A RAND NOTE

Applying the National Training Center Experience--Incidence of Ground-to-Ground Fratricide

Martin Goldsmith

February 1986

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PREFACE

This Note documents one phase of an ongoing project at the Arroyo Center in RAND's Army Research Division. The overall project is directed at applying the experience and information gained at the Army's National Training Center (NTC) at Fort Irwin, California to problems beyond the NTC's mission of training. These might include matters of doctrine, material development, or other factors for which the NTC "laboratory" can offer data and insights otherwise unobtainable. The problem reported here is one of determining the rate of ground-to-ground fratricide at the NTC by direct and indirect fire.

Instances of fratricide punctuate the history of war, sometimes with devastating results. The NTC replicates many of the aspects of war, including confusion and lack of information; consequently fratricide is also observed there. Fratricide is defined as fire upon friendly units, personnel, or equipment. It may result in suppression, damage, or destruction. The purpose of this research was to use the data available from the NTC instrumentation and observer systems to measure the frequency of fratricidal ground-to-ground engagements and to estimate their importance to battle outcome. Moreover, it was hoped that it would be possible to gain some insights into the causes of fratricide in order that measures could be devised to reduce their incidence. Although this study stands on its own, it will contribute to a broader Arroyo Center study of combat identification and fratricide.

THE ARROYO CENTER

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Army Regulation 5-21 contains basic policy for the conduct of the Arroyo Center. The Army provides continuing guidance and oversight through the Arroyo Center Policy Committee, which is co-chaired by the Vice Chief of Staff and by the Assistant Secretary for Research, Development, and Acquisition. Arroyo Center work is performed under contract MDA-903-86-C-0059.

The Arroyo Center is housed in RAND's Army Research Division. The RAND Corporation is a private, nonprofit institution that conducts analytic research on a wide range of public policy matters affecting the nation's security and welfare.

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SUMMARY

Two broad classes of ground-to-ground engagement can lead to fratricide. One is direct fire, in which the weapon aiming system is laid onto the target itself. The other is indirect fire, in which projectile trajectories are calculated to intersect a point where a target has been observed or is expected to be. The former case is typified by rifle fire, tank main gun fire, or fire by an antiarmor guided missile. The latter is typified by cannon artillery and mortars.

At the NTC direct fire is simulated by MILES (Multiple Integrated Laser Engagement System). Weapons are equipped with lasers projecting a coded signal. Players (people and vehicles) are equipped with receivers that can decode the laser signal when they are hit. A computerized system records this information, along with the location of instrumented vehicles or manpack units. The collected information is displayed at a central facility, and the battle history is recorded and can be replayed. This electronic history provides the direct fire fratricide data.

There is no equivalent laser-based method at the NTC for simulating artillery fire. When artillery fire is called for, the mission is entered into the computer system manually. The expected effectiveness of fire on the designated locations is estimated from the computer display and from field observation. Judgments based on standard tables are made of battle damage to be assessed, and the artillery information is manually recorded by control room analysts and field observers.

Because the instrumentation system records fires only from instrumented vehicles, the available data do not include such infantry weapons as Dragons or Vipers. This fratricide study therefore covers engagements between only such vehicle systems as tanks, TOWs and APCs. Using methods developed at the Army Research Institute, it should be possible in the future to extract partial information concerning instrumented vehicle kills by uninstrumented weapons. However, engagements between uninstrumented units, such as dismounted infantry, are not recorded at all except by the observer/controller teams.

The instrumentation records for 83 battles involving 15 battalion-sized task forces were examined for instances of direct fire fratricide. A substantial number of recorded vehicle kills were from unknown sources. This could be the result of engagement by an uninstrumented weapon, or a failure of the instrumentation system to make the identification. The Operations Group at the NTC has estimated that at least 40 percent of all kills are listed as unknown. In the battles examined, 18 cases of fratricidal kill were discovered. When combined with an estimate of how many instrumented kills might be expected in such a record, it has been determined that at least 1 percent of Blue vehicles are killed as a result of fratricide.

Isolated fratricides should not have an extraordinary effect on the outcome of a battle, but grouped losses might have a serious effect. Multiple kills were sought in the data record, and were found in four (out of 12) battles. In three of the four cases the events took place in darkness.

Of the 18 cases of fratricide, one-half could have been prevented had the shooting vehicle been aware of the location of a sister organizational unit, for the destroyed vehicle was located in a friendly formation with no enemy nearby. Another third of the cases could have been prevented if the shooter had knowledge of the location of individual isolated friendly vehicles, a more difficult requirement. One-sixth of the cases involved the killing of a friendly vehicle while close to opposing force (OPFOR) elements. In this class, only an Identification Friend or Foe (IFF) device could provide the information necessary to positively avoid fratricide.

The record of 116 battles, involving 15 separate task forces, was studied for indirect fire fratricide. The data were contained in logs maintained by the NTC Operations Group and listed the total missions fired in each battle, whether they were successful in striking an OPFOR target, or were fratricides. The data did not include battle damage assessment, thus mission effects are unknown. An average of 26.7 artillery missions (exclusive of smoke and illumination) were fired per battle. Of these, 33 percent were rated as successful by the observer/controller (o/c) and analyst team, in that they landed on an

OPFOR element, or close enough to result in suppression. Fratricide resulted in 3.6 percent of the missions. Variations in these values for different types of offensive and defensive battles were fairly small, but variations among different training units were more pronounced. It seemed to make little difference in the results whether the units were equipped with TACFIRE or used manual methods.

Again, the effect of fratricidal fire missions on the battle can only be inferred from this class of data. As in the case of direct fire, incidents of multiple fratricide might lead to major effects, but of the 51 battles in which there was at least one fratricidal artillery mission, only five had three or four, and only two had more.

This study made no examination of the causes of the fratricides, but because tube errors[1] do not exist in the NTC simulation, the cause must lie with the fire support command and control system. This is a complex operating system that the artillery community is now scrutinizing at the NTC. Among the issues they might consider is the fraction of missions rated as successful in the data sample. Clearly with a one-third success rate, there is opportunity to substantially increase the effectiveness of this major element of the combined arms force.

The study concludes:

- Of the friendly (Blue Force) vehicles killed in battle, at least 1 percent are killed by friendly (direct) fire.
- Most direct fire fratricides are isolated instances. Cases of multiple fratricide tend to occur in hours of darkness.
- One-half of the direct fire fratricides would have been avoided had the shooter known the location of sister units. Another third could be avoided if the shooter knew the location of all individual friendly vehicles. A sixth of the cases of fratricide could be prevented only by an IFF device.
- Three percent of Blue artillery missions land on friendly forces.

[1]Variations in munitions, gun pointing accuracy, etc.

- One-third of Blue artillery missions strike on or near OPFOR elements. Two-thirds are ineffective. Because "tube error" does not exist, the result arises from the fire support system.

ACKNOWLEDGMENTS

The author is deeply grateful for the cooperation of the Army Research Institute/Presidio of Monterey in making available their National Training Center (NTC) instrumentation tape play-back installation. Without that unique facility, the work on direct fire fratricide would have been impossible.

Special thanks also are due to the members of the artillery section of the Operations Group at the NTC, who made available the logs of indirect fire play used for the artillery analysis in this study.

Members of the Combined Army Training Activity (CATA) Lessons Learned cell and of the NTC Operations Group have made very substantial contributions to our understanding of the simulated battlefield at the NTC. Their continuing support is gratefully acknowledged.

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I. INTRODUCTION

On many occasions during training exercises at the NTC, Arroyo observers have noted instances of fratricide,[1] both by the FORSCOM units in training and by the opposing force (OPFOR). When these events were frequent or affected the outcome of some phase of a battle, they were noted in After Action Reviews. When the Arroyo Center began a study of the causes and effects of the problems of combat identification and fratricide, and their remedies, it was decided to examine the simulated battles at the NTC for insights into the frequency, causes, and effects of ground-to-ground fratricide. Air-to-ground and ground-to-air events were not included, as the instrumentation of aircraft at the NTC is not yet complete. Thus the historical record of such fratricide is either subjective or incomplete.

Three types of ground-to-ground fratricide are noted at the NTC. In some instances, uninstrumented[2] direct fire weapons, such as rifles or Dragons, fire on friendly forces (using the MILES simulated fire system). There is no adequate record of such instances for a historical study. However, review of the recorded instrumention computer record will indicate direct fire fratricide by instrumented weapons, including tank main guns and mounted TOWs, among others. A third class of event is indirect (simulated) fire by mortars and field artillery. Although the instrumentation system does not offer the artillery weapon effects data necessary to identify all fratricides, hand logs kept by the Operations Group observers and analysts do identify instances of fratricide. This study includes the latter two classes of event.

Among the questions that one would wish to answer are: How often does fratricide take place? How important is it when it does happen? Why does it happen? What might be cures for the problem? This study

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[1]Fratricide is defined as fire from one's own or allied forces striking on or near personnel, equipments or units. Effects can vary from only psychological through suppression to damage, death, or destruction.

[2]Not recorded by the NTC Core Instrumentation Subsystem (CIS).

offers data for the first question, inferences for the second question, some observations for the third question (in terms of direct fire), and possibly some guidance for the fourth question, again for the direct fire case.

II. DIRECT FIRE FRATRICIDE

MODE OF SIMULATION AND INSTRUMENTATION

The computerized instrumentation system is a notable feature of the NTC. The training area at Fort Irwin, which consists of over 600,000 acres of the California high desert, has a series of radio position/location (p/l) stations installed. These stations communicate with p/l units installed on the training unit (BLUFOR) and OPFOR combat vehicles through the Range Data Measurement Subsystem (RDMS). By triangulation, the position of each vehicle can be determined and introduced into the Core Instrumentation Subsystem (CIS), which is located near the post headquarters of Fort Irwin. This information is displayed on graphics terminals in a central facility. An analyst stationed at one of the terminals may observe the position of the engaged units during the battle; moreover he can replay action at any time during or after the battle.

In the force-on-force exercises at the NTC, the MILES is used to simulate weapon engagement. Each direct fire weapon system is equipped with an eye-safe laser boresighted to the weapon. When the weapon is fired (with blank ammo or a simulator), it emits a coded laser beam identifying the type of weapon fired. Each individual player and each tactical vehicle is equipped with laser receivers that register hits by the laser designators. For example, if a soldier is hit by an M16 rifle code, his MILES set will register the hit with a piercing audio tone, indicating to all that he is a casualty. If a tank registers a hit by an M16 code, however, nothing happens, because rifles are not able to kill tanks and the tank receiver will not respond to the rifle code.

When a tank main gun fires, several things take place. A simulator charge is fired to yield a signature, the coded laser beam is directed at the target, and a firing message is sent through the p/l unit and RDMS to the CIS. Should the laser beam hit a target vehicle squarely (kill probabilities can be accounted for), its instrumentation will register the code of the weapon type; disable the target's firing mechanism, if it is a tank; start an externally mounted strobe light;

and send a kill signal to the CIS. The CIS, on receiving such a signal, will search for a firing signal in its record to match in character and time; when one is found, a pairing is made. (Often a pairing cannot be made owing to signal masking problems.) A pairing means that the computer has matched the shooter with its target. The graphic display will then show a firing vector between the units and a kill, if that is the result of the hit. If a pairing cannot be made, one knows only that the target has been hit or killed, but not the identity of the shooter or the weapon type.

The instrumentation system will keep a record of the paired near misses, hits, and kills, show the identity and locations of the firer and target, and calculate the range. Only vehicles or weapons equipped with the p/1 radio units can communicate with the RDMS. Most infantry weapons are not so equipped. Firing of infantry weapons, such as Dragons, Vipers and dismounted TOWs, is not recorded, and therefore kills from such sources cannot be paired; the kill will simply be recorded as of unknown origin.

ANALYTIC PROCEDURE

The analytic procedure is quite simple. The taped computer instrumentation system record of an engagement (battle) or series of engagements is loaded into a readout computer system. These exist only at the NTC and the Army Research Institute facility at the Presidio of Monterey (ARI/POM). In turn, each battle is called up in the "historian" mode of computer operation. After stepping in time to the end of that segment of the record, it is possible to call up a fratricide log on a video display, which contains all instances of kill, hit, or near-miss fratricide experienced in that battle. Because the times, locations, and vehicle identities are shown in the log, it is possible to search through the battle record and replay each incident on the graphics monitor, to understand its circumstances. This procedure has been followed for several battles.

THE INSTRUMENTATION RECORD

Certain important caveats should be noted. First, only engagements between instrumented vehicles show up in the record. Thus, engagements involving howitzers, some command tracks, M2 IFVs,[1] etc. are not recorded. Engagements involving dismounted infantry weapons are likewise not recorded, because such weapons are not provided with the position-location instrumentation system on which the computer display system is based. Moreover, owing to radio link problems or equipment malfunction, many other engagements between fully instrumented units are not recorded, whether fratricidal or otherwise. This is an important point. Members of the Operations Group have estimated that only about 60 percent of kills are paired in the more open battle areas of the NTC. In some broken terrain, the fraction can be much smaller. What is seen on the instrumentation screen is that an instrumented vehicle has been hit or killed by an "unknown" weapon.[2] Hits or kills of uninstrumented vehicles, or personnel, go unrecorded altogether. Thus, the record is incomplete.[3]

There is no reason at present to suspect that the level of fratricidal engagements is any different between the recorded and unrecorded events involving instrumented vehicles. It is presumed that the causes of nonrecording owing to equipment or communication failure are not correlated with the engagement situation. That reasoning does not extend to infantry weapon engagements, of which we can learn nothing from the computer as currently configured. Thus if one were to try to

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[1]The position/location radio units, which interface with the MILES, are not yet available for the M-2 (Bradley) IFV. The M-2, with its far-seeing thermal sight, is therefore not included in the data.

[2]The raw data stream entering the CIS does contain the type code for the source of the kill, however. It is simply a software problem to extract these data, and the ARI/POM program is expected to yield this capability.

[3]However, the field observer/controllers collect post-battle data on the source of all kills, but no permanent record was kept at the time these data were taken. This information is now recorded. To determine the actual number of paired kills would require line by line review of the firing/hit record of a battle.

ascertain the percentage of kills due to fratricide, one should include in the denominator only those kills that are paired by the instrumentation/computer system. Because the actual number of paired kills has not been ascertained, it is possible only to estimate the fraction of fratricides.

Table 1 shows the data extracted from the computer records. A total of 83 battles involving 15 different battalion task forces are included. A unit and battle code, and the type of battle are listed, along with fratricidal engagements (near miss--nm, hit, kill). Most battles include no such events (0). Following the simple list is a series of notes describing what it was possible to learn about some of those engagements by replaying portions of the computer record (a graphic display of the second-by-second progress of the battle). These notes are the "real-time" observations of the author as the battle was replayed.

To place the data listed in Table 1 in context, it should be remembered that each battle involves a battalion task force. A TF will usually contain on the order of 100 instrumented tactical vehicles. The total vehicles lost during a battle can vary widely, but a figure of 40 percent (40 vehicles) will not mislead the reader in considering the magnitude of fratricide. Using such admittedly crude figures, with the estimate that a maximum of 60 percent of kills are properly recorded, one might expect to see something like 24 paired kills (at most) show up in a typical battle record. That is the magnitude of number against which the level of recorded fratricides should be compared. In the 83 battles, 18 fratricidal kills were found. This leads to the conclusion that at least 1 percent of the Blue vehicles killed are killed by friendly forces. If the fraction of paired kills were as low as 20 percent, the data would indicate that as much as 3 percent of the kills are fratricidal.

Other factors not related to the instrumentation itself affect the level of fratricide at the NTC. For example, during time segments that include only reconnaissance/scouting action few data are recorded. Yet, the level of fratricide may be significant at those times. Further, most battles involve battalions acting alone. The difficult problems of passage of lines while in contact, and of boundaries between battalions,

Table 1

BATTLE LOG

Unit	Date	Battle	Fratricides	Note
ALFA 1[a]	16	Attack	0	
	18	Def. Sec.	1 nm	1
	24	Def. B.P.	0	
	25	Unk.	1 hit, 2 nm	
	26	Night Att.	0	
ALFA 2[a]	15	Attack	0	
	17	Attack	0	
	19	Probe	0	
	20	Def. B.P.	0	
	23	MTC	0	
BRAVO 1	22	MTC	0	
	24	Sp. Att.	1 nm	2
	25	Def. B.P.	0	
	31	MTC	0	
	1	Del. Att.	0	
	3	Def. Sec.	1 nm	3
	3	Night Att.	0	
BRAVO 2	22	MTC	0	
	23	Def. Sec.	1 nm	4
	25	Night Att.	1 kill	5
	27	MTC	0	
	30	Del. Att.	1 nm	6
DELTA 1	29	Def. B.P.	0	
	1	Del. Att.	0	
	7	Del. Att.	0	
	9	Def. Sec.	0	
	10	MTC	2 nm	7
	11	Night Att.	1 nm	8
DELTA 2	30	Def. B.P.	0	
	1	Night Att.	1 kill, 2 nm	9
	2	Probe	0	
	3	Def. Sec.	0 (instr. prob.)	
	4	MTC	0 (instr. prob.)	
	5	Del. Att.	1 kill, 1 nm	10
	6	Del. Att.	0	
	9	Def. B.P.	0	
ECHO 1[a]	4	MTC	1 kill	11
	5	Del. Att.	0	
	5	Night Att.	2 nm	12
	9	Def. Sec.	1 kill,1 hit,3 nm	13
	10	MTC	0	
	12	Def. Sec.	2 nm	14
ECHO 2[a]	4	MTC	2 nm	15
	6	Def. B.P.	0	

Table 1--continued

Unit	Date	Battle	Fratricides	Note
	7	Del. Att.	2 nm, 1 hit	16
	13	Night Att.	0	
	15	Def. Sec.	1 kill, 2 nm	17
GOLF 1	9	Del. Att.	2 kill, 4nm	18
	10	Del. Att.	2 kill, 1 nm	19
	12	Def. B.P.	0	
	21	Del. Att.	1nm	20
	22	Del. Att.	0	
	23	Ctr. Att.	0	
	25	Def. Sec.	1nm	21
GOLF 2	20	Night Att.	3 kill, 2 nm	22
	23	Def. Sec.	0	
	23	Spoil. Att.	0	
	24	Spoil. Att.	1 nm	23
	25	Ctr. Att.	0	
HOTEL 1	14	MTC	(instr. prob.)	
	15	Del. Att.	0	
	16	Del. Att.	0	
	17	Ctr. Att.	0	
	18	Def. B.P.	0	
	19	MTC	2 nm	24
	21	Def. Sec.	1 kill	25
HOTEL 2	15	Del. Att.	1 nm	26
	24	Def. Sec.	0	
	25	Del. Att.	0	
	25	Night Att.	3 nm	27
INDIA 1	21	Del. Att.	1 nm	28
	22	Def. B.P.	1 nm	29
INDIA 2	20	MTC	0	
	21	Del. Att.	1 nm	30
	22	Del. Att.	1 nm	31
	25	Def. Sec.	0	
	26	Night Recon.	0	
	27	Night Att.	3 kill, 8 nm	32
JULIETT[a]	24	Del. Att.	1 kill, 1 nm	33
	26	Def. B.P.	1 nm	34
	28	Def. Sec.	0	
	2	Del. Att.	0	
	3	Del. Att.	0	

[a]Unit not equipped with thermal sights.

Notes to Table 1

1. A near miss at 0602. A tank shot near another tank at a range of 938 m. The target was in a closely mixed group of BLUFOR and OPFOR; the shot was probably aimed at an OPFOR.
2. One tank shot at another at range of 438 m with no OPFOR nearby.
3. Near miss signal from tank 63 m from shooter.
4. Near miss at range of 1188 m. Target in front of OPFOR. Probably a case where target identification is key.
5. Kill at range 1900 m. Time 0638, after dawn. No reasonable explanation available from the replay.
6. Near miss at 213 m. No reasonable explanation available from the replay.
7. The first event occurred in darkness at a range of 600 m. A tank in one team shot at a vehicle in another team. There was no movement of the target and no OPFOR in the area. The second event was a near miss by a tank on a scout vehicle at a range of 1950 m. The shooter was moving fast, while the target was still and isolated, with no OPFOR in area.
8. This engagement was by a coax machine gun at a range of 638 m. OPFOR elements were near the slowly moving target.
9. There were three fratricidal firings by a TOW at a range of about 1500 m. At 0520, a Blue tank was killed, and at 0527 and 0532 an APC was near missed in the same vicinity. The only other unit in the area was an OPFOR manpack. The nature of the OPFOR unit is unknown.
10. A tank was firing rapidly. It shot at right angle to the direction of the OPFOR, near missed once, and killed one of a cluster of Blue vehicles. Range about 1000 m.
11. A TOW killed a tank at range 2100 m. The target was located at right angle to the direction of the OPFOR, in the main body of the task force. The replay yields no reasonable explanation.
12. The first near miss was in the dark, at range of 175 m, opposite to direction of nearby OPFOR--a target identity problem. The second event occurred in the dark, when a tank fired past a nearby (175 m) vehicle at the OPFOR.
13. The kill was before dawn, at a range of 988 m. An OPFOR scout may have been nearby. Near miss when tank shoots near last known position of OPFOR scout at 763 m about dawn. Next incident involves tank shooting at OPFOR at about 2000 m, then turns and shoots at an APC about 600 m behind. In another case, a tank shoots near another located about 500 m. from advancing OPFOR--range 1400 m. Perhaps an IFF device would help here. Last incident involved right flank tank shooting across front of task force (TF) at OPFOR located beyond TF. Near miss on BLUFOR at range of 1900 m.
14. Two main gun near misses at about dawn. One tank shoots away from the direction of the OPFOR regiment at a tank 860 m away. No OPFOR anywhere in that direction. Another tank shoots near a tank in another team, with no OPFOR nearby.

Table 1 notes continued

15. At 0636 a Blue tank shot away from the objective, at another team--got a near miss. At 0818 a tank near missed a TOW to its rear, about 65 m away. It had been shooting forward at OPFOR. Such an event is difficult to understand. One suspects instrument error.
16. At 0456 a tank in the trail team hit a tank in the lead team at range 1538 m. Later, a tank near missed an APC, probably while shooting past it at OPFOR, at a range of 138 m. Another tank near missed in a confused situation at 350 m. Here may be an example of where only an IFF would help.
17. This is a classic case. One tank in the middle of the main defensive position shot another in the forward defense element, as the latter withdrew. It shot at it 12 times in two minutes as the range decreased from 2500 to 1600 meters. The target was finally killed. This occurred at 0508, looking east (the visibility issue). At 0509 the same tank near missed another in the same target group at a range of 1400 m. At 0513 the same tank fired into the same forward element at a range of 2200 m. Some never get the word.
18. At 0347 a TOW near misses and then kills a tank at 338 m. At 0420 the same TOW kills another tank at 350 m. At 0653 a tank shooting at OPFOR at 2700 m near misses a Blue tank next to the OPFOR. At 0659 a tank fires at OPFOR, near misses a nearby Blue tank. Probably not a real attempted fratricide.
19. At 0600 a tank kills another in a different platoon of the same team at range of 1200 m. The target was 1 km in front of the OPFOR in a cluster of Blue vehicles, a genuine fratricide. Twenty seconds later, the same tank kills another beside the first kill. A near miss at a later time was shot at 75 m during a close engagement. Probably not an attempted fratricide.
20. A near miss was fired at a tank of an adjacent platoon at a range of 713 m, with no OPFOR in area.
21. Tank near misses another alongside during assault on OPFOR flank. Probably not an attempted fratricide, but a shot missing its target but passing close to a friendly vehicle.
22. At 2202, tank 24A (Alpha team) killed tank 14D (Delta team) at 1300 m. No OPFOR in sight, but the teams were on separate axes. At 0521:17, tank 14A kills tank 34D at 1538 m. At 0521:36 tank 14A near missed tank 32D at 1500 m. At 0525, 14A killed 32D at 1325 m. Both teams continued firing. This event was probably brought about by the following circumstances. OPFOR artillery fell on the Delta team. The simulator flash in the pre-dawn darkness may have caused the Alpha team to think they were being fired at by OPFOR tanks, so they shot at the Delta team. This started a fire fight between the teams, which was apparent on the record, as 32D was firing before it was hit and killed (no OPFOR around). Ten minutes later teams Alpha and Delta were still in a fire fight. This event clearly exhibits a command and control problem. At 0643, tank 65D near missed 22D (same team) at range of 100 m. The shot was from east to west, and no one was within 6 km or more in that direction. Accident? Horseplay?

Table 1 notes continued

23. A near miss was shot at near max range, 2450 m. The Blues and the OPFOR were all mixed up in the target area.
24. A tank fired and near missed a teammate immediately behind him at 88 m, then fired at another at 338 m, again behind him, away from direction of the OPFOR.
25. The target tank was engaged with and killing the OPFOR, with one OPFOR vehicle nearby. It was killed by a Blue tank at a range of 1063 m. The shooter was not otherwise usefully employed at the time.
26. A near miss at 88 m. Probably not an attempted fratricide.
27. At 2156 hours a tank near misses another one behind at range of 1238 m. There may have been an OPFOR scout near the target. At 2219 a tank takes a shot at 2900 m, near missing another tank located near the OPFOR. At 2240 a tank near misses another located in the OPFOR positions, at a range of 1500 m. If these are actual attempted fratricides, an IFF device might be the only preventive.
28. Tank in rear shoots at range of 2850 m toward OPFOR and near misses a tank located just in front of the OPFOR.
29. A tank shoots at another from the same team, but separated from it by 1800 m, at a right angle to the direction of the OPFOR.
30. A tank shoots directly at the OPFOR and near misses a Blue tank immediately in front of OPFOR at range of 1400 m.
31. Near miss signal on adjacent tank (13 m).
32. Three kills and eight near misses, all by tank main guns. A tank kills an APC at 1200 m just beyond a group of OPFOR. Only an IFF would prevent this. Near miss on group of two TOWs at 2275 m. Same again two minutes later. At 400 m kills tank in front of OPFOR element 400 m further away. An IFF would help here. Near missed an APC at 2300 m with no OPFOR near. One tank, possibly a team commander, shot the following sequence at Blue units: near misses an APC at 2000 m with no OPFOR around, and shoots it again a few seconds later; three times near misses one of same group six minutes later then kills a tank in same group. Clearly a command/control problem.
33. Tank kills TOW at range 613 m, which is 1 km in front of the OPFOR position. Near miss on tank at 300 m shooting toward OPFOR position. Probably not real attempted fratricide.
34. Near miss at 1575 m, true attempted fratricide. Shoots at right angle from OPFOR into adjacent team.

are not played. Here again, it is believed that fratricide may be more prevalent. A technical problem with MILES may also tend to understate the fratricide problem. When the atmosphere is smoked or dusty, the MILES may not penetrate at longer ranges, while the thermal sights are yielding a targetable image. Again, fratricide may be more likely under the poor visibility conditions, but the MILES will not kill.

DATA INTERPRETATION

Even these limited data offer the basis for some hypotheses for the causes of and cures for direct fire fratricide. However, certain events are simply inexplicable from this class of record. Field observers might be able to add to the understanding, if they were aware of the event when it took place and were in an appropriate position. In some cases, only personal interview with the crews involved could yield insight (and even that might fail).

Many of the near miss events may be spurious. The MILES laser beam apparently passed close to a friendly vehicle when fired at an OPFOR target beyond. This analysis examines only cases of fratricidal kill.

Clearly, misidentification is the sole problem in some cases, in which a friendly is shot at when intermixed with OPFOR vehicles or positions. An IFF device may be the only solution available for such a problem (except for exhortation to crews to do better at target identification, which is a nonsolution). Only 13 of the 77 events listed in the table were of this character, and only three involved a kill.[4]

In other cases, whole friendly units are mistaken for OPFOR units. Of the 18 cases of fratricidal kill noted, nine were of this nature. Although an IFF device could be effective in these instances, other solutions suggest themselves. An improved command and control system, involving accurate real time unit position/location reporting with two-way information flow between the task force and the teams (a battlefield information system) would do much to eliminate such happenings.

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[4]Interestingly, the ratios of "misidentification" total events (13/77) and kill events (3/18) are almost identical.

Clearly a fire fight between two parts of the same unit is an extreme manifestation and represents a failure of the command and control system. As a first step, a better understanding of the commander's intent and plan might avoid some of these errors. This statement is little better than the exhortation to tank crews to improve their target identification. However, a battlefield information system would provide the necessary tool for commanders.

Six of the observed fratricidal kills involved fairly isolated friendly vehicles not in the vicinity of any displayed OPFOR units. To prevent these instances, an automated position/location and display system would have to reveal the location of each individual vehicle, rather than simply the unit location.

Because some of the fratricidal events seem to occur when there is little likelihood of OPFOR being in the area, one could consider the institution of fire control procedures for all weapons during some phases of a battle, much akin to those used for air defense ("Weapons Tight," etc.).

The limited information included in this data set also offers some insight into the overall consequences of fratricide to the outcome of battles. To repeat the analysis on page 6, in 83 battles, which may have involved the paired and recorded loss of a maximum of 2000 Blue vehicles (24 per battle, times 82 battles), 18 kills are attributable to fratricide, a rate of less than 1 percent. However, if the pairing rate were only 20 percent (a *very* conservative value) instead of 60 percent, the indicated fratricide rate would be nearly 3 percent. The actual value cannot be determined from the present data set.[1]

Of equal importance to the overall rate of fratricide is the distribution. Clearly isolated instances of fratricide are of less importance to the outcome of a battle than a concentration of losses, or worse, a fire-fight between units. The distribution of fratricidal loss in the present data is shown in Table 2.

As might be expected, fratricide is more frequent in night attacks.

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[1] Just prior to publication of this Note, a new body of data, in the form of unit Take Home Packages incorporating a new format, became available to the author. From a series of rotations which occurred over the winter of 1985-86, data for 40 battles, involving 6 task forces, yielded the following information. The average number of BLUFOR combat vehicles killed per battle was 42.2. Of all the kills recorded (manually, by the observer/controllers) 2.5% were victims of fratricide. This raw evidence corroborates the findings of the study.

Table 2

DISTRIBUTION OF FRATRICIDES

Battle Type	Total Battles Observed	Distribution of Fratricides
Night attack	11	2 battles, 3 fratricides 2 battles, 1 fratricide 7 battles, 0 fratricides
Movement to contact/hasty attack	23	1 battle, 1 fratricide 22 battles, 0 fratricides
Deliberate attack	24	2 battles, 2 fratricides 2 battles, 1 fratricide 20 battles,0 fratricides
Defend battle position	11	11 battles, 0 fratricides
Defend sector	14	3 battles, 1 fratricide 11 battles, 0 fratricides

Generally, the clustering of fratricides is more common in the dark, including the pre-dawn phases of daylight battles. Of the four instances of multiple fratricide listed, three occurred in darkness. Because such instances can (and do) lead to fire-fights between friendly units, they are particularly disruptive. If night battles are more frequent in actual combat than is practiced at NTC, the *overall* frequency of fratricide seen at NTC could be misleading.

At the other end of the spectrum of difficulty, the defend battle position mission, being the most static and organized from the Blue viewpoint, is least apt to lead to fratricide. The lower fratricide rate shown for movement to contact, compared with deliberate attack, seems contrary to expectation, and no obvious explanation for the result stands out. One hypothesis is that deliberate attacks, often mounted on parallel axes, are more likely to lead to unit identity problems.

CONCLUSIONS

The conclusions to be drawn from the data and from the discussion above can be briefly stated.

- Of the BLUFOR instrumented vehicles shown as killed in a wide range of battles, approximately 1-3 percent are killed by friendly (direct) fire.
- In most cases the fratricides occur as isolated instances. However, cases of multiple fratricide are noted, particularly in conditions of darkness. These are the instances that are most apt to have a marked effect on the outcome of the battle.
- The NTC may underplay the frequency of night fighting and does not provide simulation of some situations that might be expected to lead to fratricide.

It has been suggested that aids to the present command and control system could help prevent battlefield fratricide. The data show that:

- Half of the fratricides recorded could have been prevented by proper knowledge (on the part of the shooting tank's commander) of the location of friendly *units*.
- Another one-third of the fratricides could have been prevented if the shooting tankers had knowledge of the location of individual friendly *vehicles* (e.g., as from a display similar to the NTC instrumentation).
- To avoid the remaining one-sixth of the fratricides would require an IFF type of device.

SUGGESTIONS FOR FURTHER WORK

Because the total number of fratricides observed was limited, it would be worthwhile to examine a broader battle record to validate the present results. Also, as soon as M-2 instrumentation is available, special examination of the fratricide record of modernized units should begin. Particular attention should be given to night engagements, which are limited at the NTC.

III. INDIRECT FIRE (ARTILLERY) FRATRICIDE

MODE OF SIMULATION AND RECORDING

During force-on-force battle simulations at the NTC, artillery fires are represented on the Core Instrumentation Subsystem. Unlike direct fire, however, the inputs to and outputs from the computer must be accommodated manually, and battle damage assessment relies in part on subjective judgments.

Calls for fire pass up the normal fire direction system from the forward observers (or whoever is calling for the mission) to the artillery operations center. (Most training units use TACFIRE systems, and a few still use voice radio.) There the mission will be "fired" by order to the firing battery. Some requested missions are not fired, owing to priority allocation of fire. The fire order is also passed to the artillery analysis team in the central instrumentation facility, where the firing data are entered into the computer (tube location, target location, rounds fired, etc.). At the same time, fire markers or observer/controllers are directed by radio to mark the fires using pyrotechnic simulators at the target location.

The computer displays the mission,[1] but the analysts in the facility and the field observers or fire markers manually carry out the damage assessment. Standard tables are used to determine the damage to be assessed by a given mission (e.g. 24 rounds of high explosives) against a given target (e.g. a dismounted platoon in prone positions). The assessed artillery results are not made a part of the computer record, although the observer/controllers may make a field note of the results. The artillery analysis team records each fire mission in a log. That log shows the time of fire, the caller (if known), the type of mission, the target location, and whether the mission was good (hit

[1]An impact box of standard form is shown on the display. If the analyst watching that unit sees the box cover a part of the unit, or if the o/c or fire marker in the field, directed to the location of the "impact," finds forces near it, they can agree, by radio link, to the proper battle damage assessment.

an enemy target), no good, or has hit friendly forces. The log does not contain information about the target or the battle damage assessment. These manual logs are retained in the artillery section for a few months and are then discarded. A similar system exists for OPFOR artillery play.

ANALYTIC PROCEDURE

After-action reviews at the NTC frequently note that friendly artillery fires have fallen on the BLUFOR during an engagement. The purpose of the investigation reported here is try to ascertain the frequency of this artillery fratricide, using the data available from the artillery logs described above. The replay available from the computer record is less useful in this regard, because the location of uninstrumented vehicles or units is not shown; thus many cases of fratricide (for example, against a dismounted unit not equipped with a manpack p/l system) could escape notice. The logs combine information that the analysts are able to see on the computer display and the observations of the field controllers, but subjective judgment may also enter. For example, if the standard impact box generated by the computer falls within 500 meters of an OPFOR unit, by NTC procedure the mission is considered "good," on the basis that the fire "would have been adjusted" or would have suppressed the enemy.

The logs for each day's engagement are kept in a file folder, and the artillery analysts provide a summary sheet with the collection that includes both field artillery and mortar missions. The number of missions fired, the number of good missions, and the number of fratricides are called out. The mission total is also broken down by munition class. Thus illumination and smoke missions are included, together with FASCAM (artillery-delivered mines) and high explosive and improved conventional munitions. For purposes of this analysis, only the fire-for-effect missions were used; smoke and illumination missions were ignored.

THE DATA RECORD

From the record (involving 15 separate task forces) 116 battles were analyzed. This was the total artillery record retained in the files of the artillery section in the fall of 1985. The raw data are shown in Table 3. A unit code, battle code, and the type of battle are listed for each engagement. The actual data include missions fired, number judged good, and the number of fratricides, for both cannon artillery and mortars. Other information, such as the number of rounds of each type fired in the engagement, was available in the original logs but was not used here.

Table 4 shows overall summary averages for all battles, including the average number of missions fired per battle and the average numbers of good missions and fratricides. The average fraction of good missions is approximately one-third for the artillery and one-fourth for the mortars. In both cases the fratricide average approximates 3+ percent. Fratricidal artillery missions were fired in 51 of the 116 engagements.

DATA INTERPRETATION

Because one might suspect that the difficulty of calling accurate fires would vary between classes of battle, data are divided into five types of engagement--night attack, defend in sector, defend battle position, deliberate attack, and movement to contact/hasty attack--and are separately summarized in Table 5. The night attacks seem to use fewer artillery missions than others, and the defense of a battle position uses more on the average. The substantially higher percentage of "good" missions in the night attacks is worth further analysis. The difficult defend-in-sector engagement exhibits a lower than average success rate than the others. The percentage of fratricidal missions shows little variation among the different classes of battle. The fraction of engagements of each type in which at least one fratricidal mission was fired is also an interesting statistic: night attack, 5/10; defend in sector, 8/18; defend battle position, 9/17; deliberate attack, 15/40; movement to contact, 14/31. The fractional variation is insignificant--"at least one fratricide is fired in one-half of the engagements."

Table 3

INDIRECT FIRE DATA LOG

UNIT	DATE	NIGHT ATTACK	DEFEND SECTOR	DEFEND BTL. POS.	DELIBERATE ATTACK	MOVEMENT TO CONTACT/ HASTY ATTACK	MISSIONS FIRED ARTILLERY	MISSIONS FIRED MORTARS	GOOD MISSIONS FA	GOOD MISSIONS MOR	FRATRICIDES FA	FRATRICIDES MOR
KILO*	24				X		36	0	11	0	0	0
	25		X				46	25	14	0	1	0
	26		X				9	0	2	0	0	0
	5		X				31	1	8	0	2	0
	6					X	31	9	12	1	0	1
	7					X	68	10	46	6	2	0
	8	X					37	8	12	3	0	0
LIMA*	20				X		16	0	6	0	0	0
	21				X		34	11	16	4	2	1
	22				X		27	11	12	4	1	0
	23				X		50	9	3	1	0	0
	25			X			46	0	25	0	2	0
	27	X					9	3	6	1	1	0
	27			X			51	2	27	0	0	0
MIKE*	14					X	26	2	8	1	0	0
	15					X	23	6	5	1	0	0
	17		X				35	3	4	0	0	0
	22					X	30	3	10	1	1	0
	23		X				8	5	2	0	0	0
	24			X			54	10	12	5	2	0
	25				X		51	7	24	3	0	0
	25	X					19	0	10	0	2	0
	26					X	8	0	1	0	0	0
	27				X		30	1	8	1	0	0
NOVEMBER-1*	8					X	0	1	0	0	0	0
	9				X		16	1	2	0	0	0
	10	X					11	13	4	4	0	0
	11		X				32	4	8	0	0	0
	12					X	12	0	1	0	0	0
	21				X		50	21	5	2	0	0
	22		X				20	4	8	1	0	0
	23		X				29	10	1	3	1	0
	24					X	17	2	5	1	1	0
	25					X	29	19	4	5	2	1
NOVEMBER-2*	8		X				1	0	0	0	0	0
	9				X		21	0	10	0	0	0
	10				X		6	13	1	5	0	1
	11					X	25	5	4	3	0	0
	12			X			26	0	5	0	4	0
	21				X		22	4	15	4	0	0
	22				X		22	4	9	0	2	0
	23					X	29	3	18	2	4	0
	25		X				13	1	6	0	1	0

UNIT	DATE	NIGHT ATTACK	DEFEND SECTOR	DEFEND BTL.POS.	DELIBERATE ATTACK	MOVEMENT TO CONTACT/ HASTY ATTACK	MISSIONS FIRED ARTILLERY	MISSIONS FIRED MORTARS	GOOD MISSIONS FA	GOOD MISSIONS MOR	FRATRICIDES FA	FRATRICIDES MOR
OSCAR-1	4					X	11	3	5	1	0	0
	6			X			24	9	8	3	1	0
	7				X		43	0	5	0	2	0
	13	X					19	1	16	1	0	0
	15				X		28	10	6	2	0	0
	16				X		20	22	6	5	1	1
	17				X		25	4	19	2	0	0
OSCAR-2	4				X		1	0	0	0	0	0
	5				X		15	0	2	0	0	0
	6	X					5	0	1	0	1	0
	7				X		26	4	9	0	4	1
	9		X				40	3	9	0	2	1
	10					X	22	6	12	0	0	1
	12			X			26	3	7	0	1	0
PAPA-1	28					X	14	0	4	0	0	0
	29			X			22	0	7	0	0	0
	30			X			17	15	1	1	1	0
	1				X		37	4	9	0	2	0
	3		X				31	14	3	5	1	0
	4					X	30	2	1	2	1	0
	5				X		16	4	1	0	0	0
	6				X		14	11	2	0	2	3
PAPA-2	30					X	18	12	10	7	1	1
	1				X		32	6	8	1	1	1
	7				X		25	17	5	3	2	1
	9		X				23	0	4	0	7	0
	10					X	43	17	10	7	2	0
	11	X					16	4	7	1	1	0
QUEBEC-1*	22					X	4	1	0	0	0	0
	23		X				23	0	3	0	0	0
	24	X					11	5	3	1	0	1
	25	X					18	6	9	2	0	0
	27					X	32	4	3	1	1	1
	29			X			39	11	8	1	0	1
	30				X		13	9	2	4	1	1
QUEBEC-2*	22					X	7	0	1	0	0	0
	23			X			5	2	0	0	0	0
	24					X	22	7	12	3	0	0
	25			X			3	0	0	0	0	0
	30					X	56	12	15	0	1	0
	1				X		19	3	12	2	0	0
	3		X				28	8	8	2	1	0
	4	X					34	10	20	5	1	0

UNIT	DATE	NIGHT ATTACK	DEFEND SECTOR	DEFEND BTL. POS.	DELIBERATE ATTACK	MOVEMENT TO CONTACT/ HASTY ATTACK	MISSIONS FIRED ARTILLERY	MORTARS	GOOD MISSIONS FA	MOR	FRATRICIDES FA	MOR
ROMEO-1	15				X		12	1	2	0	0	0
	16				X		29	1	6	1	0	0
	17					X	38	0	3	0	0	0
	19					X	34	0	11	0	2	0
	20			X			37	0	6	0	1	0
	22		X				28	1	11	0	0	0
	23					X	21	1	7	0	0	0
ROMEO-2	15				X		12	1	2	0	0	0
	16					X	20	0	3	0	1	0
	18		X				8	5	3	0	0	0
	25			X			32	1	17	0	1	0
	26					X	19	3	6	0	1	0
	27				X		21	9	5	2	4	1
	28				X		3	9	1	0	0	0
SIERRA-1	10					X	23	3	2	1	2	0
	12			X			78	3	17	1	8	2
	14			X			65	1	47	0	0	0
	18					X	43	0	33	0	0	0
	20					X	19	10	6	6	0	0
	21				X		59	11	16	4	0	0
	22				X		71	11	18	2	3	1
	23				X		52	20	16	4	0	0
SIERRA-2	15				X		30	2	16	0	0	0
	16				X		27	4	3	0	2	0
	17				X		55	6	29	1	1	0
	18			X			23	0	15	0	0	0
	20			X			31	12	10	8	0	0
	21				X		13	8	8	1	0	0
	22				X		29	12	10	3	0	1
	24		X				49	31	29	8	0	0
TOTALS		10	18	17	40	31	3094	646	1021	166	95	23

*TACFIRE-equipped units.

Table 4

AVERAGE VALUES FOR ALL BATTLES

	Missions Fired		Good Missions		Fratricides	
	FA	Mor	FA	Mor	FA	Mor
Average Number	26.7	5.6	8.8	1.4	0.8	0.2
Percent of Missions			33.0	25.7	3.1	3.6

Table 5

AVERAGE VALUES FOR BATTLE TYPES

	Missions Fired		Good Missions		Fratricides	
	FA	Mor	FA	Mor	FA	Mor
Night Attack						
Average Number	17.9	5.0	8.8	1.8	0.6	0.1
Percent of Missions			49.2	36.0	3.4	2.0
Defend in Sector						
Average Number	25.2	6.4	6.8	1.1	0.9	0.1
Percent of Missions			27.1	16.5	3.5	0.9
Defend Bttl. Pos.						
Average Number	34.1	4.1	12.5	1.1	1.2	0.2
Percent of Missions			36.6	27.5	3.6	4.3
Deliberate Attack						
Average Number	27.7	6.8	8.5	1.5	0.8	0.3
Percent of Missions			30.7	22.5	2.7	4.8
Movement to Contact						
Average Number	24.9	4.6	8.3	1.6	0.7	0.2
Percent of Missions			33.3	34.8	2.8	3.5

A similar simple examination of the record for each of the separate rotational units reveals a different story--sizable variations among the units are found. The fraction of battles in which fratricides were recorded varies from 2/8 up to 6/6. Most units fall near the average, only a few are outliers. This point may bear upon training issues. A brief examination of the artillery data has been made to see if there is a differentiation between TACFIRE-equipped units and those still relying on manual/voice methods. Table 6 compares them. No truly significant differences exist, although individual units in both classes exhibited substantial variations; that is, the differences between units in the TACFIRE and manual cohorts exceed the differences between cohort averages.

The data have been analyzed for other possible correlations. For example, in Fig. 1, the missions fired in each of the separate battles are plotted in descending order to yield a visual image of the distribution. Also plotted is the number of "good" missions fired during that engagement. There appears to be no useful correlation between the fraction of good missions fired and the total fired. In Fig. 2, a correlation between the number of fratricidal missions and the number of good missions was sought. The "good" missions in the battles are plotted in descending order, and with them are shown the number of fratricidal missions for those battles. Again, no useful correlation can be observed.

Table 6

AVERAGE VALUES FOR ALL BATTLES

	Average Missions Fired	Percent Good Missions	Percent Fratricides
Manual Units	28.0	33.0	3.6
TACFIRE Units	25.3	33.1	2.5

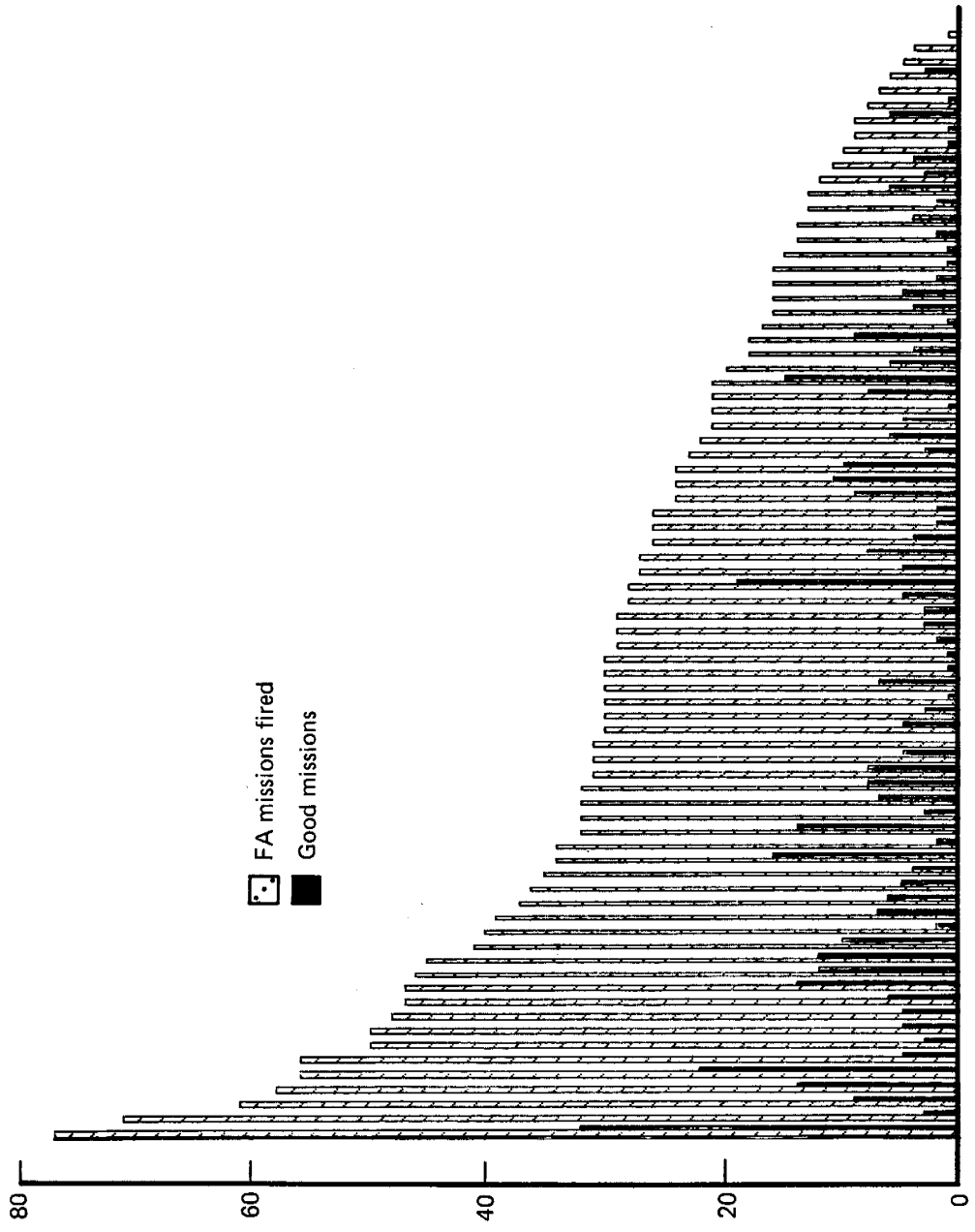

Fig. 1 -- Fire mission distribution--total/good

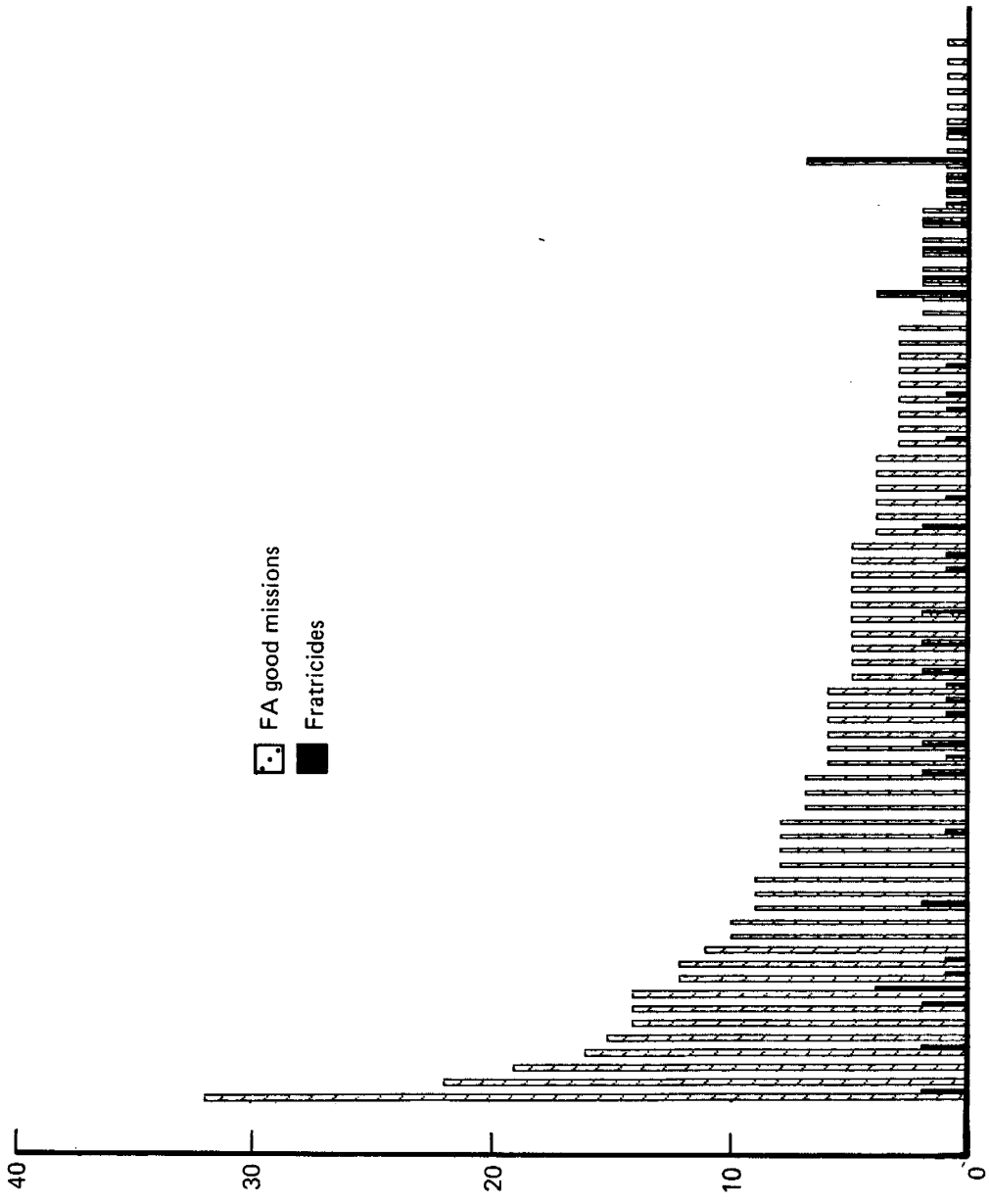

Fig. 2 -- Fire mission distribution--good/fratricide

As in the case of direct fire fratricide, an important issue is whether the fratricidal events affect the outcome of the battle. By replay of the CIS record, one might be able to observe some effect on battle tempo or progress as a result of the fratricidal missions. However, the instrumentation record alone may conceal or mislead,[2] and we have not conducted that battle review. However, it is reasonable to assume that a single, isolated fratricidal fire mission would not usually greatly affect the battle outcome. Of course, destruction of a breaching team or some similar critical happening would have a significant consequence. But on the whole, multiple fratricidal missions are the ones that should cause concern. The data were examined for such clustering. The variation of number of fratricidal fire missions among the battles is limited. In the 51 battles in which an artillery fratricide was recorded, 27 show only one such mission, 17 show two, and five show three or four. Only two show a larger number. These data indicate that in only a small fraction of the battles does artillery fratricide come in multiples and these multiple fratricidal missions may not be grouped in time or space. (That point was not examined in this analysis.) Moreover, the data shown here do not reflect the number of rounds in a mission. Considerations involving effects of artillery, including fratricidal effects, will require more detailed scrutiny.

Although the number of fratricidal artillery missions fired is lamentable, it is not necessarily alarming in a combat effectiveness sense. The hypotheses expressed above concerning the effect of artillery fratricide are confirmed by observation of battles; in few cases do the fratricidal artillery fires seriously affect the outcome of the battle, according to the observer/controller teams of the NTC Operations Group. They warn, however, that misplaced artillery-delivered mines (FASCAM) missions can and do have important consequences. The data analyzed here offer no insights into the question of consequences but

[2]To understand a battle is not generally possible unless the operation orders and other information is also available. The effect of fratricide is only apt to emerge during the After Action Review.

could be interpreted to suggest that artillery fratricide is not so pervasive as to be a major factor in battle dynamics.

This optimistic viewpoint should be tempered by another less sanguine observation. Although only one out of 30 fire missions falls on friendlies, only one of three fall on OPFOR. Thus about one-tenth of fire missions that hit something, hit friendlies.

What also becomes a matter of concern is the fraction of missions estimated to be on target by the NTC artillery control team. This fraction is lower than many experienced military officers generally expected. If means could be found to increase that fraction significantly, the effectiveness of a very major asset of the combined arms forces would be greatly increased. It is possible that a fairly small expenditure in fire control measures could yield a highly leveraged result. However, the artillery effectiveness numbers may only reflect the nature of the NTC simulation system, and not represent combat reality.[3] The entire issue of artillery methods and training at the NTC has been identified for more detailed scrutiny by the Army's artillery community.

CONCLUSIONS

1. The NTC artillery observer/controller teams judge approximately 3 percent of artillery fire missions to be fratricidal. This figure does not vary a great deal among various types of battle.
2. Approximately one-third of all BLUFOR fire missions are judged to land on OPFOR elements. There may be an opportunity to improve methods of fire control that will yield very cost/effective results.

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[3]A single example may illustrate the problem. There is often a time-lag between the firing of a mission and the marking of the fire at the NTC. The artillery observer therefore cannot observe and terminate (or adjust) a misplaced mission (or more particularly, a fratricidal mission).

SUGGESTIONS FOR FURTHER WORK

It is important to continue to investigate the artillery play at the NTC from several standpoints, applicable to both fratricide and effectiveness issues. Among suggested topics are: the adequacy of the artillery simulation and assessment, the infrequency of use of fire adjustment methods, the effectiveness of the forward observer/FIST system, the effectiveness of the fire support element located at the task force tactical operations center, the positioning of the battalion fire support officer, and the time responsiveness of the fire support command/control system.