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EFFECTIVENESS OF NAVAL SURFACE FIRE SUPPORT TO THE ARMY BRIGADE COMMANDER IN A LITTORAL CAMPAIGN

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ABSTRACT

Since the end of the Cold War, the Army has engaged in an unprecedented number of joint contingency operations hinting at future missions aimed at protecting U.S. interests worldwide. To engage and defeat future threats to our national security, the Army must transform itself into a more strategically responsive, lethal force. This paper analyzes the effectiveness of Naval Surface Fire Support (NSFS), which can help lighten the force by providing support for brigade-sized units. The Fire Support Simulation Tool (FSST) simulates the employment of various indirect fire courses of action (COA's) for analysis. Comparing the utility of several well-constructed COA's using the FSST's output can help decision-makers determine the effectiveness of NSFS for specific campaigns. The results of this analysis conclude that there is strong *quantitative* and *analytical* evidence to support the effectiveness of NSFS to an Army Brigade commander engaged in a littoral campaign.

1 INTRODUCTION

Since the end of the Cold War, the Army has been engaged in an unprecedented number of joint contingency operations that run the gamut from humanitarian efforts in Cuba and Haiti to peace-enforcing and peace-keeping in Bosnia to full scale war in Southwest Asia. As stated by the Army Chief of Staff, GEN Shinseki,

> With the emergence of an increasingly complex international security environment, sources of conflict and tension are increasing. Sources of unrest and conflict range from competition between states to the instability caused by the collapse of states unable to meet the strains of resource scarcity, population growth, and ethnic and religious militarism. The technology enabling real-time transmission of information from any point on the globe has facilitated the rise of sub-national and transnational groups, including criminal and terrorist elements that may pursue objectives that threaten U.S. interests (Shinseki, 2000).

Over the last ten years, there has been a steady increase in rapid-deployment, multi-dimensional, joint contingency missions to combat these threats. As we move into the 21st century these missions will certainly become more and more complex and more commonplace. To meet the requirement to engage and defeat these threats to our national security, the Army must transform itself into a more strategically responsive, lethal force that is dominant across a broad spectrum of military operations such as peace-keeping, combating criminal and terrorist activities, and full scale war. General Shinseki's vision for the Army is one of transformation from a Legacy Force designed to defeat Soviet forces in Europe to an Objective Force designed to preempt and if necessary defeat threats from all corners of the globe. This transformation should ultimately result in a force designed to take advantage of technology to facilitate the ability to rapidly deploy forces and to synchronize and integrate combat power through the design of compatible systems throughout the Army, Navy, Air Force, and the Marines.

Based on General Shinseki's vision, the Army is faced with the challenge of lightening the force while simultaneously increasing its survivability and lethality. To do that, the Army must break free from the paradigm of a self-sufficient and self-contained force. It must fully develop its capabilities as an integrated, joint force able to synchronize the lethal and non-lethal fires of all services at the brigade level. Reach-back technologies from sea, air, and space can provide Army units with added lethality without encumbering them further.

This paper analyzes the effectiveness of Naval Surface Fire Support (NSFS) for use in supporting land-based Army forces in the littoral. Rather than simply analyzing the different characteristics and specifications of available indirect fire weapon systems to determine their effectiveness, a model was created. This model, the Fire Support Simulation Tool (FSST), takes the capabilities and limitations of the weapon systems being studied and simulates their employment in the context of a well-defined scenario.

This paper analyzes the data produced by the FSST to draw some broad conclusions about the future of indirect fire support for Army operations.

2 METHODOLOGY

The objective of this paper is to determine the effectiveness of NSFS to the Army at brigade level and below in a littoral campaign. In order to determine the effectiveness of NSFS, the objective is defined in terms of measures of effectiveness or MOE's. The process of determining the MOE's begins by defining the problem statement in several more concise sub-objectives, called top-level objectives. The top-level objectives are to maximize reliability, flexibility, and lethality. They will be discussed in more detail below.

When the top-level objectives are met, the system being measured or analyzed is effective. The process continues by successively redefining each of the higher-level objectives with lower-level objectives that are needed to satisfy them. These objectives continue to be redefined until they are quantitative in nature. These quantitative objectives are the bottom-level objectives or MOE's. The condensed objective tree (the intermediate level objectives are not shown) that was developed to measure the effectiveness of NSFS is shown below in Figure 1.

2.1 Maximize Reliability

Reliability is an important part of integrating an asset into an operation. For an Army brigade commander to effectively integrate and synchronize the indirect fires into an operation, he must know that the asset will deliver its munitions on target at the prescribed place and time.

To a brigade commander reliability of indirect fires generally consists of two screening criterion: (1) capability of an asset to respond to and engage various threats and (2) timeliness in its response to the request for indirect fires. Quantifying each of these objectives results in the lowest level objectives needed to measure reliability. These lowest level measurable objectives are the percentage of missions that the asset was capable of engaging, the percentage of those missions that were successful, and the time that each asset took to engage each threat.

The percentage of missions that each COA *could* engage encompassed the brigade commander's first criteria for reliable indirect fires. This bottom-level objective tells the brigade commander whether the assets at his disposal can cover a sector of his tactical plan with the ammunition available.

The percentage of successful missions pertains to the second of the brigade commander's criterion. Measuring the percentage of successfully engaged targets of those that could be engaged tells the brigade commander how responsive the indirect fires are to his requests. It measures their ability to reliably engage the targets he wants engaged and inflict the requisite damage on those targets.

The average time to engage targets is a measure of the timeliness of the indirect fires in a particular COA. This pertains to the brigade commander's third criterion.

2.2 Maximize Flexibility

Flexibility is the ability of an asset to perform and successfully accomplish diverse missions. Flexibility includes more than the ability to range targets. It includes having the right munitions to engage hardened targets and having the precision to engage targets that are positioned in awkward or protected locations. The sub-objectives listed below were identified as crucial to measuring flexibility.

High precision allows an asset to be used to engage targets that are in close proximity to friendly troops or noncombatants. By measuring the number of errant rounds that induce collateral damage in each scenario, the simulation can measure the precision of indirect fires in that scenario. By carefully modeling this parameter, collateral damage for different environments can be measured. For example, in a rural setting, on average, collateral damage might only be induced by 0.1 percent of the rounds that are errant by 200 or more meters, while in an urban setting, collateral damage might occur with a 50% chance if a single round misses its mark by more than 50 meters. These specific parameters are included in the scenario.

Maximizing coverage allows one asset to provide indirect fires in the maximal number of situations. By measuring the percentage of the area of operations covered by indirect fires, we can compare the differences in different courses of action.

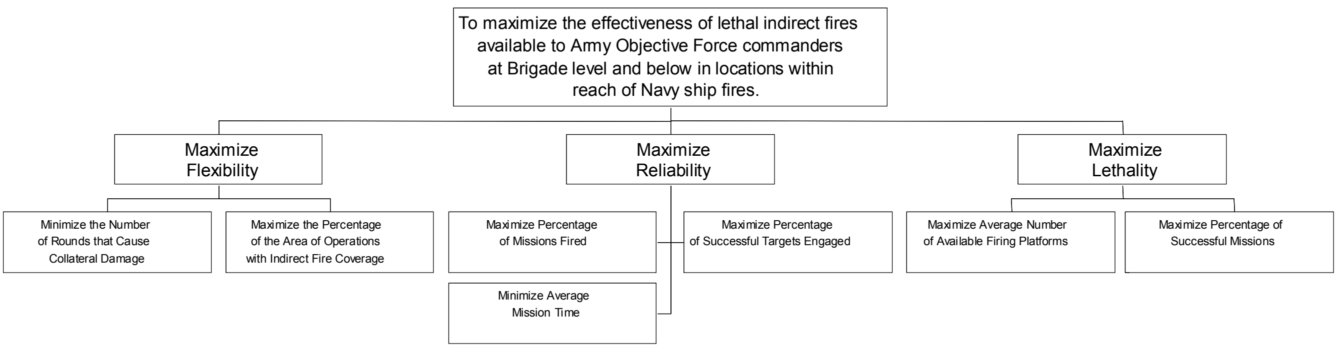

Figure 1: Condensed Objective Tree

Ultimately, maximizing flexibility consists of the following two bottom-level, measurable objectives: number of rounds that cause collateral damage and percentage of the area of operations that is covered by indirect fires.

2.3 Maximize Lethality

Lethality is the cornerstone of Army operations. Without lethality, or the perception of lethality, we are ineffective. Precision and massing of indirect fires attains lethality.

By maximizing the availability of artillery at any given moment, we can measure the extent to which we can mass fires. It is worthwhile to note that although this objective is listed under lethality, it is really a multidimensional objective that gives the commander a measure of flexibility and reliability as well. The average availability of firing platforms indicates how likely it is that at any given moment he can effectively engage a target (reliability), and can serve as an indicator to the commander that he has the flexibility to shift assets and move assets on the battlefield to enhance his ability to engage the enemy. Ultimately, maximizing the availability of firing platforms provides the commander with the lethality he needs to mass indirect fires, the flexibility he needs to move assets on the battlefield, and the reliability he wants to immediately engage targets as they become available.

A single fire mission supports the overall mission of the organization by doing its part in the concept of the operation. By maximizing the total percentage of missions engaged successfully, the success of the mission is maximized. This differs from the reliability measurement, since it only measures the percentage of missions that result in success of the ones engaged (# success/# engaged * 100%), while reliability measures the percentage of targets successfully engage with respect to the total number that arrive (# success/total * 100%).

2.4 Multi-Attribute Utility Theory

To measure the effectiveness of a specific course of action (COA), multi-attribute utility theory or MAUT, was used. This method provides a simple, relatively intuitive way to weight and quantify the value of very different decision-making criterion.

First, the decision-maker or his representative weights each of the MOE's based on its relative importance. Each raw score for each MOE in a particular COA is then compared with the corresponding raw scores from each other COA. The "best" raw score is assigned a utility of 1, while the "worst" raw score is assigned a utility of 0. Utility of the remaining MOE's is assumed to be linear, and is computed using the following formula, where i = MOE number, j = COA number:

$$\text{Utility Score MOE}_{i,j} = (x_{i,j}-\text{worst}_{i,j})/(\text{best}_{i,j}-\text{worst}_{i,j}),\ \forall\ i,j$$

The total utility of each COA is computed by summing the utilities for each MOE. The best COA, is the COA with highest total utility score (Canada and Sullivan, 1989).

2.5 The Simulation

Due to the complex, stochastic nature of this problem, there is no closed-form solution to measuring the effectiveness of NSFS. Because of this, simulation is a good tool to investigate the effectiveness of NSFS using the MOE's outlined above (Law and Kelton, 2000).

The Fire Support Simulation Tool (FSST) is a discrete-event simulation written in the programming language JAVA. The FSST uses Simkit, a discrete-event simulation package created by Assistant Professor Arnold H. Buss and LT Kurt Stork (Stork, 1996) written in Java. The objective of the FSST is to obtain the raw MOE data for each COA as determined by the value systems design described earlier. By accounting for the stochastic nature of target arrival times and fire mission times, the FSST can draw a complete picture of the strengths and weaknesses of each COA in terms of the MOE's and their variances when applicable. This is powerful information for a decision-maker and offers valuable insight into the performance of the assets being evaluated. For example, a commander who is very concerned with success of critical fire missions might chose an asset that is more stable (has lower variance in success rate) over one that is more chaotic with a higher average success rate. This simulation should reveal those chaotic behaviors allowing the commander to make a more informed decision. Since FSST is easy to set-up and execute, it should also allow any staff to quickly create and run multiple courses of action (COA's) for each scenario. The staff can then present the results and their analysis and their best scenarios to the decision-maker, expanding his flexibility and offering even more insight into the behavior of his assets in his environment.

2.5.1 Overview

The event graph shown in Figure 2 is a basic depiction of how the simulation works. The actual model is too complex to show in one simple event graph, but the basic model is depicted below in this one-dimensional event graph of a queuing model with one target or fire mission type and one server type.

The circle with RUN sets up the queuing model by initializing all attributes. The simulation begins with the arrival of a target that causes the model to initiate the arrival of another target at some discrete time, t_a, in the future (circle with "Target Arrives, Request FM"). The interarrival times, t_a, of the targets are modeled by random exponential interarrival times. When a fire mission arrives, it is queued if it is within range of a shooter (circle with "Add FM to Queue"). The algorithm discussed above determines the shooter whose queue that fire mission goes into. If the shooter is immediately available, the fire mission is processed t_s time units later (circle with "Attack tgt"). The parameter t_s is a function of the range from the shooter, the shooter type, and other variables.

Once the target is attacked, if the desired results are achieved *or* the target has fled, the mission is ended (circle with "End FM") and that shooter becomes available for another fire mission. If that particular shooter has another fire mission in the queue, it services that fire mission t_s time units later. If the desired results are *not* achieved *and* the target is still available, the fire mission is immediately repeated, with effects being considered t_r time units later. The parameter t_r is based on the time it takes for that particular shooter to refire the mission. Although this event graph does not depict it, the FSST computes and maintains the number of arrivals, the number of missions rejected for any reason (such as range or lack of ammunition), and the number of successful and unsuccessful missions.

Each arriving target is identified and engaged somewhere in a box that we consider the area of operations. To simulate different types of missions, units, and/or tactics the user can vary the size of that box. Throughout the battle, these targets would be identified and engaged in different areas of the box.

The distribution of the arriving targets within the box is scenario-based, and can be varied by the user. For instance, in a guerilla-type operation where there is no built-up enemy, and our forces are deployed in a decentralized manner, we might expect to acquire targets uniformly across the box since the enemy has freedom of maneuver and he is probably much more familiar with the terrain

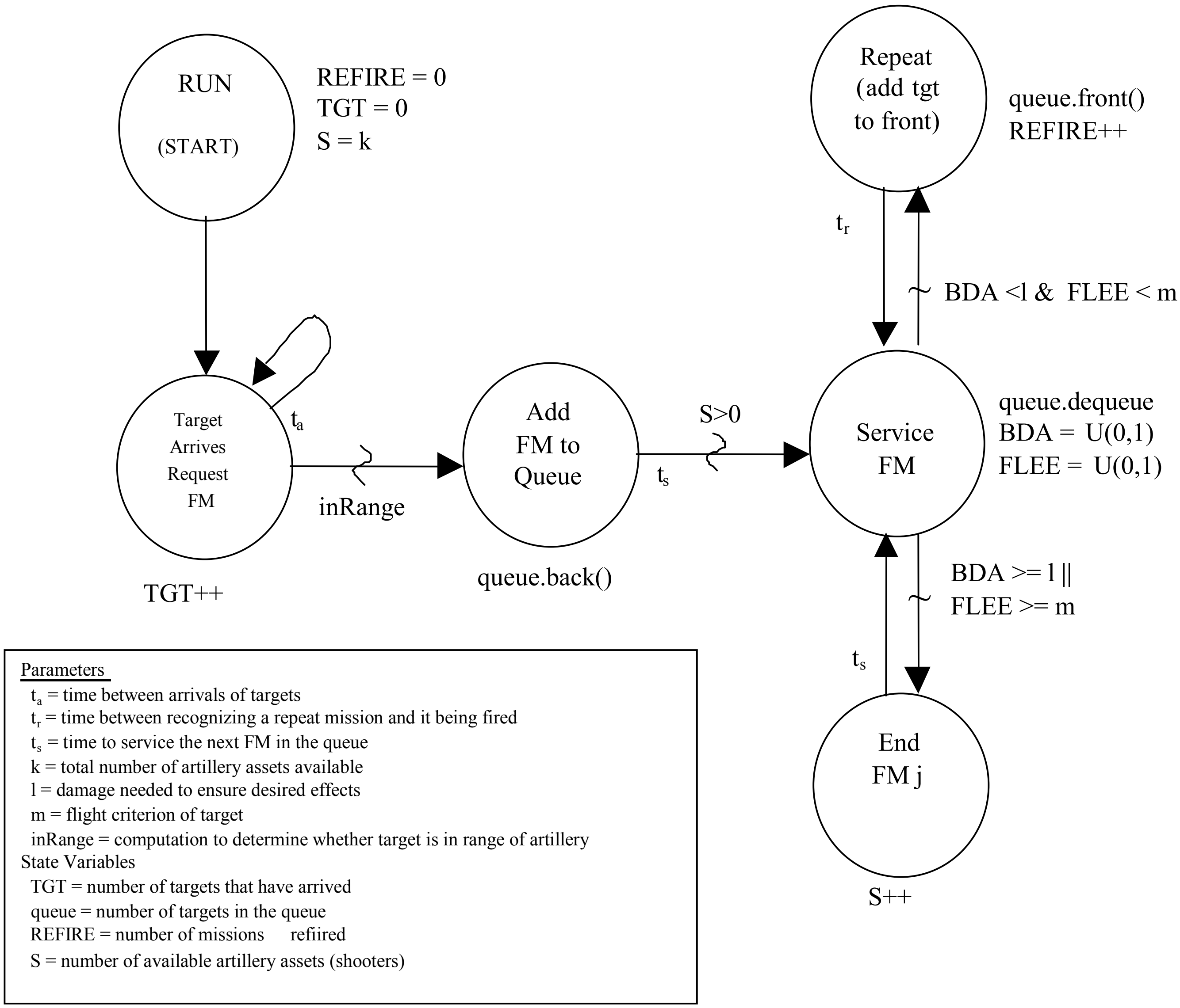

Figure 2: Event Graph

than we are. By contrast, in a conventional-type operation, we might expect to acquire targets uniformly across our front and exponentially in the depth of our position since we own the ground we are occupying and have well-defined boundaries that are protected.

The user will also be able to tactically place artillery battalions and naval assets in the area of operations according to the scenario. Artillery and ships, once placed, will not move throughout the scenario. Figure 3 is a graphic depiction of a sample scenario with artillery and naval range fans depicting limits of engagement for these assets. The user will be able to easily set up, simulate, and analyze a scenario like this.

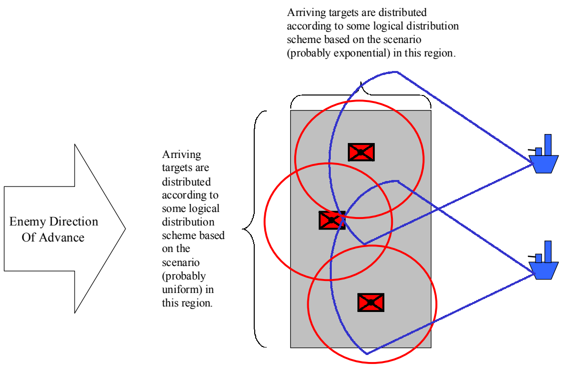

Figure 3: Sample Scenario Graphic

Each scenario involves running the simulation for each COA listed above. By varying the inputs for the model such as parameters for the indirect fire assets and the properties of the area of operations (dimensions and distribution of arriving targets) the FSST can model the scenario in which each COA will occur.

2.5.2 Target Arrivals

Targets arrive at a rate corresponding to a distribution. Based on past simulations, targets probably would arrive at an exponential rate with a mean based on the situation. This simulation allows the user to determine the arrival rate of the targets and the mean interarrival time (i.e. exponential with mean 5.0). Each target will then be further defined by its type – armor, armored personnel carriers, light skinned vehicles, infantry in the open, or infantry dug in, and the mission associated with the target, destroy, neutralize, or suppress. Again, the user can determine the percentages of each type of target and the mission associated with each target.

An example of how the arrival process works is as follows. A random number generator determines the arrival time of the first target. Another randomly generated number stochastically determines the target type. A third randomly generated number determines the mission associated with the target, and a random target location is generated based on the distribution of the locations of targets. The first target then enters the model, and another target arrives at a randomly generated interarrival time based on the arrival distribution, and the process begins again. The distribution of target types and mission types used for this paper are shown below in Tables 1 and 2.

Table 1: Distribution of Mission Types

Mission Types	Percentage
Destroy	30%
Neutralize	50%
Suppress	20%

Table 2: Distribution of Target Types

Target Types	Percentages
Armor	40%
Infantry in the Open	10%
Infantry Dug In	0%
Armored Personnel Carrier	30%
Light Skinned Vehicle	20%

2.5.3 Target Servicing

When a target enters the model, it becomes a fire mission and is sent to a specific artillery or naval gunfire unit called a shooter. Each shooter is queried to determine whether it can range the particular target and whether it has the ammunition needed to engage the target. Once it has been determined which assets can effectively engage the target, an asset is chosen based on a weighting of the following criteria – platform or shooter type (NSFS or field artillery), number of fire missions in that shooter's queue, probable error in range, and shooter to target range.

A version of MAUT is used for the selection of a shooter for each target. The value of each of the first three criteria for a particular shooter is compared with the corresponding values of all shooters that can effectively engage the target. Subscripting the criteria being compared using the letter j, the utility of each shooter is computed with respect to each criteria using the following formula:

$$\text{Utility} = (x_j\text{-worst}_j)/(\text{best}_j\text{-worst}_j)$$

The total utility for each shooter is then determined using the following formula:

$$\left[\sum_{i=1}^{3} Utility_i * WEIGHT_i\right] + WEIGHT_{NSFS} + WEIGHT_{FA}$$

The shooter that gets the fire mission is the one with the highest total utility score. If no assets have the required number of rounds to effectively engage the target, the asset with the most rounds that can range the target is chosen. The fire mission is then put into the shooter's queue.

2.5.4 Target Engagement

Each shooter engages targets when they are at the front of the queue and no targets are being serviced. The processing time (t_p) and engagement times (t_e) are randomly determined from the distribution of the processing and engagement times entered for that shooter, and the time of flight (tof) for the rounds is computed based on the target range. By accounting for the rate of fire, the number of rounds desired, and the number of guns associated with the chosen shooter the total time for the fire mission can be computed using the following formula:

$$t_p + t_e + \text{tof} + \lceil(\#\text{rounds})/(\#\text{ tubes})\rceil * (\text{rate of fire})$$

2.5.5 Mission Success

The location where each round lands is determined stochastically using the probable error in range, probable error in deflection, and shooter-target range. The definition of success for a particular mission is pre-determined in the scenario, and is a function of the number of rounds that land within a certain distance of the target for a particular target type (i.e. armor) and mission type (i.e. destroy). For destroy and neutralize missions that distance is the burst radius of the round. For suppression missions, that distance is 2 times the burst radius since the objective is mainly to distract and rattle the enemy, not to kill him. To determine if the mission is successful, the simulation compares the number of *hits* needed with the number of *hits* the target has already sustained plus the number of additional *hits* if any. If the total number of *hits* sustained is greater than or equal to the number needed, the mission is successful.

If a mission is successful, the mission is ended, and the shooter fires the next mission in the queue, or waits for the next mission if none are currently queued. If the mission is not successful, the target "remembers" how many rounds have had the desired effects, and the mission is repeated if 1) the target has not fled – determined stochastically by scenario intput and 2) if the shooter still has rounds available. If both conditions are met, the mission is repeated, if not the mission is ended and is unsuccessful. The engagement time for repeated missions is generally faster than for the initial volley. The assumption is that the guns are already trained on the target, and are awaiting repeat or end of mission orders. The following formula determines the time for repeating the mission:

$$\text{tof} + \lceil(\#\text{rounds})/(\#\text{ tubes})\rceil / (\text{rate of fire})$$

This process is repeated until either the mission is successful, the target flees, or the shooter runs out of ammunition. The total mission time is then computed and tallied. Successful and unsuccessful missions are also tallied.

2.5.6 Collateral Damage

Collateral damage can occur each time that a target is engaged. If a round misses its intended target by more than a distance predetermined in the scenario, that round *can* cause collateral damage. Each errant round causes a random number to be generated, which determines stochastically whether that round causes collateral damage according predetermined percentage of errant rounds that cause collateral damage (a scenario input).

2.6 Scenario Development

A scenario consists of the parameters that quantify enemy and friendly actions, the effects of the environment and terrain on the military operation, the level at which the battle is being executed, and the year in which the effectiveness of NSFS is being measured. These parameters are kept constant for each COA within the scenario so that COA's can be compared using a common criterion.

Terrain quantifying parameters include the size of the area of operations (AO), the definition of an errant round, and the probability of collateral damage by an errant round. Enemy parameters include the rate at which targets arrive, their location in the AO, and the target type (armor, infantry, etc.). Friendly parameters include the distribution of the mission types (i.e. destroy, neutralize, suppress), the attack criterion for different targets (i.e. how many rounds to fire in suppression of armor), and the definition of a successful mission in terms of how many target hits are required to get the desired effects. Additionally, the scenario includes the weighting scheme the decision-maker uses to choose an asset to engage targets, which will be explained in more detail later.

For this paper, two scenarios are being modeled. Both scenarios involve effectiveness of NSFS to the Army Brigade Commander. The first scenario modeled is of a littoral battle using the Army's Interim Brigade Combat Team (IBCT) during the year 2005. The second is of a littoral battle using the Army's Future Combat Systems (FCS) during the year 2015. The year the scenario models does not determine parameters for the scenario in and of itself, rather it determines what technologies and systems are projected to be available, which in turn dictate the parameters of the artillery platforms to be used in each COA. The terrain, enemy and friendly parameters, and level of the battle remain basically the same for each of the scenarios being modeled.

2.7 COA Development

Each COA is developed within the context of a specific scenario that determines the year and the tactical and operational considerations of the battle. The year determines the firing platforms available for the COA along with their technical capabilities and limitations and their locations on the battlefield. The technical capabilities and limitations of the firing platforms include maximum range, firing rate, probable error in range and deflection, distributions for target processing and preparation for firing, and the bursting radius of a single round. Tables 3 and 4 below show an overview of the COA's and the factors that are varied or changed for each COA.

Table 3: COA Overview

FACTORS	COA (same for each Scenario)			
	A	B	C	D
Field Artillery	3	0	6	3
Naval Ships	0	3	0	3

Table 4: Hardware Parameter Overview

Parameter	IBCT		FCS-OF	
	FA	NSFS	FA	NSFS
Number Guns	6	2	4	2
Rounds per Ship/Battery	2520	2400	2520	2400
Range (meters)	30,000	112,000	45,000	162,000
Munition Burst Radius	50	75	50	75
PER	35	100	1	10
PED	2	2	1	2
Max Rate of Fire	8	24	12	24
Acquisition Time Distribution	Normal	Normal	Normal	Normal
Mean Acquisition Time	4.0	5.0	2.0	2.5
Acquisition Std Deviation	0.75	1.0	0.25	0.5
Firing Time Distribution	Normal	Normal	Normal	Normal
Mean Firing Time	1.0	0.5	0.25	0.5
Firing Time Std Deviation	0.2	0.1	0.05	0.1

3 EXPERIMENTAL DESIGN AND ANALYSIS

The experiment was designed to measure the effectiveness of NSFS using a common sense approach. The objective was to create and execute a design that was simple and could be easily understood by the end user, a military officer unschooled in operations research techniques. Because of this restriction, the design consisted of a relatively simple simulation program written in Java that provided easily interpreted output. The intent of the model was not to simulate every aspect of the indirect fire fight, but to simulate the more important aspects that are needed to determine the effectiveness of NSFS. The MOE's from the previous chapter determined the output needed for the simulation and the level of complexity with which to simulate the indirect fire battle.

The experiment consisted of four different COA's for each scenario, each with seven MOE's. Each of these COA's was replicated 50 times, for a total of 400 simulation runs producing 2800 individual pieces of data. This data was collated and processed using the MAUT methodology weighting each MOE equally. This produced 50 sets of finalized output in the form of utility for each COA, or 200 separate bits of numerical output each of which was linked to a specific COA for each scenario. This data served as the baseline case to measure the utility of each COA.

Once the experiments were complete, the data were analyzed using the analysis of variance (ANOVA) procedure. Two single factor ANOVA tests were used (one for each scenario) to test the null hypothesis (H_o) that the treatment (COA) means were identical, or that total utility is not affected by weapon selection (Devore, 1995). For both scenarios, the null hypothesis is rejected, indicating that there was a statistically significant difference between at least one of the treatments in each scenario. Further analysis of the data indicated that the COA's consisting of a mixture of Field Artillery and NSFS had the highest utility using the equal weighting scheme. A boxplot of the output for the IBCT and FCS scenarios is shown below in Figures 4 and 5.

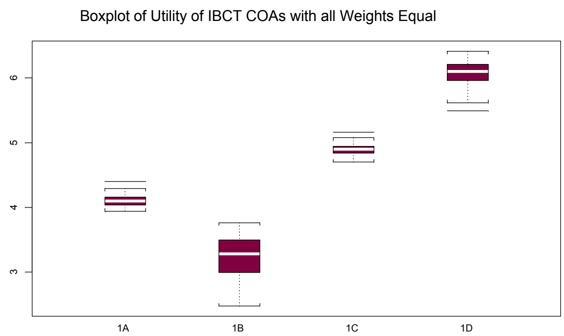

Figure 4: Boxplot of IBCT COA's

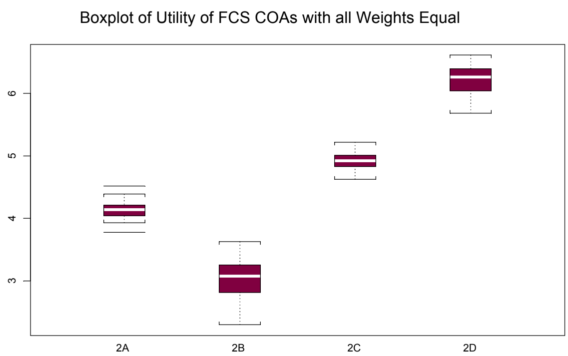

Figure 5: Boxplot of FCS COA's

4 RESULTS

The results of this thesis indicate that NSFS can be effective in providing support for Army units at brigade level in a littoral campaign for the IBCT and the FCS scenarios. The measures of effectiveness used for this analysis were fire mission times, available firing platforms, percentage of missions fired, percentage of successful missions based on all arriving targets, percentage of successful missions based on missions fired, number of rounds that caused collateral damage, and the percentage of the area of operations covered. COA's were developed consisting of different artillery task organizations of Army and Navy artillery for each scenario. Using the Fire Support Simulation Tool developed for this thesis, each COA was simulated 50 times to get values for the MOE's.

Using multi-attribute utility theory each MOE for each COA replication within a particular scenario was given a utility rating based on the actual value of that MOE/COA combination compared with other MOE/COA combinations in the scenario. The final utility for a specific COA replication in a scenario was determined by weighting and then combining the utility of the MOE's for each COA replication in a particular scenario. Single factor ANOVA and Tukey's procedure for multiple comparisons was used to determine whether there was a statistically significant difference among the COA's.

When using equal weights for all of the MOE's, the best COA for both scenarios was the COA that consisted of a mixture of Army and Navy artillery. Based entirely on the weapon systems specifications used, this result indicates that there could be a scenario for the IBCT and FCS where NSFS adds more utility and is effective as a fire support weapon in a littoral campaign.

5 ISSUES

This analysis revealed that there is merit to the use of NSFS in place of Army artillery for reinforcing fires in the littorals. However, nothing can truly replace the feeling of ownership that a unit commander feels by having supporting elements on the ground with him and within arm's reach. Most if not all leaders feel very comfortable with the capabilities and limitations of those assets they are most familiar with. Joint training exercises between Naval and Army units are extremely rare. Lack of that joint training and personal prejudices build distrust, which may prove an insurmountable obstacle if not corrected.

Nothing speaks more highly of dedication to success of a mission than having a personal stake in the outcome of the mission. Most soldiers stake their lives on the successful completion of their missions. If assets providing support in the form of naval gunfire do not have that same stake, Army commanders feel uncomfortable.

The results of this analysis assume the relatively efficient use of available assets to accomplish all fire missions. If assets such as naval gunfire can be called away at a moment's notice, their reliability to the commander on the ground becomes suspect. This leads to inefficient use of the asset. Basically, the Army commander will try to get as much as he can out of that asset before it gets taken away. This type of misuse will almost certainly create prejudice and mistrust among the Navy towards the Army.

These issues must be addressed before naval gunfire can be integrated seamlessly into Army operations now or in the future. Digital synchronization, future technologies, and memorandums of agreement will help, but alone they will not suffice. Soldiers know that the soldier across the street will be ready because they see him and her working and training every day. These issues of mistrust must be worked out on the ground, commander to commander, sergeant to petty officer, and soldier to sailor.

6 CONCLUSIONS

This paper has shown that by combining the strengths of Army artillery and naval gunfire, an Army Brigade commander can organize a fire support team that is better able to support his missions than a pure strategy. Although effectiveness is strongly dependent on the weighting scheme the commander adopts for the MOE's presented earlier, this paper has demonstrated that there can be an added benefit to using NSFS which should be explored further.

Expert selection of the weighting scheme, inputs for the simulation, and scenario development are all necessary to properly evaluate the effectiveness of NSFS for the unique missions that will ultimately need to be analyzed. The FSST provides the user with a simple, easy to use, and quick tool to gain broad insights into the effectiveness of the available assets.

Although there is evidence supporting the use of NSFS in support of Army operations in the littorals, there are a myriad of issues such as training, mistrust, and synchronization that must be addressed to make these types of joint campaigns successful. In the final analysis, it was determine that there is strong *quantitative* and *analytical* evidence to support the effectiveness of NSFS to an Army Brigade commander engaged in a littoral campaign.

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