R-811-PR
November 1971

FAST-VAL:
A Study of Close Air Support
(A Briefing Summarizing the Comparisons of Model with Combat Results and Illustrating the Influence of Supporting Arms on Fire-fight Outcomes)

J. R. Lind, K. Harris and S. G. Spring

A Report prepared for
UNITED STATES AIR FORCE PROJECT RAND
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Rand
SANTA MONICA, CA. 90406
PREFACE

The Forward Air Strike Evaluation Model, Phase II (FAST-VAL II), was developed at Rand to measure the influence of close air support upon the outcome of ground engagements of regimental size or smaller. This two-sided simulation model measures the contribution of artillery, mortars, and small arms as well as air-delivered weapons upon the outcome of a fire fight. This research is intended to assist the Air Force in selecting weapons, vehicles, and operational techniques for the close-air-support mission.

This report is the text of a briefing presented at Hq. USAF, Hq. TAC, and Hq. USMC in December 1970. The briefing (1) summarizes the comparison between FAST-VAL simulation results and actual results of several combat actions in Vietnam (R-810-PR, FAST-VAL: Summary Report on the Comparisons of Model with Combat Results (Infantry Fire-Fight Outcomes and Effectiveness of Small Arms, Bombs, Artillery, and Mortar Rounds), presents more complete comparisons) and (2) illustrates the use of the model in estimating supporting-fire requirements in a Vietnamese framework.

The combat data on each fire fight came from interviews with fire-fight participants and from official records. The interviews with military personnel were conducted in Okinawa and Vietnam during March and April 1969 under joint Air Force-Marine Corps sponsorship.

A bibliography of related FAST-VAL reports appears on the following pages.
BIBLIOGRAPHY OF RELATED FAST-VAL REPORTS


R-817-PR Harris, K., and S. G. Spring, FAST-VAL Expected Casualties from Small-Arms Fire (U), The Rand Corporation, November 1971 (Confidential).


R-822-PR Lind, J. R., S. G. Spring, and K. Harris, FAST-VAL: Case Study of a Series of Mortar Attacks on a Marine Infantry Company at LZ Margo, 16 and 17 September 1968 (U), The Rand Corporation, November 1971 (Secret).

RM-4567-PR Harris, K., R. N. Snow, and J. R. Lind, FAST-VAL: Target Coverage Model (U), The Rand Corporation, March 1966 (Confidential).


SUMMARY

This briefing describes the FAST-VAL simulation model, presents comparisons between actual combat data and model outputs, and illustrates the use of the model to estimate supporting-fire requirements in a Vietnamese framework.

From the comparisons between combat data and model outputs we conclude that the estimates of munitions effects obtained by means of FAST-VAL are consistent with battle experience in Vietnam and that they are also consistent with the "conventional wisdom" as to such engagements, e.g., that it is difficult to dig defenders out of foxholes, that force ratios on the order of 3:1 or better are preferred for attack, and that ratios of 2:1 are marginal. In addition, the model outputs suggest that relatively modest and timely supporting fire can stop an infantry attack and that the attacker's weapon requirements against a defense position are impractically high with current standard bombs, shells, and fuzes.

The illustrative comparisons of munitions effects against a defense position suggest that while weapon requirements can be substantially reduced by the use of one of the newer bomblet munitions (the CBU-24), weapon requirements would remain high. Continued development of bomblet munitions promises to reduce these requirements to practical levels. The argument for these munitions is reinforced by their high potential effectiveness in support of the defense.

This briefing touches upon just one delivery tactic—area delivery. FAST-VAL can be used to analyze other tactics as well as other weapons in the context of a fire fight. Such analyses, coupled with appropriate costing, should provide a basis for making improved choices among weapons and delivery systems and for answering a variety of associated questions dealing with logistics, sortie demands, delivery timing, and weapons alternatives, e.g., gunships and armed helicopters.
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FAST-VAL: A STUDY OF CLOSE AIR SUPPORT

INTRODUCTION

Our purpose is to discuss the product of one of Rand's tactical air studies, FAST-VAL. Its objective has been to measure the influence of air power in support of friendly troops "in contact" with enemy forces—in essence, the close-air-support mission. Rand has developed and tested the FAST-VAL simulation model to assist in the understanding of the close-air-support mission through a better understanding of the interactions of air and ground forces on the battlefield.

We shall discuss several facets of the study (Slide 1). First,

FAST-VAL: A STUDY OF CLOSE AIR SUPPORT
- HISTORY
- SIMULATION MODEL
- COMPARISONS WITH COMBAT DATA
- GENERALIZED FIRE FIGHTS—VIETNAM
- POSSIBLE APPLICATIONS OF FAST-VAL

we bring the scope of the study into focus by sketching its history and discussing the simulation model. Second, we discuss consistency between the model and combat data as shown by a series of comparisons between simulation results and actual combat outcomes. Third, using the comparisons as a base, we illustrate the scale of air and ground support fire requirements in a Vietnamese framework. Finally, we outline some possible Service uses of FAST-VAL to assist in specification of weapons and delivery systems that can significantly change the outcome of fire fights.

HISTORY OF FAST-VAL

The FAST-VAL study was begun several years ago in search of a technique that could help in evaluating the effectiveness of air power
in the forward battle area. Among other things, this objective implied that (1) the casualty-producing effects of weapons on ground forces had to be measured, not merely described, and (2) the interaction of men and weapons, both air and ground, had to be understood.

A simulation model was built and a set of input parameter values was developed. These parameters were distilled from many earlier studies of ground combat, weapon tests, and theoretical examinations. The model had been applied only to hypothetical tactical situations on company through regimental levels until detailed reports on the 1967 fight for Khe Sanh became available to us. Our simulation of the fight for Hill 881 South produced results that compared favorably with those given in official reports and interviews with participants. Encouraged by the apparent realism of the simulation results, the Air Force and Marine Corps jointly sponsored us in a visit to Southeast Asia to gather data on additional fights. The purpose was to simulate the fights and determine how well the results compared with the combat data and whether or not the parameters developed could be verified by the combat data. We shall discuss comparisons based on these new data.

THE MODEL (Slide 2)

Studying the interactions of men and weapons on the battlefield forces us to consider many details. To handle the detail and keep track of the interactions, we use a straightforward model that is readily adaptable to a wide variety of situations. For example, each weapon employed, whether it be a rifle or 2000-lb bomb, has a damage function that changes with firing range, aiming accuracy, fragment velocity, etc. If two companies attack an enemy position, they can proceed independently or they can act together, they can bring in air before the attack or after, the defense can hold fire or not. Since offense and defense actions differ significantly, the model has to be two-sided and dynamic. Two deployed forces are placed in opposition and exchange artillery fire, mortar fire, and air strikes. Attacking rifle companies advance and exchange small-arms fire with defending rifle companies. The FAST-VAL model is a set of computer programs designed (1) to calculate the expected casualties suffered by each force over time.
FAST-VAL SIMULATION MODEL

**PURPOSE:** TO ASSESS THE INFLUENCE OF AIR POWER IN FORWARD BATTLE AREA

**HOW:** MEASURE EFFECTS OF AIR AND GROUND MUNITIONS ON GROUND-FORCE OPERATIONS

**MODEL:** STRAIGHTFORWARD

- INCLUDES MANY BUILDING BLOCKS
  - Weapon damage functions
  - Situational information
  - Behavioral parameters
- READILY ADAPTABLE TO A WIDE VARIETY OF SITUATIONS

TWO SIDED AND DYNAMIC

MEASURES

- EXPECTED CASUALTIES
- FIRE-FIGHT OUTCOME

and (2) to predict the fire-fight outcome. In building the model, our objective has been to allow an analyst to examine the change in the outcome of a fight for a change in one or a set of building blocks.

The kind of building blocks that are handled can be explained in terms of the pattern we used to obtain the details of fire fights from interviews with platoon, company, and battalion commanders. In general, we wanted to obtain both an overview and as much detail as possible about the engagement. One of the engagements, *Attack in the DMZ,* is depicted in Slide 3. Two companies of Marines were sweeping a road near the Ben Hai River in the DMZ. They had seen evidence of the NVA and had located abandoned enemy artillery positions. As they continued sweeping the road, one company on each side with the platoons in trail, they came upon an NVA platoon in an ambush position.

From interview information given by officers from each of the
two companies, we reconstructed the general disposition at the start as shown (Slide 4). The fight started with a fixed-range, 30-minute exchange of small arms (rifles and machine guns); this was followed by an attack by the company on the right at the same time that the two reserve platoons of the company on the left were hit by 20 to 30 mortar rounds. Following the attack, there was a running fight as the NVA withdrew. Air and artillery were brought in against the NVA as they retreated toward the Ben Hai River.

From knowledge of this disposition, we can develop input data for the simulation (Slide 5). The area is overlaid with a grid of 100-by-100-ft squares. Within appropriate squares, we locate the riflemen, machine guns, etc., for each unit. This initial snapshot of the positioned forces allows us to begin keeping track of each man and weapon and of what is happening to the unit as a whole, in each 4-minute interval of the action. The gridding also allows us to specify the aim points for air, artillery, and mortars. We compute damage functions for both men and equipment using this grid; that is, we compute the probability of producing a casualty (or disabling a weapon) at each grid point. Thus, for these two reserve platoons, we chose a pattern of aim points to simulate the mortar attack as the NVA "walked the mortar rounds" across the position. The covering of an area by "walking mortar rounds" or artillery "zoning and sweeping" or air "rippling" bombs in a string is, of course, a standard technique for indirect fires directed against the diffuse target presented by infantry units.

The interviews enabled us to learn about the posture of troops and equipment as well as their locations (Slide 6). By troop posture we mean, for example, whether they are protected by foxholes or natural terrain; by equipment posture, for example, whether or not mortars are in pits. The interviews also gave us a time history of events from which we could (1) develop appropriate movement rates to insure that actions take place when they occurred in the actual fight, (2) insure that small-arms fire is delivered at appropriate times and ranges, and (3) specify appropriate coordinates and times for supporting arms and air strikes. It is this interview information, even if incomplete, that makes realistic simulations of actual fights possible.
Slide 5—Marine attack in the DMZ, 8 Oct. 1968: 100-by-100-ft grid overlay
SITUATIONAL INFORMATION

MEN (NUMBER, LOCATION, POSTURE)
EQUIPMENT (TYPE, NUMBER, LOCATION, POSTURE)
MOVEMENT RATES
SMALL-ARMS FIRES (NUMBER FIRED AND RANGES)
MORTAR AND ARTILLERY FIRES (NUMBER, AIM POINT, MODE, RANGE, TIME OF DELIVERY)
AIR MUNITIONS (NUMBER, AIM POINT, MODE, TIME OF DELIVERY)

BEHAVIORAL PARAMETERS
"STOP" CRITERION
"BREAK" CRITERION
SUPPRESSION

WEAPON INFORMATION

$P_k$'s FOR SMALL ARMS
$P_k$'s FOR SUPPORTING ARMS AND AIR MUNITIONS

RESULTS
CASUALTIES FOR BOTH SIDES
THE OUTCOME

Slide 6—Schematic view of model
The FAST-VAL model requires two more areas of basic data—
weapon effectiveness and unit performance factors. The weapon $P_K$'s are
calculated for small arms and supporting weapons as functions of firing
ranges, modes of delivery, and target posture. By modes of delivery
we mean the accuracy, the burst conditions, etc.

Unit performance is defined in terms of several parameters
which characterize the course of the action as well as the outcome.
Specifically, "stop" and "break" criteria relate to the end of the fight.
The side that first reaches a "stop" or "break" threshold is by defini-
tion the loser. As you know, an attacking company tries to advance
as a deployed unit against the defender until it reaches the final co-
ordination line (sometimes called the squad-release line). This is
followed by an assault movement to the enemy position, followed by a
hand-to-hand fight if the defender stays. The "stop" criterion may be
unfamiliar. The experiences of the military consultants on the Rand
staff suggested that attacking companies stop to reorganize if casual-
ties reach 20 to 25 percent before they reach the final coordination
line. We have used 23 percent as the nominal threshold in the simula-
tions. We did find some combat confirmation for this value, which we
shall discuss later. If an attacking company does not "stop," it con-
tinues the attack until either it "breaks" at 30 percent casualties or
the defender "breaks" at 50 percent casualties. These two "break" cri-
teria were developed from historical research by the Operations Research
Office (ORO) and from practices outlined in the Department of the Army
Manual entitled Maneuver Control. We obtained no new data on the "break"
criteria from our interviews. We shall, however, discuss how weapon
requirements would change as the "break" criteria vary.

FAST-VAL reflects another behavioral aspect of unit performance—
suppression. When we say that a man is suppressed we mean that he is
forced to crouch to reduce his vulnerability to incoming rounds, and
this reduces his rate of fire. The FAST-VAL rule of thumb is that a
1-percent-per-minute casualty rate from fragmenting rounds will suppress
a man. Unfortunately, we obtained no data from our trip that were de-
tailed enough to permit a direct check on this parameter value.
Given the input data that we have described, FAST-VAL calculates the casualties sustained by both sides and distinguishes the winner from the loser.

The actual outcomes of the fire fights are derived from our two sources—the interviews and the official records. The question is, Are the real and simulated results similar? Then, if they are, we can measure with some confidence which improvements (in weapons or tactics) significantly change the outcome of a fight.

We shall turn now to the specific cases simulated (Slide 7). With the exception of Khe Sanh, descriptions of the two-sided infantry engagements listed here were gathered in our trip to Southeast Asia. Notice the variety of situations: In one case (Kin), a platoon attacked what it believed was a squad, but which turned out to be a company; in another (DMZ), two companies attacked a single platoon. Friendly forces were supported by air, artillery, and mortars in three cases (Fox-trot, An Hoi, Khe), air in two (An Tam and Kin), and air and artillery in one (DMZ).

In this slide, we show both unit designations and the initial number of troops. Later, we shall be talking about "troop force ratio," and by that term we shall mean the ratio of the number of attacking troops to the number of defending troops, rather than the corresponding ratio of the number of units (say, companies).

The results of the two-sided engagements are shown in Slide 8. For each case, we show the forces attacking and defending. In all cases, the FAST-VAL predicted outcome was the same as that of the actual fight. For example, in the DMZ case, the attacker actually pushed the defender out of the position. In the simulation of this case, the attacker reached the defender's position, the defender suffered 50 percent casualties, and the simulation stopped before the attacker had suffered 30 percent casualties. In Fox-trot the attacking NVA were stopped just as the lead elements reached the Marine defensive position. In the simulation, one NVA company was "broken" (30 percent casualties) during the advance; the other "broke" just after passing the final coordination line (i.e., just short of the Marine position).
<table>
<thead>
<tr>
<th>ENGAGEMENT NAME</th>
<th>FORCES ENGAGED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATTACKER</td>
</tr>
<tr>
<td>DMZ</td>
<td>2 CO. (195)*</td>
</tr>
<tr>
<td>FOXTROT</td>
<td>2 CO. (176)</td>
</tr>
<tr>
<td>AN HOA</td>
<td>1 CO. (97)*</td>
</tr>
<tr>
<td>KHE</td>
<td>2 CO. (416)*</td>
</tr>
<tr>
<td>AN TAM</td>
<td>2 PLTN (65)*</td>
</tr>
<tr>
<td>KIN</td>
<td>1 PLTN (37)*</td>
</tr>
<tr>
<td>DMZ (1)</td>
<td>2 PLTN (59)*</td>
</tr>
<tr>
<td>DMZ (2)</td>
<td>1 PLTN (37)*</td>
</tr>
</tbody>
</table>

* U.S. Forces

Slide 7 — Two-sided infantry engagements
<table>
<thead>
<tr>
<th>ENGAGEMENT NAME</th>
<th>FORCES ENGAGED</th>
<th>NUMBER OF FRIENDLY CASUALTIES (MIDRANGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATTACKER</td>
<td>DEFENDER</td>
</tr>
<tr>
<td>DMZ</td>
<td>2 CO. (195)*</td>
<td>1 PLTN (42)</td>
</tr>
<tr>
<td>FOXTROT</td>
<td>2 CO. (176)</td>
<td>1 CO. (106)*</td>
</tr>
<tr>
<td>AN HOA</td>
<td>1 CO. (97)*</td>
<td>2 CO. (170)</td>
</tr>
<tr>
<td>KHE</td>
<td>2 CO. (416)*</td>
<td>3 CO. (630)</td>
</tr>
<tr>
<td>AN TAM</td>
<td>2 PLTN (65)*</td>
<td>1 PLTN (50)</td>
</tr>
<tr>
<td>KIN</td>
<td>1 PLTN (37)*</td>
<td>1 CO. (72)</td>
</tr>
<tr>
<td>DMZ (1)</td>
<td>2 PLTN (59)*</td>
<td>1 PLTN (42)</td>
</tr>
<tr>
<td>DMZ (2)</td>
<td>1 PLTN (37)*</td>
<td>1 PLTN (42)</td>
</tr>
</tbody>
</table>

* U.S. Forces

Slide 8 — Comparison of FAST-VAL calculated casualties with actual casualties — two-sided infantry engagements.
In Slide 8 the FAST-VAL computed casualties are compared with actual casualties. Note that we give no reported NVA casualties and no corresponding FAST-VAL estimates, for our experience suggests that the reports of NVA casualties are too unreliable for our purposes here. The average of the absolute difference between computed and reported casualties is 2.2; the maximum difference is 4.5 casualties. We have also made casualty comparisons in terms of percent casualties. The average difference among the cases is 2.5 percent; the maximum is 5.8 percent. (The last two cases listed, DMZ (1) and DMZ (2), though two-sided, were not full engagements.) The FAST-VAL calculated casualties shown here are the midpoint of a range. By this we mean that if the interviewee estimated a spread in the number of incoming rounds, which was often the case, we have shown the casualties corresponding to the midpoint of the spread in incoming rounds.

The DMZ fight reflects a compound midrange estimate (Slide 9). Assuming the casualties resulting from the midpoint volume of small-arms fire, we show the variation in computed results with the uncertain number of 60mm mortar rounds received. From the interviews, we learned that between 20 and 28 mortar rounds were walked across the position. We calculated a spread in total fire-fight casualties of 20 to 23, depending upon the number of mortar rounds received. At 24 rounds—the midpoint—we calculate 21 casualties from all causes. The reported casualties totaled 22.

While the computed and actual casualties seem, by eye, to match well here, we need an objective measure of closeness (Slide 10). To do this, we have applied a simple statistical test. Taking the FAST-VAL computed casualties to be the mean of a binomial distribution, we then calculate the standard deviation and construct a band two standard deviations wide about the mean. This band will fail to contain the reported casualties only about 5 percent of the time, given that the observed casualties reflect only chance variations from the computed outcomes. While this is a coarse statistical test, it is useful for spotting gross disparities. For example, if the reported casualties were above or below the band, we would suspect the model, our interpretation of the data, or perhaps the weapon effects.
Slide 9 — Attack in the DMZ
Several of the fights had distinct phases that allowed us to test our measurements of casualties produced by small arms only or by fragmenting weapons only. We obtained data on 8 separate attacks involving only fragmenting weapons which will now be discussed (Slide 11). Analysts have, of course, had methods of calculating expected damage from indirect-fire weapons (bombs, mortars, and artillery) for many years. These computations involve experimental shell-fragmentation data, angle of impact, velocity, aim accuracy, etc., and a target vulnerability criterion. Most studies have employed the "BRL* 5-minute assault" vulnerability criterion for casualties, that is, a casualty results from a wound severe enough to stop a man from performing his military duties within 5 minutes.

Combat records, unfortunately, do not identify at what time a man stopped performing his duties after he was hit; but it was possible, with the assistance of interview information, for us to compute casualties from received mortar rounds as a function of protection. In two cases, DMZ (3) and Margo (1), troops were in the open; in the six other cases, troops had the protection of foxholes. In three cases, Margo (3), Margo (4), and Margo (5), some foxholes had overhead cover. In practically all the attacks, the mortars were "walked over the position" with apparently no attempt to hit specific points within the area. Since earlier calculations suggested that crouching in foxholes makes one only 10 percent as vulnerable as being prone, we were interested in using these attacks to appraise the actual effect of posture. The number of rounds received among the 8 cases was between 12 and 100—an average of 45. We show the midrange estimates of rounds received and of posture in these cases. The greatest difference between calculated and actual casualties is 3.8; the average difference is 1.54.

Small-arms fires are an important part of any fire fight (Slide 12). We illustrate one small-arms situation, the 30-minute exchange of rifle and machine-gun fire between two platoons of Marines and one NVA platoon. This was part of the DMZ fight. The fight occurred at a fixed range somewhere between 30 and 50 meters. We show

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* Ballistics Research Laboratory, Aberdeen Proving Ground, Aberdeen, Maryland.
<table>
<thead>
<tr>
<th>ENGAGEMENT NAME</th>
<th>UNIT</th>
<th>STRENGTH (No. of men)</th>
<th>PROTECTION</th>
<th>FOXHOLES</th>
<th>ROUNDS RECEIVED (midrange)</th>
<th>NUMBER OF FRIENDLY CASUALTIES (MIDRANGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HILL 256</td>
<td>1 CO.</td>
<td>193</td>
<td>PRONE %</td>
<td>UP %</td>
<td>DOWN %</td>
<td>40</td>
</tr>
<tr>
<td>DMZ (3)</td>
<td>2 PLTN</td>
<td>51</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>FOXTROT (1)</td>
<td>1 CO.</td>
<td>106</td>
<td>-</td>
<td>20</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>MARGO (1)</td>
<td>1 CO.</td>
<td>169</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>MARGO (2)</td>
<td>1 CO.</td>
<td>125</td>
<td>20</td>
<td>-</td>
<td>80</td>
<td>25</td>
</tr>
<tr>
<td>MARGO (3)</td>
<td>1 CO.</td>
<td>122</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td>MARGO (4)</td>
<td>1 CO.</td>
<td>122</td>
<td>15</td>
<td>25</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>MARGO (5)</td>
<td>1 CO.</td>
<td>112</td>
<td>15</td>
<td>25</td>
<td>60</td>
<td>25</td>
</tr>
</tbody>
</table>

Slide 11 — Comparison of FAST-VAL computed casualties with actual casualties for 8 cases of mortar/artillery attacks on U.S. positions
Slide 12—U.S. casualties versus amount of small-arms fire received in 30-minute exchange
the comparisons for calculations based on the midpoint of the firing range, 40 meters. Without machine-gun fire, the 1000 to 2000 rounds of rifle fire are calculated to cause 1 to 2 casualties. Adding the machine-gun fire (500 to 1000 rounds from each of 3 guns) brings the calculated casualties into reasonable agreement with reported casualties.

We made a series of runs varying range and posture for this case and for five others, including one where only rifle fire was exchanged. The results do not prompt us to change the existing FAST-VAL method of calculating small-arms expected casualties.

Now that we have shown that the FAST-VAL method of computing casualties seems generally satisfactory, how about the FAST-VAL behavioral criteria? "Stop," for instance.

We have been using a "stop" threshold of 23 percent for advancing companies (Slide 13). This nominal value reflects professional
military judgment that companies stop to reorganize when they have suffered between 20 and 25 percent casualties. In the fire-fight data we collected, there were three instances in which friendly companies stopped and withdrew before reaching the enemy defense position—the DMZ, Khe Sanh, and An Hoa cases. The average casualties at "stop" were 21.5 percent. The spread of fraction casualties in each case shown in this chart reflects our inability to pinpoint the exact fraction casualties at which a unit stopped its advance. So, the FAST-VAL stop criterion used here seems appropriate for these Vietnamese actions.

In FAST-VAL we have set the parameter value for the "break" criterion at 30 percent casualties for an attacker and 50 percent for the defender. Unfortunately, we obtained no reliable combat data against which to judge the realism of these threshold values. The casualty levels for "stop" and "break" are, of course, inputs to the simulations. Later, we shall discuss some sensitivity investigations of these thresholds.

FAST-VAL simulations usually are based on the assumption that an attacking force deploys and advances at a specified rate, dependent on terrain and ground cover, unless slowed by incoming fires. This practice had to be modified for our Vietnam cases; the fire fights seem to start at relatively short ranges (50 to 100 meters) with fixed-range exchange of fires taking place.

To sum up (Slide 14): From these comparisons, we have concluded that these FAST-VAL simulation results are consistent with these combat results.

<table>
<thead>
<tr>
<th>COMPARISONS OF FAST-VAL SIMULATIONS WITH COMBAT DATA</th>
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</thead>
<tbody>
<tr>
<td>FIGHT-BY-FIGHT COMPARISONS</td>
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<tr>
<td>• ACTUAL AND SIMULATED OUTCOME MATCHED IN ALL CASES</td>
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<tr>
<td>• SIMULATED FRIENDLY CASUALTIES APPROXIMATED ACTUAL</td>
</tr>
<tr>
<td>CASUALTIES CLOSELY</td>
</tr>
<tr>
<td>AVERAGE DIFFERENCE IN TWO-SIDED ENGAGEMENTS WAS</td>
</tr>
<tr>
<td>2.2 CASUALTIES (2.5% FRACTION CASUALTIES)</td>
</tr>
<tr>
<td>MAXIMUM DIFFERENCE WAS 4.5 CASUALTIES (5.8%</td>
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<tr>
<td>FRACTION CASUALTIES)</td>
</tr>
</tbody>
</table>

Slide 14
The combat data enabled us to calibrate some of the FAST-VAL parameters (Slide 15). In general, the weapon-effects calculations

\begin{center}
\begin{tabular}{|l|}
\hline
COMPARISON OF FAST-VAL SIMULATIONS WITH COMBAT DATA \\
CALIBRATION OF PARAMETER VALUES \\
\begin{itemize}
\item SMALL ARMS \\
RANGE AND TARGET-POSTURE EFFECTS APPEARED REALISTIC \\
\item FRAGMENTING WEAPONS \\
"5-MIN ASSAULT" CRITERION CORRESPONDED TO "KIA + MEDEVAC" \\
\item ATTACKER "STOP" CRITERIA \\
AVERAGE OF COMBAT DATA = 21.5%; NOMINAL FAST-VAL LEVEL = 23% \\
\item "BREAK" CRITERIA \\
NO NEW EVIDENCE \\
\item ATTACKER ADVANCE RATE \\
MODIFIED TO REFLECT FIXED-RANGE SMALL-ARMS FIGHTS
\end{itemize}
\hline
\end{tabular}
\end{center}

appear realistic for both small arms and fragmenting weapons. We concluded that the casualties calculated using the BRL 5-minute assault criterion corresponded reasonably with "KIA plus Medevac" casualties. The combat data confirmed our nominal value of 23 percent casualties for the "stop" criterion.

These comparisons have given us confidence in generalizing infantry fire fights by means of the FAST-VAL analytic method.

**SUPPORTING-ARMS REQUIREMENTS**

While we were comparing the FAST-VAL model with combat data, we also executed a series of simulations designed to measure supporting-arms requirements as a function of force ratio, within the Vietnamese framework.

We have looked at support on behalf of both the offense and the defense, using casualties and expected fire-fight outcome as measures
of effectiveness. Our objective here is to put a scale on support requirements—to determine when support is needed and in what quantities. We also want to compare requirements for different weapon types and show the relative requirements for the offense and defense.

First, we shall look at the basic fire fight when neither offense nor defense has supporting fire (Slide 16). The expected number of casualties at the time that a FAST-VAL decision point is reached is shown as a function of initial troop force ratio. This series of simulations is based on a defending force of one NVA company of 140 men. With initial troop force ratios less than 1.0, the attacking unit suffers 23 percent casualties before reaching the final coordination line and, by FAST-VAL decision rules, stops.

With initial troop force ratios between 1.0 and 2.0, the attacker does reach the final coordination line. At that point the attacking force moves rapidly across the remaining 30 meters toward the defending position. However, the attacker breaks before the defender does. That is, the attacker suffers 30 percent casualties before the defender suffers 50 percent casualties. With initial troop force ratios greater than 2.0, the attacks are successful, but the number of attacker casualties does not drop below that of the defender until the initial troop force ratio exceeds 3.8.

Neither side is afforded supporting fire here—not even mortar support. The casualties and outcome are the result only of the exchange of rifle and machine-gun fire, which begins when the forces are about 100 meters apart.

Two factors significantly influence these outcomes. The first is posture. The attacker is assumed to be prone, while the defender is assumed to occupy open foxholes. Thus, the attacker is more vulnerable than the defender. And second, because the defender is in a fixed position, his rifles and machine guns are assumed to be more accurate than those of the attacker.

The difference in posture becomes even more significant when we look at the relative effects of supporting arms upon the fire fight. First, we shall show an example of how supporting fire for the defense can alter the fire fight (Slide 17).
Slide 16 — Fire-fight outcome—no supporting fire
Defender delivers no 81mm mortar rounds

Defender delivers 50 81mm mortar rounds

Slide 17—Fire-fight outcome—supporting fire by defender
Here we have shown the effect when the defender delivers fifty 80mm mortar rounds before the exchange of small-arms fire begins. The minimum initial troop force ratio required for the attacker's success has risen from less than 2.0 to about 2.3. The attacker's casualties in the success region have risen from about 70 to 90, and even at an initial troop force ratio of 4.0, are greater than those of the defender. In the region of favorable outcome from the point of view of the defending company, defending casualties drop substantially.

Next, an example is presented of what the attacker can effect with supporting fire (Slide 18). Here we show the change in the basic fire fight when the attacker delivers 100 CBU-24 canisters before the exchange of small-arms fire begins. The minimum initial troop force ratio required for the attacker's success has dropped from about 2.0 to 1.5. In the entire expanded region of success, the attacker's casualties are less than those of the defender. The 100 CBU-24 canisters have caused the defender 20 percent casualties, or 27 men.

We have shown two examples of the effect of supporting fire using the 81mm mortar and the CBU-24. Next we would like to compare alternative weapons; first, in support of the defense and then in support of the offense (Slide 19).

Here we show the number of weapons of four alternative types required to defeat an attack when the attacker has no supporting fire. The curve establishes the minimum weapon requirement to defeat the attack as a function of initial troop force ratio. For example, faced with an attack at a ratio of 3.0, the defender must deliver on the order of 500 105mm howitzer rounds to stop the attack.

For illustration, we have shown comparative weapon requirements for two air-delivered weapons, the CBU-24 and the 500-lb bomb, and two ground-force weapons, the 105mm howitzer and the 81mm mortar. There are, of course, many other air and ground munitions which can be compared in the same way. In computing the weapon requirements shown here, we viewed the attacking units as area targets and delivered weapons uniformly over the occupied area.

We shall not discuss the problems associated with the delivery of these quantities of weapons, such as the time required to identify
Slide 18—Fire-fight outcome—supporting fire by attacker
Slide 19—Weapons required by defender to defeat an unsupported attack

- Attacker: prone
- Defender: open foxholes

Defense: 1 NVA company (140 men)

Initial troop force ratio (attacker/defender)

- 81mm Mortar Rounds
- 105mm Howitzer Rounds
- MK-82 High-drag 500-lb bombs
- CBU-24 canisters
the target area and deliver the weapons. Indeed, in places our weapon-
requirement scales go far beyond reasonable levels, especially in later
slides when we show offensive support requirements. We realize this,
but our emphasis here is upon scaling the support requirements and com-
paring weapons.

Given initial troop force ratios less than 2.0, supporting
fire for the defender is not required to defeat the attack. As initial
troop ratio increases to 4.0, the supporting-fire requirement rises to
about 200 mortar rounds or, alternately, 6 CBU-24 canisters. Using the
CBU-24s, one A-7 sortie suffices to help stop the entire range of at-
tacks shown here.

Slide 19 has shown the defender's weapon requirements against
unsupported attacks. Next, we show how the defender's weapon require-
ments increase when the attacks are supported (Slide 20). Slide 20 is
the same as Slide 19 with two additional curves showing the defender's
weapon requirements when the attacker delivers 100 and 200 CBU-24 can-
isters in support of his attack. For example, faced with an attack at
a ratio of 3.0, and anticipating 200 CBU-24 canisters, the defender must
be supported by about 750 105mm howitzer rounds to defeat the attack.

Even with this high level of attacker's support, the defender's
weapon requirements do not increase dramatically. At any initial troop
force ratio, a large increase in attacker's support can be offset by a
relatively small increase in the defender's support. If the defender
is supported by mortars, the increase from the unsupported attack to
the attack supported by 200 CBU-24s is on the order of 60 mortar rounds.
Indeed, the defense can stop the entire range of attacks shown here with
less than 300 mortar rounds. If CBU-24s are used to support the defense,
one A-7 sortie loaded with 10 canisters can also do the job.

We have examined how sensitive these results are to the input
stop and break levels. When we reduce the attacker's stop and break
levels, making the defender's job easier, these curves simply shift to
the right, maintaining their basic shape. A 20 percent reduction of the
attacker's stop and break levels causes a shift of 0.4 troop-force-ratio
units. For example, the curve defining requirements against an unsup-
ported attack would intersect the abscissa at 2.3 rather than 1.9. This
Slide 20 — Weapons required by the defender to defeat a supported attack.

Number of CBU-24 canisters fired by attacker against defender = 200

Attacker: prone
Defender: open foxholes
Defense: 1 NVA company (140 men)

Initial troop force ratio (attacker/defender)

81 mm Mortar Rounds

300 225 150 75 0

105 mm Howitzer Rounds

1250 1000 750 500 250 0

MK-82 high-drag 500-1 lb bombs

100 75 50 25 0

CBU-24 canisters

4 0
lateral shift amounts to a decrease in the defender's weapon requirements of 30 mortar rounds or one CBU-24 canister.

A 20 percent reduction of the defender's break criteria, making the attacker's job easier, shifts the curves to the left 0.25 troop-force-ratio units, but only when the force ratios are less than 2.0. This shift amounts to an increase in the defender's weapon requirements of about 20 mortar rounds.

Thus, as much as a 20 percent reduction in the stop and break levels does not have a significant effect upon the defender's weapon requirements. However, after we have compared alternative weapons in support of the attack, we can show how changes in the stop and break criteria become more significant (Slide 21).

Here, comparing the same four types of weapons, we show the number of weapons required in support of the attack when the defender has delivered 0, 50, and 100 mortar rounds. For example, when attacking with an initial troop force ratio of 2.0 and anticipating 50 incoming mortar rounds, the attacker has a requirement on the order of 100 CBU-24 canisters. This amounts to ten A-7 sorties, each loaded with 10 canisters. We can see that as the initial troop force ratio drops below 2.0, the attacker's weapon requirements against a defender supported by 50 mortar rounds rapidly increase to impractical levels with today's weapons.

We have compared surface-bursting weapons here to reflect today's practices. However, if one could solve all the problems associated with attaining air burst at optimal burst heights, the requirement here, against an open-foxhole defense, could be reduced substantially—to about one-third for the 500-lb bomb and to about one-fifth for the 105mm howitzer rounds. Nevertheless, the attacker's support requirements for initial troop force ratios below 2.0 remain high, and relative to the support requirements for the defense, very high.

Returning to the question of the sensitivity of weapon requirements to the stop and break levels, again the effect is to shift these curves to the right or left while maintaining their basic shape. Because the slope of these curves is so steep, a small shift can imply a large change in weapon requirements for a particular troop force ratio.
Slide 21—Weapons required by the attacker to defeat a supported defense.
For example, given a troop force ratio of 2.0 and 50 defensive mortar rounds, a 20 percent reduction in the attacker's stop and break criteria, which shifts the curves to the right 0.4 troop-force-ratio units, increases the attacker's support requirement from 100 to 175 CBU-24 canisters.

Thus, for a particular troop force ratio, the attacker's weapon requirements are very sensitive to a 20 percent reduction of the attacker's stop and break criteria. However, the basic relationship of offensive and defensive support requirements does not change. That is, heavy support for the offense can still be offset by a relatively small increase in the defender's supporting fire. What really changes is the reference point on the troop-force-ratio scale where the relationships apply.

Thus, in this situation, a 20 percent uncertainty in the stop and break levels can be viewed as equivalent to an uncertainty in the troop-force-ratio estimates of about 0.4, or 54 men.

Next, we shall illustrate the value of the attacker's supporting fire for initial troop force ratios greater than 2.0 where support is not mandatory for success but does reduce the attacker's casualties (Slide 22). As a reference point, we show the levels of supporting fire that can reduce the attacker's casualties to no more than those of the defender. Against the unsupported defender, 50 CBU-24 canisters can bring the attacker's casualties below the defender's even at an initial troop force ratio of 2.0. When the defender is supported by 50 mortar rounds and initial troop force ratios are between 2.0 and 3.0, 120 to 150 CBU-24s suffice. With initial troop force ratios between 3.0 and 4.0, 100 to 120 CBU-24 canisters can equalize the casualties. Again, 100 CBU-24 canisters amount to ten A-7 sorties.

Slide 23 summarizes the results of the series of simulated attacks against one NVA company in defense. When the initial troop force ratio is less than 1.0, the attacker must break the defender with supporting arms. This can be accomplished with about 250 CBU-24 canisters. When the initial troop force ratio is greater than 1.0 but less than 2.0, the attack must be supported to be successful. At the midpoint of this region, 1.5, the requirement is 100 CBU-24 canisters.
Slide 22 — Attacker's weapons required to win with casualties equal to defender's
<table>
<thead>
<tr>
<th>FORCE RATIO (ATT/DEF)</th>
<th>EFFECT OF SUPPORTING ARMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELOW 1:1</td>
<td>TO WIN, ATTACKER MUST BREAK DEFENDER WITH SUPPORTING ARMS</td>
</tr>
<tr>
<td></td>
<td>250 CBU-24s</td>
</tr>
<tr>
<td>1:1 - 2:1</td>
<td>TO WIN, ATTACKER MUST HAVE SUPPORTING FIRE</td>
</tr>
<tr>
<td></td>
<td>100 CBU-24s VS UNSUPPORTED DEFENSE (1.5:1)</td>
</tr>
<tr>
<td></td>
<td>200 CBU-24s VS SUPPORTED DEFENSE (1.5:1)</td>
</tr>
<tr>
<td>2:1 - 4:1</td>
<td>TO WIN, DEFENDER MUST HAVE SUPPORTING FIRE</td>
</tr>
<tr>
<td></td>
<td>8 CBU-24s</td>
</tr>
</tbody>
</table>

Slide 23—Role of supporting arms in attacks against one NVA company of 140 men
(Posture: attacker, prone; defender, in open foxholes)
against an unsupported defender and 200 CBU-24 canisters against a defender supported by 50 mortar rounds. When the initial troop force ratio is greater than 2.0, the situation reverses and the defense must be supported if it is to stop the attack. Eight CBU-24 canisters are adequate to stop attacks through initial troop force ratios of 4.0. In general, when initial troop ratios are below 2.0, the attacker requires heavy supporting fire to win. When initial troop force ratios are greater than 2.0, the defender needs supporting fire to stop the attack.