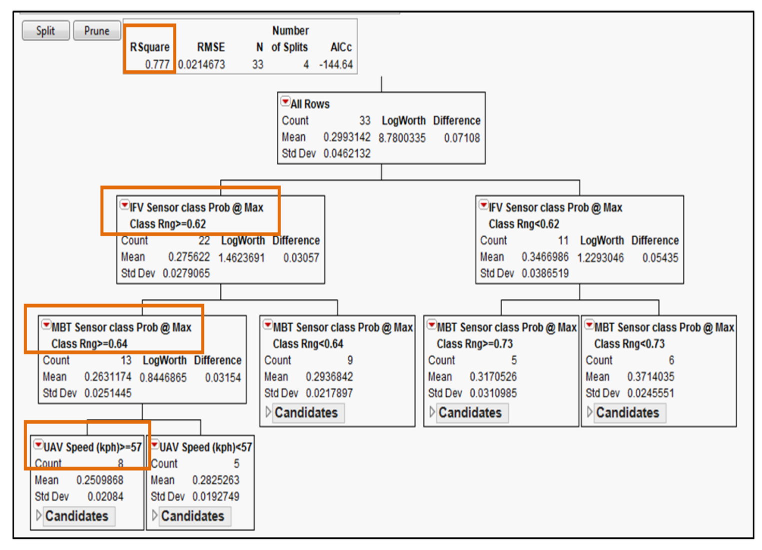


- Space filling property
  - No large empty spaces
  - NOLH sampled well

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.


Results of Regression Analysis


Results of Partition Tree Analysis

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.

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