16204

PROJECT GUARDIAN: OPTIMIZING ELECTRONIC WARFARE SYSTEMS FOR GROUND COMBAT VEHICLES

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ABSTRACT

A comprehensive U.S. Army study was recently conducted to evaluate the combat worth, cost and risk associated with the application of electronic warfare suites to ground combat vehicles. The study, Project Guardian, represents a new process for determining the optimum set of sensors and countermeasures for a specific vehicle class under the constraints of threat projection, combat survivability, cost, and technical and operational risk.

The process begins with a thorough projection of anti-armor threats for a specific time frame. Threat and EW performance is then modeled and incorporated into CASTFOREM; the approved U.S. Army force-on-force simulation used on all major weapon system cost operational effectiveness analyses. Simulation runs, using a variety of scenarios, are conducted to evaluate EW suite combat effectiveness in terms of point defense (i.e., each vehicle provides its own defense) and as a force protection measure (i.e., EW assets are distributed across the battle unit). Next, the cost of development, production and installation is estimated using industrial and international sources. The risk portion of the study employs a standard process for estimating the technical and operational risks associated with the EW components. The final stage of the study uses combat effectiveness, cost and risk criteria to arrive at optimum EW suites for further development.

THREAT ASSESSEMENT

Threat projections were targeted fo the year 2005. Today's threat and new, projected threat systems expected to be on the battlefield in approximately ten years were incorporated in the study. System Threat Assessment Reports for U.S. tanks, armored personnel carriers, and mobile field artillery were the basic documents used in developing the threat. Other Defense Intelligence Agency and Army approved Foreign Science & Technology Center sources were also used for detailed information purposes.

SELECTING THE SCENARIO

In selecting the scenario, care should be taken to pick a range of situations so as to not prejudice the outcome of the analysis. A span of at least three criteria should be sought in establishing the combat situation. First, the terrain should be varied to permit full deployment of smart weapons at one extreme and, at the other extreme, a topography that restricts the operation of such advance technology threats. For instance, scenarios involving southwest Asia where the terrain is

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flat and line of sights are greater than weapon ranges permit smart weapons to be used to their full potential. Conversely, European regions have shorter line of sight terrain characteristics and ranges of engagement are consequently less.

A second criteria to be remembered in scenario selection is engagement type. Meeting engagements entail the dynamic movement of threat weapon systems and EW protected platforms. Inherent in such engagements are tactics which may favor the use of certain threats and the placement of certain types of blue vehicle systems. In addition to meeting engagements, defensive situations should also be used in the analysis. Defensive positions permit blue vehicles to be in defilade and increases the effectiveness of such countermeasures as multi-spectral smoke.

A final criteria to be considered in selecting a scenario is that of vehicle mix. Variations in the relative number of tanks and APCs can have a significant effect on the killer - victim scoreboard and hence the conclusions one reaches when analyzing cost and combat effectiveness plots. The variation of this criteria should span the range of vehicle mixes that the user intends to use in actual wartime situations.

In the final analysis, results between various scenarios should be compared to uncover trends in the data produced. Performance of selected EW suites should, in general, be consistent between scenarios. Specific suites, however, may be effected by terrain, engagement type, or vehicle mix. Considerable insight can be gain in such circumstance by informing the user how to best equip his vehicle fleet in advance of a particular combat engagement.

A PROTECTION CONTINUUM

In Project Guardian, a continuum of protection options were considered. At one end of the continuum is point defense where each major vehicle system is equipped with the same EW suite to protect itself from a majority of the threats encountered. This option is generally the most combat effective option but also proves to be the most costly method to protect the force.

The second point in the continuum is termed selected defense. In this case specific vehicle classes are equipped with the same EW suite, other vehicle classes do not possess EW assets. This option generally proves to be cost effective by providing enhanced protection to forces' high value targets. Depending on the type of scenario, protecting only the tanks or only the field artillery systems may prove to be highly effective from a cost and combat payoff standpoint.

A third distribution of EW assets is possible if sensor equipment is shared among vehicles within a battle unit. Battle units considered were either platoons or sections of vehicles. This option, called distributed protection, provides lower cost since sensors are generally the more expensive component of an EW suite. Vehicles in the battle unit all have a full complement of countermeasures with the possible exception of Radar Warning Receivers (RWR) and Radar jammers. Inherent in this option is the existence of an intra-vehicle communication system capable of transmitting threat information to the vehicles being targeted.

At the upper end of the protection continuum is area protection. In this option, a single vehicle is equipped with the sensors and a countermeasures capable of protecting the battle unit. For example a radar jammer could protect a battle unit against threats using radar to target the unit. This option also depends on a communication link between vehicles of the battle unit to be effective since not all sensors are amenable to area detection in its purest form.

In the table below are examples of each of the protection options just described. Sensors indicated are Laser Warning Receiver (LWR), Missile Warning Receiver (MWR), and Radar Warning Receiver (RWR).

	POINT	SELEC	DIST	AREA
LWR	ALL	M1	M1	ALL
MWR	ALL	M1	M2	NONE
RWR	ALL	M1	NONE	NONE
CM	ALL	M1	ALL	ONE

COST ESTIMATING

Estimating the cost of EW componentry involves an examination of three cost factors; development costs, production costs, and integration costs. If the sensor or countermeasure is in a development phase, an estimate of the cost required to fully develop the item for production is required. This estimate is then prorated over the number of units expected to be produced. Production quantities depend on what option will be selected from the protection continuum. A consideration of the fleet size enters at this point and for Project Guardian Force Level One, an Army projection of future combat vehicle production quantities, was used. For example, suites for point defense used 1079 M1A2 tanks as a reference in the cost estimating.

Integration of EW suites are also included in any final total cost estimate. Such integration can generally be accomplished at a depot and involves the labor and fixtures required to install the sensors and countermeasures to the vehicles exterior. Integration cost may vary between vehicle classes due to the need for positioning the sensor or countermeasure in such a manner as to not interfere with other equipment or system operation.

Much of the cost estimates were obtained from suppliers of EW equipment and vehicle producers. In addition to this source, benchmark data was also obtained from manufactures of aircraft EW systems, and foreign companies.

COMBINING COST AND SURVIVABILITY

A number of representations were examined to portray the relationship between cost of EW suites and the resultant survivability. Metrics such as force exchange ratios and cost as a percentage of vehicle cost were used at various stages of the study and were found to be less than satisfactory in depicting the combat worth of such equipment. The parameters of choice in the study were blue vehicles lost and the cost of the suite as a percentage of the scenario fleet cost. A representative plot of these factors is shown in Figure 1.

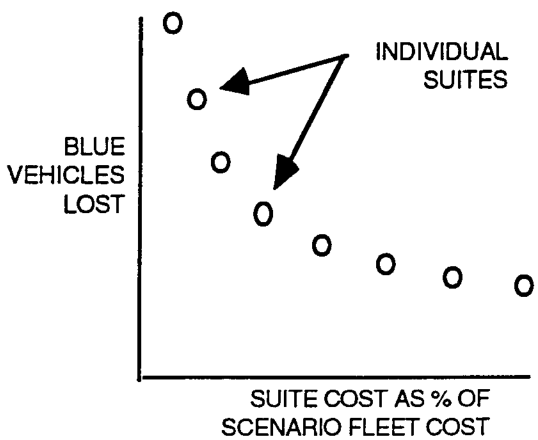

FIGURE _____

EW suites that exist above this lower boundary of data points are ignored in the search for an optimum suite because they will be both less survivable and more expensive than the suites which lie near them and on the boundary.

There is a natural tendency at this juncture to try and convert both parameters into common units so that a suite on the boundary nearest to the origin could be selected as optimum; a minimum of both cost and vehicles lost. Unfortunately, the vehicle mix of blue losses varies with the particular suite analyzed.

Optimal suites can be selected by the simple expediency of accepting only those suites which save more than 20% of those vehicles which are lost in the baseline case (i.e., blue losses when no EW suites are deployed) and cost no more than 15% of the scenario fleet acquisition cost.

In order to affirm that the above selection of optimal suites satisfy a minimum cost - minimum loss approximation, a second parameter was calculated called Net Return on Investment(NROI)

$$\text{NROI} = \frac{\text{Cost of blue vehicles saved} - \text{Cost of EW equip lost}}{\text{EW cost to equip scenario vehicles}}$$

Suites with NROI values greater than one were judged to be near approximations to the min-cost / min-loss conditions and subjected to further analysis. Selected and distributed protection options will generally show high NROI values compared with point defense since any reduction in the cost of the EW componentry greatly effects the denominator of the above equation.

RISK; A THIRD PARAMETER

A formal process for estimating risk, developed by the Defense Systems Management College, was employed in Project Guardian. Risk should be thought of as a function of two variables: the probability that something will fail (P), and the consequence of that failure (C). Estimates of these two variables for each sensor and countermeasure considered in the study were arrived at through a series of meetings with experts in the technologies involved.

The process consideres probability of failure due to hardware and software inmaturity and complexity and the likelihood that the component will fail to meet its prescribed performance goal or exit criteria. Consequence covers impact on schedule, cost, and performance should failure occure.

The formal equation for risk using this process is as follows

$$R = P + C - PC$$

where P and C vary between zero and one. Figure 2 shows some representative results for the risk of three different suites. The curves labeled R=.3, R=.7 and R=1.0 are isorisk curves. Suite #1 has a risk value of .57 and is considered to have medium risk. Suite #2 risk value is .97 and has a very high risk. Suite # 3 risk value is .87. The topography of this equation depicts a risk adverse approach to risk taking.

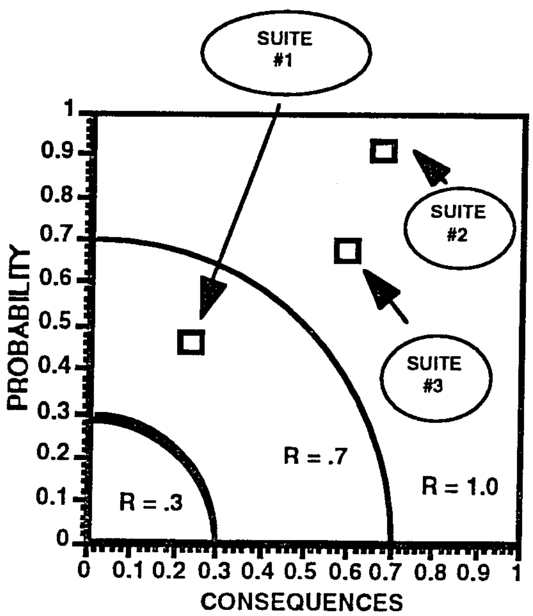

Figure 2

Both probability and consequences for given suite can be mitagated if redundancy is built in or if the sensors and countermeasures are capable of handling more than one threat. In the case that a series of misfortunes can occur within the suite as it counters the threat, the highest probability and greatest consequense is generally assumed.

The process of estimating risk is most effective when a relatively large group of experts are employed. This diversity of opinion leads to fruitful discussions and can, in some instances, lead to the generation of ideas on how to modify the suite in order to reduce the probability of failure or lessen the consequences of system malfunction.

PUTTING IT ALL TOGETHER

Combining combat effectiveness, cost, and risk can take a number of forms. One method used in Project Guardian was the use of a series of criteria or filters as subsequent stages of the analysis were performed. For instance, the criteria used after combat simulation was the requirement that only those suites that saved more than 20% of the blue vehicles lost in the baseline be passed on to the next stage of the analysis. At the cost estimating stage, the criteria employed eliminated any suite whose cost to equip the scenario fleet cost more than 15% of the cost to aquire the vehicles within the scenario fleet. At this point, only those suites which were approximately near the min-cost, min-loss region survive the process. Net Return On Investment serves to suppliment or reaffirm that second phase of the filtering process. The final filter is risk. Medium risk or even high risk suites can survive this final stage if the risks are balanced by the utility of the suite to counter a wide range of anti-armor threats.

Graphically these three criteria can plotted on the same chart to permit comparison. Figure 3 is one such plot using hypothetical suite data.

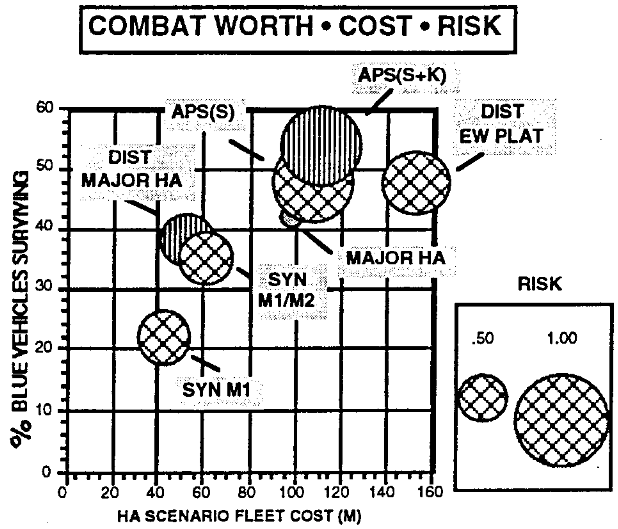

Figure 3

CONCLUSIONS

Project Guardian utilized a unique process normally reserved for the evaluation of a combat system already under development. The process of evaluating combat effectiveness, cost, and technological and operational risk of survivability measures which are still in the R&D stage provides improved focus for advanced development of such equipment. Using simulations already accredited for major acquisiion decisions, costs estimated from privious applications of the components, and a standardized risk methodology, the Guardian process permits an effective selection from a myriad of EW components those suites which have the best chance of providing significant combat worth.

Future applications of Projedt Guardian are envisioned to cope with the changing world of combat. Advances in threat technology, EW sensors and countermeasures, and other survivability factors can be readily be incorporated into the process to permit effective development of combat equipment well in advance of future combat.

Dr. Parks is the Director of the Survivability Technology Center (STC) at the U.S. Army Tank-Automotive RDE Center. His responsibilities include the planning, control, and resource management of technology efforts aimed at improved survivability of ground combat vehicles. STC programs include armor technology development and warfare technologies; development, integration and testing of vehicle signature reduction, and vehicle system fire suppression. Dr. Parks's experience spans 15 years of government service and 12 years industry experience pertaining to the conduct and management of defense related research and development.