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WEAPONS EFFECTS IN CITIES

VOLUME I

December, 1974

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INTREC, INC.
Santa Monica, California 90401

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SUMMARY

The primary study objectives are: (a) to determine whether there are significant deficiencies in the information available for evaluating the city fighting effectiveness of standard U.S. ground force weapons, and (b) where physical testing could address such deficiencies, to develop the nature of the tests needed. The study analyzes combat experience since WWII to determine the major combat functions and weapon uses in city fighting. Existing U.S. weapons capabilities and the available supporting effectiveness data are examined. Findings related to the study objectives, as well as additional insights obtained, include the following:

1. Review of the pattern of growth of dense city centers and newer, more open urban areas in Central Europe since WWII, combined with historical analysis of the reasons for city fights, provides no basis for the assertion that the incidence or importance of city fighting will be greater in the foreseeable future than it was in WWII.
2. In most of the city battles reviewed, troops had to learn city fighting skills during combat--at a considerable cost in lives. Significant increases in city fighting effectiveness are more likely to result from better tactical training for combat in cities, built-up and fortified areas than from weapons developments or modifications.
3. Due to the resulting penalty in effectiveness in other higher-priority forms of combat, there is little reason to develop single purpose weapons that improve only city fighting capabilities.

There are excellent reasons and opportunities for improving selected weapons for use across the spectrum of combat types.

4. Weapons developments that, if feasible, could prove useful for general purpose combat as well as city fighting include a shoulder-fired anti-tank weapon with no backblast and a hand-emplaced charge to create man-sized breaches in walls. Also useful would be the adoption of effective HEAT and anti-personnel rifle grenades and a gammon grenade.

5. Because of the widespread need for demolitions in most forms of combat including city fighting--and because sufficient numbers of combat engineers are rarely available--insuring that a sizable proportion of infantrymen are trained and current in combat demolitions skills can significantly enhance infantry effectiveness.

6. Communications are vital in city combat--however, they are frequently interrupted by radio line-of-sight problems and wire-cutting by artillery fragments. A non-weapons test of importance to city fighting would be a communications field test of standard infantry radios in cities.

7. The most important effectiveness information deficiencies are common to city fighting and higher priority forms of combat; these deficiencies include lack of valid estimates for the anti-personnel effects of most projectiles, the anti-tank lethality of current tank and anti-tank weapons, and the combat accuracy of most direct-fire weapons.

CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

CHAPTER I

INTRODUCTION

PURPOSE

In the past few years, there has been an upsurge of interest in city fighting as evidenced by numerous reviews (270, 215, 264, 265)* and studies aimed at new and improved city fighting weaponry (205, 206, 258, 253, 129). A number of hypotheses have been raised, including the following:

1. Increasing worldwide urbanization, particularly in Europe, will increase the incidence and importance of city fighting in future wars.
2. U.S. ground forces place insufficient emphasis on techniques and weapons for city fighting.
3. The current U.S. weapons inventory has important deficiencies in major capabilities needed for city fighting.
4. The development and acquisition of special purpose weapons to address these deficiencies will significantly increase U.S. city fighting capabilities.

If true, these hypotheses would imply that there are probably significant deficiencies in the basic effectiveness information necessary to improve the city fighting capabilities of U.S. weapons. This study has been undertaken on behalf of the Defense Advanced Research Projects Agency (ARPA) in order to determine whether, in fact, there are such deficiencies

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*This notation identifies references listed in the Bibliography in Appendix H.

and to outline physical weapons test concepts to address those deficiencies found to be important. At the same time, the research necessary may lead to useful insights concerning the above four hypotheses.

SCOPE

At ARPA's request, the study emphasizes city fighting in European-type cities. The focus is on cities large enough that at least one division would be required to overcome a determined defense. At the same time, the study recognizes that there is substantial overlap between fighting in cities, villages, and other built-up or fortified areas.

The term "city fighting" as used in this study is taken to mean conventional combat in densely built-up city center areas having a high proportion of contiguous buildings. Fighting in towns and villages shares many of the same building attack and defense techniques, but involves much smaller built-up areas consisting of a few clustered buildings. Combat in fortified areas also involves some of the same techniques and weapons used in city fighting, but is restricted to the attack and defense of heavily armed and prepared defensive structures or earth works. Fighting in built-up areas covers a broader range than city fighting, since it includes fighting in more open and trafficable areas, such as suburbs.

The weapons examined are those useful in city fighting and currently standard to U.S. ground forces (or those that could be readily obtained). Air weapons are excluded, as are developmental weapons.

METHOD

The study approach uses the following task outline:

1. Compilation and analysis of combat experience to determine the nature of city fighting, the major combat functions in cities, the ways in which weapons are used in city fights, and the nacure of the city physical environment and changes therein (Chapter II).
2. Based on the above, classification and description of the important city fighting combat tasks and the weapons used to accomplish them (Chapter III).
3. Compilation and evaluation of the test and/or combat information available for judging the adequacy of the weapons used to accomplish the important combat tasks (Chapter IV).
4. Identification of those areas where absence of information regarding weapons effectiveness seriously limits U.S. city fighting capabilities (Chapter IV).
5. Based on the information needs identified, development of general testing concepts for obtaining the needed information (Chapter V).

CHAPTER II

THE NATURE OF CITY FIGHTING

INTRODUCTION

This chapter summarizes city fighting experience since the start of WWII and subsequent changes in the physical environment of cities, in order to provide the basis for the Chapter III classification of weapons and combat tasks necessary in city fighting. This historical examination also provides insights into the reasons for fighting in cities and identifies some factors influencing the effectiveness of such fighting.

CITY FIGHTING AND STRATEGY

In essence, there appear to be four valid reasons for attacking or besieging a city:

1. Inability to establish, within the available time, an advance route and/or line of communication (LOC) of sufficient capacity that bypasses the city. Lack of a bypass route was frequently encountered in the days of reliance on railroads; it is less frequently encountered with truck-mounted or armored forces.
2. Belief that seizing the city interdicts a critical enemy LOC or communications hub (often invalid for truck-supported LOC's).
3. Fear of strength of city defenders and their possible reinforcements in case of a breakout. If the attacker bypasses the city, the breakout may be in his rear.
4. Belief in the political, economic or symbolic importance of possessing the city (or of not allowing the enemy to possess it).

This includes such objectives as liberating a friendly population or preventing the destruction of valuable facilities.

Other reasons for seizing cities are prevalent in history. These include miscalculation, egotism of leaders, accident and revenge. Appendix A contains a case-by-case review of the reasons for the initiation of nine city and town battles.

The defender's reasons are always to prevent achievement of the attacker's objectives. In addition, the defender may actively seek to lure the enemy into a city battle to tie up, attrit and delay the attacker's forces with relatively small defending forces.

The Decision to Fight Inside a City

Except for those few cases where a siege has been planned, most city battles are initiated with the objective of quickly seizing the city before serious defenses can be organized inside the city--particularly since city defenders usually deploy their main defenses outside the city. Fighting inside cities is rarely attractive for attacker or defender. Losses in people and materiel are usually high on both sides. Heavy civilian population casualties and massive property destruction are likely. The defender loses the ability to shift forces pinned down in the city. The attacker can be tied up for weeks and months in the grinding process of rooting out small groups of defenders fortified in thick-walled buildings and rubble.

Despite the unattractiveness of city fighting, attacks frequently fail in achieving surprise or seizing the key city terrain features quickly enough. In this case, the attacker must choose among the alternatives of withdrawing, initiating a siege, or paying the price to fully reduce the defenses. He may choose the latter because he doesn't believe he has the forces or the time (within an overall campaign advance schedule) to establish a secure siege or to bypass. Occasionally, the attacker may feel compelled to continue against a determined defense to prevent demolition by the defender of valuable facilities (e.g., port facilities) or because he is unwilling to starve out a friendly population in a siege. Most frequently, the attack is continued because of "sunk costs" in lives and materiel already expended or to avoid admitting failure. No matter what the reason, history shows few cases in which the resulting destruction, delay and losses incurred in reducing entrenched city defenses were not significantly greater than the time and forces required to break off and execute an alternate operation.

Reasons for and Outcomes of Some City and Town Battles

An overview of a sample of historical city and town fights--giving the objectives, contending forces and weapons, engagement mode and outcome--is useful to provide insights into the typical circumstances and likelihood of success of this type of combat. Table II-1 provides such an overview for ten city battles ranging from Stalingrad to Hue. More detailed material on these is available in Appendices A and B.

Stalingrad

Stalingrad was the largest and most costly city battle in military history; it provides a graphic demonstration of most of the reasons for avoiding city fighting. Hitler ordered the initial attack for economic reasons: he wished to cut the heavy wheat, oil and mineral shipping on the Volga River. Whether, in fact, seizing Stalingrad was the best way to interdict Volga freight traffic is open to serious question. In attacking

TABLE II-1

SUMMARY OF TEN CITY AND TOWN ENGAGEMENTS[a]

Battle, Date & Length of Battle	Size of Attacking Force[b]	Types of Weapons used by 1) Attacker 2) Defender	Size of Built-up Area	Mode of 1) Attack 2) Defense	Objectives	Outcome	Remarks
Stalingrad[c]: German attack 17 July-17 Nov. 1942 4 months Russian attack 19 Nov. 1942-2 Feb. 1943 2.5 months	German 6th Army Front of six armies	1. Complete WWII German military arsenal including close air support. 2. Complete USSR ground force arsenal.	City of over 500,000 population	1. Attempt to quickly drive to Volga; changed to building-to-building assault. 2. Defense from rubble strongpoints; extensive infiltration, sappers, use of underground routes. Isolation of attacker.	Take important communications and industrial center; changed to symbolic battle and test of will. Soviet objective to tie up and destroy German 6th Army.	German disaster; 6th Army destroyed.	Germans unable to subdue entire city. German defeat was due to inability to reinforce.
St. Mere Eglise 6 June 1944 8 hours	One U.S. parachute bn.	1. Small arms, rifle grenades, hand grenades, knives, bayonets, AT mines, bazookas 2. Small arms.	2-3 blocks	1. Through streets and against individual buildings. 2. Not seriously defended.	Capture communications center and permit rapid advance.	Successful	Pre-WWII heavy stone and masonry construction.
Eindhoven 18 Sept. 1944 1 day	One U.S. parachute bn.	1. Small arms, hand and rifle grenades, demolitions, 60mm mortars. 2. Small arms, 88mm SP guns, mortars.	City of 170,000 population	1. Through streets. 2. Mainly in streets -- highly restricted because of surprise.	Take bridge approaches to permit rapid crossing of the Eindhoven Canal and Dommel River.	Successful	Pre-WWII heavy stone and masonry construction.

[a]Details included in Appendices A and B.

[b]Size of defending forces not included because of large uncertainties usually attached to estimates.

[c]Considered in Appendix A where reasons for city battles are reviewed.

TABLE II-1 (Continued)

Battle, Date & Length of Battle	Size of Attacking Force	Types of Weapons used by 1) Attacker 2) Defender	Size of Built-up Area	Mode of 1) Attack 2) Defense	Objectives	Outcome	Remarks
Schierwaldenrath Raid 7 Oct. 1944 5 hours	One U.S. inf. bn., 2 eng. co.	1. Small arms, hand and rifle grenades, bazookas, demolitions, supporting artillery fire. 2. Small arms, 20mm guns, supporting artillery fire, anti-tank guns, Tiger tanks.	2-3 blocks	1. Surprise attack through streets and into buildings, destroy bldgs. and withdraw. 2. Withdraw then counter-attack.	Revenge and to free prisoners.	Uncertain - probably not worth losses	Pre-WWII heavy stone and masonry construction
Aachen 11-21 Oct. 1944 10 days	Two U.S. inf. bn. and, in last two days, two tank and one armored inf. bn.	1. Small arms, hand & rifle grenades, demolitions, flame throwers, 105mm artillery support, 155mm in direct fire against bldgs. 2. Small arms, 75mm SP guns, 105mm & 150mm artillery, MK IV tanks.	City of 170,000	1. Building-by-building. 2. From buildings--determined at times.	Administrative convenience. City entirely surrounded, garrison would not surrender.	Extensive built-up area destruction. Questionable overall success.	Pre-WWII heavy stone and masonry construction. Many civilians killed; Aachen badly damaged.
Enchenburg 7-8 Dec. 1944 2 days	One U.S. inf. bn.	1. Small arms, hand and rifle grenades, bazookas, anti-tank mines, mortar & artillery support, smoke, snipers. 2. Small arms, plastic antitank mines, tanks, mortar support.	2-3 blocks	1. Through streets and attack of individual buildings. 2. From buildings, one tank used plus anti-tank mines.	1. Join up in town with another battalion. 2. Accident--had attacker known the town was defended, he probably would have avoided it.	Successful	Pre-WWII stone and masonry construction.

TABLE II-1 (Continued)

Battle, Date & Length of Battle	Size of Attacking Force	Types of Weapons used by 1) Attacker 2) Defender	Size of Built-up Area	Mode of 1) Attack 2) Defense	Objectives	Outcome	Remarks
Manila 2 Feb. - 3 Mar. 1945 28 days	Two U.S. inf. divs., one airborne division (about 17,000 Japanese defenders from assorted naval and ground force units).	1. All weapons available to U.S. corps. 2. Full range of Japanese infantry and artillery weapons.	City of 1,000,000; metropolitan area of 110 sq. mi.	1. Building-to-building reduction of enemy strongpoints. 2. Buildings heavily fortified and defended despite Japanese HQ decision not to defend.	Administrative convenience and to meet a time table for liberating Manila.	Major disaster.	Central Manila destroyed. 100,000 civilians reported killed 16,000 Japanese KIA 6,000 US WIA 1100 KIA.
Remagen 7 March 1945 1 day	One U.S. armored inf. bn. and tank support.	1. Small arms and tanks. 2. Little defense.	2-3 blocks	1. Avoid fire in built-up area and infiltrate to seize bridge. 2. No systematic defense--occasional rifle fire.	Capture bridge to permit rapid crossing of the Rhine.	Successful This is an example of a non-battle.	Pre-WWII stone and masonry construction.
Seoul 20-29 Sept. 1950 9 days	One U.S. inf. div., one Marine div.	1. All weapons organic to Korean war inf. and Marine divs. plus close air support. 2. All weapons available to NKA, heavy tank and artillery support.	About 2,000,000 population (large open spaces, wide streets, mostly flimsy structures).	1. Down streets by infantry supported by tanks, artillery and close air. 2. Street barricades and tank/infantry counter-attacks.	Retake Korean capital to cut off enemy supply routes and gain a symbolic victory.	Successful	Battle developed like those in countryside where maneuver is possible. Non-typical city fight because NKA did not defend from buildings.

TABLE II-1 (Continued)

Battle, Date & Length of Battle	Size of Attacking Force	Types of Weapons used by 1) Attacker 2) Defender	Size of Built-up Area	Mode of 1) Attack 2) Defense	Objectives	Outcome	Remarks
Hue Phase 1 NVA attack 31 Jan-1 Feb 1968 1 day	4 NVA Inf. bns., up to 2 VC bns.	1. Small arms, RPG-7, B40, 12.7mm MG, demolitions, 120mm mortars, 122mm rockets. 2. Small arms, artillery support.	140,000 population, modern and ancient quarters	1. Surprise, penetrate through streets and take MACV and ARVN 1st div. headquarters. 2. Position defense of the two headquarters.	Capture ancient capital of Vietnam for symbolic and political impact on RVN and U.S. populace.	Succeeded in seizing Hue, did not hold but achieved political impact.	Surprise attack did not capture two vital areas or seal off the forces in city from reinforcement.
Phase 2 ARVN - USMC attack 1-24 Feb 1968 24 days	3 US Marine bns. and 10 ARVN and VN Marine bns.	1. Small arms, tear gas, M79 grenade launcher, artillery support, 3.5 in. RLs, M48 tanks, CS, naval gunfire, 106mm RR, Ontos. 2. Small arms, RPG-7, B40, 12.7mm MG, demolitions, 120mm mortars.	140,000 population, modern and ancient quarters	1. Deliberate block-by-block clearing of old city and modern section. 2. Block by block fortification of strongpoints.	Retake major built-up area of Hue to prevent gain of political advantage by NVA.	Successful in dislodging NVA but destroyed areas of religious and symbolic significance.	Long and bitter battles cleaning out strongpoints.

the city, the Germans relinquished decisive advantages in maneuver and tactics that had allowed them to penetrate almost 1000 miles into Russia against much larger forces. The Soviets were able to bring their manpower superiority to bear by continually infiltrating more men to defend in the air- and artillery-created rubble of Stalingrad while grinding down the German attackers. At the same time, they moved up forces to cut off and surround the Germans, a maneuver made feasible by Hitler's decision to forbid any withdrawal and to contest the city as a symbolic battle of will rather than as a military objective. In the course of seven months of static warfare, attrition, starvation, and cold destroyed almost 50 divisions comprising the German Fourth and Sixth Armies, the Rumanian Third and Fourth Armies, and the Italian Eighth Army. Personnel losses were 400,000 Germans, 130,000 Italians, 120,000 Hungarians and 200,000 Rumanians. The cost to the Soviets was equally appalling: Russian casualties suffered were 750,000, together with the almost total destruction of Stalingrad, its heavy industry, and its 500,000 civilian inhabitants.

Manila

Manila represents a large scale WWII city battle fought mostly due to command mistakes on both sides. The U.S. XIV Corps was in a hurry to get into Manila because little resistance was expected and a major victory parade was scheduled. The Japanese joint commander, Gen. Yamashita, had ordered a withdrawal from Manila in order to make a determined stand in the mountains of Luzon; however, his subordinate Navy commander, Admiral Iwabuchi, committed 12,000 sailors and 4,000 rear area soldiers to an all-out, to-the-last-man defense of the city. U.S. HQ restrictions on the use of artillery within the city to avoid needless destruction were gradually lifted as stiff opposition developed; eventually, most of central Manila became a free fire zone. The U.S. took substantial losses in assaulting heavily fortified, thick-walled strongpoints and burned and shelled large sections of the city to the ground. Fire and rubble impeded the advance as much as it helped. The result was a disaster for both sides: the Japanese lost 16,000 KIA, the U.S. took 7,000 casualties, and 100,000 Filipino civilians were killed.

Hue

More recently, the seizure of Hue by the NVA and its recapture by the U.S. and the RVN represents a 25-day city battle fought mostly for political reasons. The NVA wanted to seize Hue as part of their overall Tet offensive to demonstrate Communist strength and influence Vietnamese and U.S. public opinion against the war. Hue's importance in this regard was increased by the fact that it was Vietnam's religious capital. The NVA surprised the virtually undefended city and in one night seized all of it except the two main NVA objectives, the ARVN 1st Division HQ and the U.S. MACV compound. The remaining 24 days of battle were spent by three USMC and 10 RVN battalions in the slow, grinding process of cleaning out strongpoints, building by building. The enemy was never successfully isolated and managed to resupply and replace by infiltration every night. It took two USMC battalions 13 days to clear out one section of only seven blocks.

Overall, the battle of Hue was far from a success for either side. Although the NVA achieved significant political impact with their incomplete capture of Hue, they failed in their military objectives and suffered heavy casualties in trying to hold. The U.S. and RVN, on the other hand, could not retake the city fast enough to wipe out the political gains made by the Communists, and used so much U.S. artillery and naval gun fire that they destroyed most of the religiously significant sectors of Hue. Civilian casualties, as usual under these circumstances, were high.

Aachen

A similarly stiff and desperate resistance was encountered by two U.S. battalions in taking the small city of Aachen, defended by 5,000 low quality fortress troops. Aachen was already surrounded and bypassed by U.S. forces; thus, there was little reason other than Hitler's fanaticism for defending to the last man. Similarly, there was little apparent logic in the U.S. building-by-building reduction of the defenses. In the event, what few areas of Aachen had remained undamaged by previous bombing were reduced to rubble by air and artillery--without reducing resistance much. Heavy civilian casualties were inflicted prior to the U.S. victory (see Figure II-1).

Seoul

Of the large city battles examined in this study, only the taking of Seoul would be termed an unqualified success--and then mostly because there was little building-by-building city fighting. Seoul was attacked immediately after the Inch'on landing in order to cut off the main supply route and rear area support to the NKA's Naktong Line, which had bottled up most of the UN forces in the southern tip of the Korean peninsula. Furthermore, after their initial defeats, the UN forces badly needed a symbolic victory, which the recapture of the capital of Korea would provide. One NKA division plus two regiments established their main defenses in the hills to the west of Seoul and were mauled by one USMC and one Army division in four days of bloody fighting outside the city. Because Seoul was an unusually open city with wide avenues, large parks and few solid buildings--and possibly because

FIGURE II-1

U.S. RIFLEMAN ADVANCES PAST BURNING BUILDING
(AACHEN, GERMANY - OCTOBER, 1945)

the NKA had decided on a delaying action rather than a determined defense--the fighting in the city proper took place entirely in the streets. The principal actions consisted of combined tank and infantry assaults on NKA street barricades--the defenders used buildings mostly for sniping. The UN forces advanced for four days along narrow wedges towards key buildings and high points in the city; when these were taken, resistance collapsed. Seven thousand prisoners were taken, with perhaps 14,000 enemy KIA--at a cost of 3,900 U.S. casualties. Shortly afterwards, UN forces broke out in the south and the Naktong Line collapsed.

Small Cities and Towns

Fights in smaller cities and towns such as Eindhoven, Enchenburg, Remagen, St. Mere Eglise, and Schierwaldenrath are also of interest in understanding the reasons for initiating fights and the elements of success in city fighting. Most of these smaller fights were initiated to overcome obstacles on the advance route or to capture key bridges. One was fought in revenge for a previously unsuccessful raid--and also came off badly. Where surprise was achieved and local commanders made immediate decisions to quickly seize key points, success at low cost resulted in every case reviewed. Perhaps the most successful of these engagements, the capture of the bridge at Remagen, resulted because infiltration rather than fighting was decided on.

City Growth and Effects on Current Strategy

Large-scale city fighting in WWII, Korea and Vietnam was a relatively rare occurrence--and for good reason, as evidenced by the preceding discussion. Far more cities changed hands without a fight than with one.

Nevertheless, because metropolitan areas have grown significantly in size and population since WWII, it is tempting to conclude immediately that city battles will be harder to avoid in future wars and that it will become a more important capability for armies than in the past.

This question can be addressed by examining recent patterns of urban growth. Looking at Central Europe, it appears that neither the evidence on population growth nor on urban development supports the notion that building-to-building fighting in dense city centers is likely to increase in frequency. (See Appendix C for a more detailed examination of the evidence on Central European urban growth.)

Population increases in Central Europe have been modest. The West German population has increased 36 percent since 1939, with half of the growth absorbed in metropolitan areas (which include but are not limited to city center areas). At the same time, the number of dwelling units have increased by over 50 percent, thus creating the pressure for expansion of metropolitan areas. Most of this expansion has taken place outside city center areas, in the form of lower density residential and industrial development.

Examination of city maps (see Appendix E) shows that these newer areas probably do not have enough building density to support defensive positions based on interlocking building strongpoints and street "canyons"--a characteristic element of city combat. The wider, straighter streets and open areas surrounding the newer buildings are more likely to lead to the type of fighting that took place in Seoul, where street mobility remained relatively high and street barricades became the most hotly contested points. This is a form of combat that might be termed "suburban" and one probably not very different than fighting along roads and through hamlets in rural areas.

There are, in fact, a number of physical changes in Central Europe since WWII which would tend to decrease the frequency and importance of city fighting. Of these, the most important may be the expansion of the major highway network--particularly that portion bypassing cities. To the extent that these highways cannot be permanently destroyed or interdicted, rates of march and opportunities to bypass cities should be significantly increased in future wars.

Another change which may have reduced the incidence, or at least the defensive advantages of holding in cities, was the destruction by bombing of many of the massive pre-WWII stone and masonry buildings in city centers. These older buildings generally have been replaced by new reinforced concrete structures with far less wall thickness (e.g., 20 to 50 cm of concrete replacing 150 to 230 cm of harder-to-penetrate stone) and greater surrounding open spaces.

An important strategic difference is that in WWII the Allies advanced into Germany from the west while today's threat must advance from the east. Because most of Germany's major cities are in the west along the Rhine and Ruhr valleys or in the northwestern coastal areas, the Allies encountered defended cities as soon as they entered Germany. In contrast, there are few cities suitable for integrating into an overall defense scheme against invasion from the east. In fact, there are only eight to ten cities of over 100,000 population near the eastern border and the likely invasion routes of major Warsaw Pact forces. (See Appendix C.)

The question of whether NATO should plan to delay and defend in these cities is not easily settled. Planning in peacetime for defending inside cities entails obvious political liabilities. Militarily, defending in cities exposes the defending units to the risk of being surrounded and cut off; on the other hand, if Warsaw Pact forces should contest rather than bypass cities, small NATO defending forces could tie up and significantly delay much larger Pact attacks. In any case, although a defensive strategy cannot and should not be based entirely on defensive engagements, development of NATO city defense capabilities may be of somewhat higher strategic priority than development of city attack capabilities.

COMBAT EXPERIENCE IN CITY FIGHTING TACTICS

Overview

To provide a framework for defining effectiveness of city fighting, it is desirable to examine combat experience at the most detailed levels of tactics and weapons techniques. Standard histories rarely emphasize such detail; therefore, it is necessary to assemble a perspective of combat experience from unit records, interviews, gleanings from standard histories, retrospective articles, combat photography, etc. As part of the effort to develop this perspective, General S. L. A. Marshall was asked to document small unit actions in ten city and town engagements; the results are included in Appendix B. Much of the combat experience summary presented in this chapter is based on General Marshall's accounts.

Initiating the Battle - Surprise, Speed and Information

Probably the most important single element in effective attack of cities and towns is to achieve sufficient surprise and speed to avoid building-to-building city fighting. Thus, the outcome of the battle hinges directly on the first on-scene decisions of the commander. Only if he can infiltrate troops, bypass strongpoints, and seize critical headquarters and city terrain features before city defenders dig in, can a city or town be taken without the normally excessive losses in time, casualties, and materiel associated with the building-by-building approach. Many of the most successful surprise engagements, e.g., St. Mere Eglise, Colleville, Eindhoven, Remagen, and Hue, began with an infiltration, often at night, and orders to the troops to avoid fighting in buildings and to avoid slugging it out with heavy weapons.

To achieve surprise and quick movement, detailed knowledge of a city's geography and the enemy's dispositions is often critical. The use of local civilians as guides and informants can be strikingly effective, e.g., St. Mere Eglise and Eindhoven. For underground movement of troops into the enemy rear--as demonstrated by the Soviet use of sewers in Stalingrad--local knowledge is essential.

Preparing Cities for Defense

Given a few days' warning, dense city centers can be transformed into deadly defensive fortifications. Appendix A gives a more detailed discussion of defensive preparations in cities. The most successful defensive dispositions have consisted of selected thick-walled building or rubble strongpoints dispersed in depth and having overlapping fields of observation and fire, as demonstrated at Stalingrad, Hue, Aachen and Manila. Buildings in most city fights are fortified by blocking entrances and hallways with timbers, steel beams, wired furniture, barbed wire, and sandbags. Firing points, consisting of rooms with good fields of fire to prevent attacker movements down streets and backyards, are strengthened against breaching and spall with sandbags along the walls, plus piles of mattresses, furniture, and sandbags around the weapon positions to minimize fragmentation effects of incoming shells and grenades. Wherever possible, rifles, machine guns and rocket launchers are fired from well within the rooms to reduce exposure and firing signature.

The attacker's movements are normally further impeded by street barriers, barricades, mines, rubble and craters. The latter two are often created by the attacker (see Figure II-2). Barriers and barricades are made of any combination of cars, trucks, trolley cars, heavy machinery, sandbags, barbed wire, dirt-filled oil drums, telephone poles and rails or posts driven into pavement.

Artillery, when available to the defense, can be more effectively used by the prepared defender than by the attacker, due to the availability of survey and preplanned concentrations, as well as knowledge of local landmarks and mask conditions.

Assault of Building Strongpoints

Advance to the assault position, as in rural fighting, takes the best protected route to the covered position nearest the objective, preferably within 20 or 30 meters. Riflemen normally advance through streets by moving along the building walls on both sides of the street and covering the opposite side for possible enemy snipers, riflemen or machine gunners firing from rooms (see Figure II-3). Advances through backyards are often better protected but slower and more fatiguing. Both attacking and defending troops have used sewers, subways and utility tunnels to attack in the enemy's rear by moving underground (see Appendix A, Stalingrad; Appendix B, Aachen).

FIGURE II-2

U.S. RIFLEMEN ADVANCE ALONG THE SIDES OF A RUBBLE-CHOKED STREET
(LUDWIGSHAFEN, GERMANY - MARCH, 1945)

FIGURE II-3

U.S. RIFLEMEN ADVANCE CAUTIOUSLY ALONG BUILDING WALLS AND RUBBLE PILES COVERED BY OTHERS ACROSS THE STREET (AACHEN, GERMANY - OCTOBER, 1944)

This normally requires a native guide with detailed knowledge of the underground routes.

Attacking or assaulting troops enter buildings through doors, windows, breaches in the wall, "mouseholes" from adjacent buildings or down through the roof--no best method exists, due to the variety of buildings and defensive dispositions encountered. The process of clearing a building is concisely described by Eric Ambler in State of Siege (Bantam Books, New York, 1957), in a quote from a British NCO:

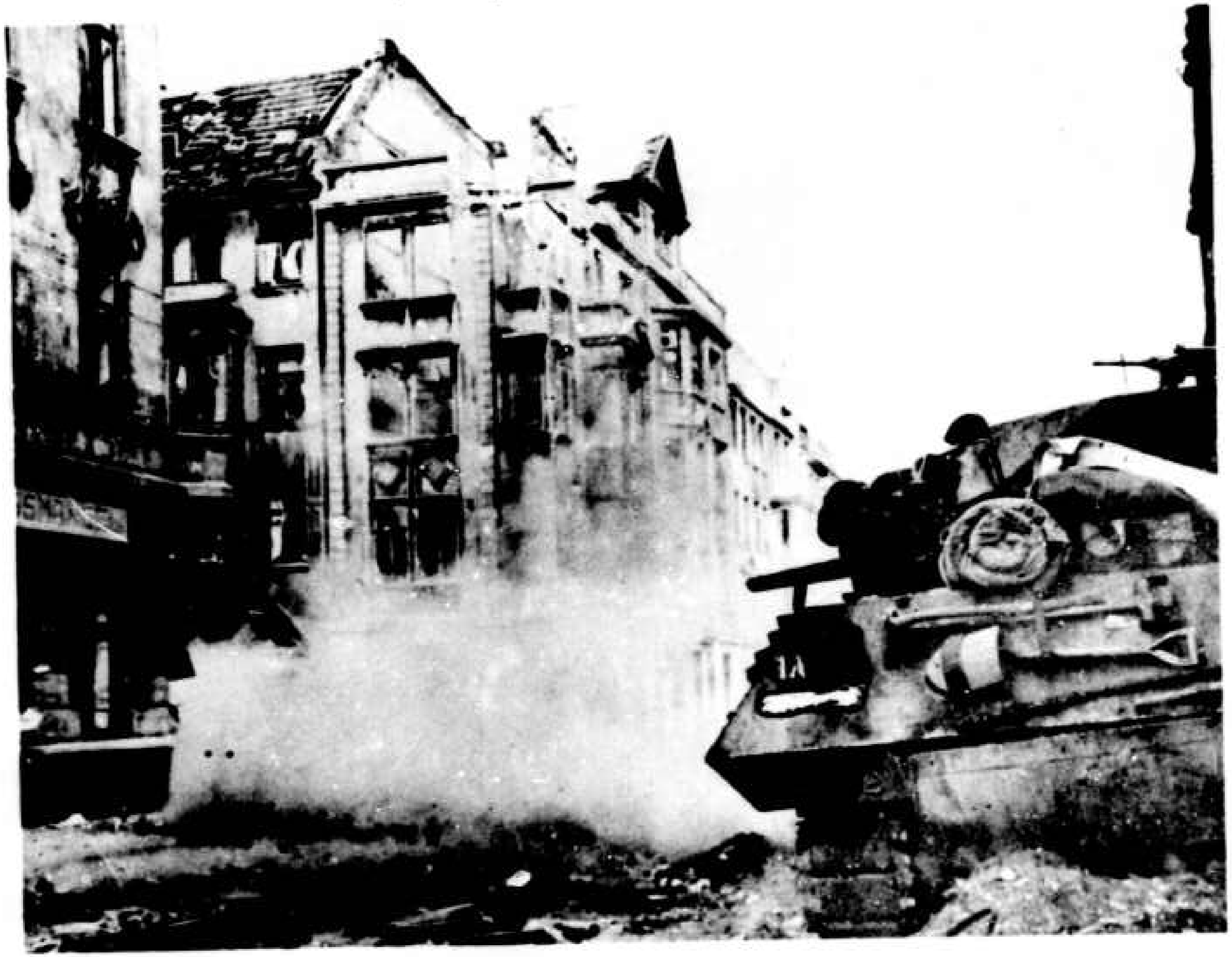
> It's an art, sir, rushing a building. . . . They can't stop you if you know how. You just have to get near enough first. That's the dodgy bit. There's usually plenty of cover, though, shell holes, ruins and that, but you've got to have patience. Crawl, dig your way there if you have to, but don't start until you're within thirty yards of a window. Then go mad. Put a four-second grenade in first and follow it. . . . Then, you go through the whole house. Quick as lightning. Every room. First a grenade, and then yourself. . . . Then, comb it out with your machine pistol. If it's a soft house, put a burst up through the ceiling and catch them bending. But don't stop for a second. . . . They're more frightened of you than you are of them because you're attacking. Blind 'em and then hit 'em with everything. And when you run out of ammo, still keep going while they're dazed. Knife, shovel, the lot! Keep going and there's nothing can stop you, sir.

Preparatory indirect fire for assault of buildings is rarely useful and is likely to create rubble providing improved defensive positions. Large caliber direct fire for knocking out machine gun or other infantry weapon emplacements in buildings can be usefully employed in support of assaults, where conditions permit bringing up tanks or artillery to close enough range (see Figure II-4).

Due to the difficulties of bringing up artillery, demolitions--particularly for breaching--are extensively used by the attacking infantry.

FIGURE II-4

U.S. TANK DESTROYER FIRING INTO A DEFENDED BUILDING
(AACHEN, GERMANY- OCTOBER, 1944)



Demolitions are also heavily used by defenders to impede movement. As attrition builds up, availability of demolition-trained infantry becomes critical.

Once a city attack has bogged down in building-to-building attack, attackers must clear out thoroughly each block and potential strongpoint. Moving too fast at this stage invites attack from the rear--as happened to the U.S. Army in Aachen. Even General Patton, a noted advocate of speed in attack, said of city fighting: "The main thing is not to hurry." (25: p. 343).

Night is often used by attackers to infiltrate and move to assault positions, and by defenders to reinforce, resupply and redeploy. However, most commanders are reluctant to fight at night in cities, e.g., St. Mere Eglise, Schierwaldenrath, Enchenburg, Seoul, and Hue. There are good reasons for this reluctance: control of units, already difficult in cities, is further hampered at night. Moving units are even more likely to get lost at night in cities than in the daytime. Mines and booby traps are almost impossible to avoid in the dark. One of the few documented battalion-scale nighttime city actions was launched by the NKA in Seoul against a U.S. Marine battalion (see Appendix B). The attacking battalion took a heavy beating, losing 250 KIA and six of fourteen armored vehicles in about four hours. Similarly, in Hue, the only battalion-scale actions during the NVA takeover were the two several-battalion night attacks against the MACV compound and the ARVN 1st Division Headquarters. Despite the small and unprepared defending forces and the surprise achieved, both attacks failed.

Combined Arms in City Fighting

By the end of WWII, armor and self-propelled artillery had become widely used as supporting direct-fire weapons for city fighting. Where streets are trafficable, tanks advance cautiously, together with covering squads of infantry to protect against hidden anti-tank weapons. The tanks, in turn, provide heavy firepower for neutralizing weapons positions in buildings or for wall breaching; they also provide machine gun firepower. SP artillery, though more vulnerable, can be brought up with covering infantry.

Problems with tanks in cities continue to be the traditional ones of being stopped by mines, infantry shaped charge weapons, "Molotov cocktails" dropped from windows, or the need to break off combat for resupply. As was learned and relearned in many city battles, among them Aachen, Seoul and Hue, when infantry learns to rely on their supporting tanks, attacks tend to stall as soon as the tanks are stopped.

An instructive example of a mop-up operation by armor in a several block area of a small city can be found in the fight at Arnhem (27). Two thousand men and 40 to 50 tanks with supporting SP guns, towed artillery, and light armor from the 10th Panzer division attacked 700 British parachutists holding a small residential section of Arnhem. These parachutists were the only British force to get into Arnhem. This city was a major objective of Operation Market Garden because of its bridge across the lower Rhine.

The British seized a complex of mostly contiguous, three- to four-story buildings of brick construction surrounding the end of the bridge. They were promptly cut off by German attacks and remained with their backs to the river and the hostile-held opposite bank for the three days of fighting that ensued.

The fighting began at dusk and continued day and night during the three-day period. On the first "day" of fighting, the German infantry attacked heavily through the streets and into the houses, resulting in bloody grenade and bayonet fighting. The Germans took heavy losses from British grenades and small arms, as well as from the small amount of artillery support provided by British forces outside Arnhem.

At this point, the Germans changed tactics to employ direct fire against the walls of the British-held buildings. The German commander's stated intent was to remove the covering outer walls or collapse the structures floor by floor, beginning at the top. Tanks were used at short range and towed cannon were used where they could be sited outside of small arms range.

By this time, the British parachutists could no longer obtain much artillery support, were out of mortar ammunition and had almost no anti-tank rounds left. They stayed and fought until their strongpoints were knocked down or set afire; then they moved downstairs or next door.

By the middle of the third night of fighting, the British were squeezed into a much smaller area of perhaps several large city blocks and one outlying school building--and had fewer than 200 effectives. Twelve hours later, it was all over. The few remaining "walking wounded" attempted to escape as individuals or in small groups, usually unsuccessfully.

After the German infantry got mauled on the first day, tank and direct artillery fire did the bulk of the killing, with the infantry only keeping up the pressure. The attrition and the destruction of one strongpoint after another forced the extraordinarily determined British parachutists into an ever-smaller perimeter until their last positions were literally collapsed around them. Despite the extremely armor-favorable circumstances--unusually long fields of fire, exhaustion of the defenders' anti-tank ammunition, brick rather than concrete walls, little defensive artillery support and overwhelming force superiority--it still cost the armor-heavy attacker three days and heavy casualties to clear an area only a few blocks wide and deep.

Massive Destruction, Bombing and Indirect Fire in Cities

Armies do not normally consider city destruction as one of their traditional tasks; since WWII, air forces have accepted--perhaps not explicitly--the mission of massive destruction as one of their combat tasks. The effects of massive destruction in cities caused by heavy preparatory bombing or artillery fires can be more harmful to friendly advancing forces than to the enemy.

The attack on Cassino by the 2nd New Zealand Division represents a classic example of the ineffectiveness of city destruction. The results of a 1000 ton bombing raid (of which 300 tons hit within the city) and a massive 40 minute artillery preparation are briefly described by the official U.S. Army history (7: p. 442).

> General Freyberg and other commanders expected the air bombardment and artillery shelling to pulverize Cassino, destroy enemy strongpoints, disrupt German communications, neutralize hostile artillery, and inflict heavy casualties on the Germans--in short, to so stupefy, daze and demoralize the Cassino defenders that the ground troops would attain their objectives and occupy the town quickly with hardly any losses. He expected his tanks to be through the town in six to twelve hours. Contrary to these expectations, "plenty of defenders remained; plenty of fight, plenty of guns, ammunitions, observation points, and plenty of perseverance." When tankers in immediate support of the assaulting infantry advanced, they found their routes blocked by debris and craters. Some commanders and staff members had realized that progress through Cassino would be slowed by the bomb holes and

> the wreckage of the buildings, but the actual conditions were far worse than they had expected. Rubble choked the narrow streets, and some craters were so large--forty to fifty feet in diameter in a few instances--that they had to be bridged before the tanks could pass.

Nine days after it had begun, the attack was recognized to be a failure and was halted. The defenders still held key strongpoints in the city.

Similar problems were found in Aachen and Stalingrad, which were bombed and shelled before and during the city battles. Bombing was prohibited in Manila, but equivalent damage was done by tremendous artillery barrages, which were also prohibited at first. Again, resistance remained strong.

The same lessons emerged once again at Hue: artillery was initially prohibited; then artillery, naval gunfire and bombing were brought to bear. Massive destruction ensued, yet surprising numbers of the enemy survived and reoccupied the ruins, which were harder to destroy than the original buildings. The enemy remained full of fight and in the end infantry small units had to dig him out.

EFFECTS OF CITY FIGHTING ON ORGANIZATION IN COMBAT

Basic Factors

Several previously mentioned aspects of city fighting impact on combat organization. These include the following:

1. As in night combat, movement and control of tactical units in cities is difficult, at best. Troops get disoriented and lost. Units in contact are quickly separated by buildings and often fight in isolation. Commanders frequently have no way of seeing

or locating units. This makes it difficult for higher command levels to influence the battle by committing reserves.

2. The opportunities for commanders to influence the battle by allocating supporting weapons are also restricted by building masks and the impossibility of assigning forward observers to each isolated squad or platoon.

3. Communications in most city fighting have been poor to nonexistent. Platoon leaders are frequently out of sight and earshot of squads. Wire gets cut quickly by projectile fragments ricocheting in the streets. Clear lines of sight for radios rarely exist.* An exception is Hue, where PRC-25 radios were reported to have worked well, perhaps because command posts and transmitting antennas were easy to emplace on top of the flat-roofed buildings prevalent in Hue.

These factors all decrease the influence of command on the on-going city battle. In cities, battle outcome is even more dependent on the performance of small infantry units than it is in normal combat.

Soviet Organization for Combat in Stalingrad

Shortly after Marshal Chuikov took command of the defense of Stalingrad, he made a number of sweeping changes in tactics and organization (see Appendix A for details), based on his recognition of the importance of small unit fighting and the reduced influence of higher level commanders in city fighting.

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*The solution used by police and taxicab communications, i.e., placing multiple antennas on tall buildings throughout a city, may be difficult to implement during a city battle. Nevertheless, the overwhelming importance of communications may well justify the extra effort and training involved--if testing establishes that this solution works as well for military radios as it does for radios at civilian frequencies.

For assault of buildings, he formed specially tailored platoons of 18 to 24 men, called "shock groups." Each shock group consisted of three differently armed and tailored 6 to 8 man squads, called the "storm group" (lightly armed with submachine guns, grenades, daggers and sharpened spades used as axes in hand-to-hand fighting), the "reinforcement group" (heavily armed with machine guns, anti-tank weapons, demolitions, picks and crowbars), and the "replacement group" (armed to replace losses in either of the other two groups). The storm group broke into the fortified building, the reinforcement group exploited the initial entry and prepared for counterattack, and the replacement group defended against flank attacks while providing attrition replacements. The storm group commander led the overall shock group. The new doctrine also called for an unusually detailed and intensive "storm plan" for each building assault covering minute details of the structure and the defenses, as well as details of squad tasks, reserves, supporting fires and communications.

The soundness of Chuikov's organizational changes was demonstrated by the tenacity and success of the subsequent defense in Stalingrad, as well as by the persistence of Chuikov's organizational concepts in Soviet city battles throughout the war, up to and including Berlin (9: pp. 127-33; 8: pp. 284-303).

HISTORICAL USE OF WEAPONS IN CITY FIGHTING

Small Arms and Grenades

Small arms have been, and continue to be, the most important class of weapons in city fighting. Bolt action and semi-automatic rifles, hand grenades, rifle grenades, submachine guns, and machine guns were the principal weapons used to defend or attack building and street positions in WWII (see Figure II-5). Firing at the usual targets in the open as well as targets

FIGURE II-5

HEAVY .30 CALIBER MACHINE GUN EMPLACED BEHIND RUBBLE PILE
COVERS U.S. TROOPS CLEARING OUT BUILDINGS
(WORMS, GERMANY - MARCH 1945)

behind doors, shutters, windows, ceilings and light walls was and is common. With the advent of automatic assault rifles (i.e., the StG 44, AK-47 and M-16), every rifleman now can have a weapon with greater firepower than the WWII BAR--thus, if anything, increasing the importance of small arms. Submachine guns were favored for building assaults in WWII due to both the fully automatic capability and the handiness associated with short length and light weight. Their role in clearing out buildings and other close quarter combat has been replaced by the 5.56mm assault rifle, which is more lethal and practically as handy as the submachine gun.

Typical ranges at which small arms are used in cities have always been short--though it should be noted that small arms engagement ranges in rural fighting are also much shorter than is commonly believed. Map analysis of city lines of sight in dense German city centers (see Appendix E) shows that maximum possible firing distances from defended buildings are typically between 30m and 190m, with the shorter distance representing an attack using the approach with the best cover. Actual engagement ranges are, of course, even shorter, with a significant amount of firing at practically arms length. Essentially the same maximum possible engagement ranges apply to the heavier direct fire weapons used in cities, from grenade launchers to tanks and 8 inch SP howitzers.

Heavy use of hand grenades by both sides is typical in the final assault and mop up. The rather artificial WWII concept of "offensive" vs. "defensive" grenades--that is, the concussion grenade with its short required safety distance vs. the Mk 2-type fragmentation grenade with its long safety distance (due to the 20 to 25 grain size of the largest fragments)--has now disappeared since current fragmentation grenades (e.g., M26, M33) with 1 to 2 grain fragments do not require thrower protection when thrown from about 15m or more. However, as will be discussed, the modern small fragment grenade may be significantly less lethal against troops protected by furniture and mattresses inside buildings.

Anti-personnel rifle grenades were used with considerable effect in cities by WWII riflemen, both in direct fire situations such as shooting into windows and in indirect fire as a short range, limited accuracy, light "mortar." Rifle grenades, as well as hand grenades, could be defeated by the heavy shutters generally found on European buildings--at least until the shutters were blown in.

The companion U.S. anti-tank rifle grenade of WWII had too ineffective a warhead to receive much use. European nations have retained both types of rifle grenades while significantly improving their effectiveness. The U.S. has retained neither type.

Other types of grenades extensively used in cities were white phosphorus (WP) grenades and gammon grenades. The WP grenade's dense smoke and burning fragments were effective in neutralizing weapons positions in buildings, in addition to its usual roles in target marking and setting fires. The gammon grenade was a field-expedient, hand-thrown demolition developed by the British and used at very short range against tanks, light structures, shuttered windows, and weapons positions in buildings. The grenade consisted of a contact-detonating fuse attached to a "sock" which could be stuffed in the field with several pounds or more of plastic explosive. The effect was essentially that of a sizable "squash-head" or HEP projectile.

Infantry Light Anti-Tank Weapons

The German WWII Panzerfaust, a shoulder-fired anti-tank grenade launcher usable at ranges up to 50m, was the first effective anti-tank weapon available to the rifle squad. It greatly increased tank vulnerability in any type of close terrain, from city streets to hedgerow country. Even U.S. troops used captured Panzerfausts when available, due to the low effectiveness of the U.S. 2.36 inch anti-tank rocket. Grenade and rocket launchers proved to be useful weapons in WWII and subsequent city fighting, being used for knocking out weapon positions (see Figure II-6) and wall breaching in light to moderate thickness structures.

The 2.36 inch rocket launcher was eventually replaced by emergency shipments of the more effective 3.5 inch rocket launcher to U.S. forces being overrun by North Korean armor at the outset of the Korean War. The 3.5 inch (89mm) was first replaced in the U.S. Army by the excessively heavy 90mm recoilless rifle and then by the LAW, a 66mm rocket with a throw away launcher and a relatively small warhead. The 3.5 inch, which has been retained by the USMC, was reported to have proven effective in breaching walls in the city fight in Hue; the LAW was reported to be ineffective, presumably because its warhead is too small (270: pp. 28, 29, 32).

Longer range infantry anti-tank weapons, the company-level 57mm and battalion-level 75mm recoilless rifles, were also developed and distributed in limited quantities to U.S. troops before the end of WWII. They were superseded before the end of the Korean War by the 106mm recoilless rifle.* The latter, though "replaced" by the TOW, continues to be available as a battalion-level, general purpose, large caliber, direct fire weapon for the

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*Other countries have focused greater development effort in the area of squad and platoon level anti-tank rocket and grenade launchers. The Soviets have proceeded from their Panzerfaust-equivalent, the B40, to the much-respected RPG-7. The Germans have a rocket-boosted modern Panzerfaust and the French have the highly effective STRIM. Effective ranges are up to double those of the U.S. 3.5 inch and LAW. Some have both HEAT and HE warheads, thereby increasing their general usefulness in city fighting, as well as in normal combat.

FIGURE II-6

BAZOOKA, COVERED BY RIFLEMEN, ABOUT TO KNOCK OUT A WEAPONS POSITION
IN BUILDING UNDER ATTACK
(MANNHEIM, GERMANY - MARCH, 1945)

infantry. It was used effectively to breach walls and to neutralize NVA weapon positions inside buildings in Hue (270; 162).

Demolitions, Mines, Booby Traps and Incendiaries

Field-expedient demolitions such as "satchel" charges, "pole" charges and cratering charges have been extensively used in almost all city fights. In preparing defenses, they have been used to open up exits and passages, make craters and create obstacles. In the attack, explosives have been typically used to create wall breaches and "mouseholes," detonate mines, and destroy structures and obstacles.

Mines and booby traps appear in all intense city fighting. Street obstacles and barricades generally use both anti-personnel and anti-tank mines as part of the defenses. Rubble is easy to mine in order to deny movement to infantry. Buildings are often booby-trapped as they are abandoned in order to slow down the building-by-building clearing process.

In city fighting, as in most combat in built up or fortified areas, almost every squad or platoon is confronted with the necessity for demolition tasks such as breaching, clearing mines and booby traps, cratering, collapsing structures and blowing up obstacles. Sufficient numbers of combat engineers cannot be made available to support each squad and platoon in these tasks. Equally important, engaged units often cannot afford to break off combat and wait for demolition specialists to be brought up. In WWII airborne units, the high priority need for infantry demolitions capability was met by providing several riflemen in each squad with about two weeks of formal combat demolition training; in addition, a demolition officer at the regimental level was charged with the responsibility of maintaining demolitions skills throughout the regiment. Although this was not done to prepare airborne troops specifically for city fighting, these capabilities were extremely useful when airborne units were committed to such fights.

Intentional burning of buildings in cities appears to have been less frequent than it is in rural combat, perhaps due to the fact that an out-of-control city fire can hinder both sides. Unintentional fires, of course, are common. Tracers, flame throwers, white phosphorus shells and thermite grenades have all been used to set fires. A newly standardized flame weapon with some application in cities is the M202 A1, a 27 pound, four tube, shoulder-fired rocket launcher firing LAW-sized flame rockets. These rockets have warheads that dispense a napalm-like liquid and were originally intended to clear out bunkers.

Indirect and Direct Fire Support

Indirect fire by artillery has often been unavailable to infantry units in city combat, due to building mask, lack of enough forward observers, and difficulty of observation over any extended area. This has not been so much of a problem in less dense city areas or towns.

Mortars have some advantage in opportunities to fire, due to higher angles of fall and the ubiquity of light mortars. The WWII U.S. 60mm mortar, due to its portability, found extensive use in cities for denying streets to personnel and unarmored vehicles. The USMC used the 60mm mortar extensively in Vietnam. The U.S. Army does not have a current standard 60mm mortar but does have one under development.

Direct fire support by artillery, engineer vehicles, anti-tank cannons and tanks was common in all large-scale city battles. Heavy direct fire has generally proven effective in knocking out specific firing positions and strongpoints behind barricades and in thickwalled buildings, though the task is often much more difficult than expected and the resulting enemy attrition is generally lower than expected.

Indiscriminate structure destruction, by direct or indirect fire support,* as well as by close support** and high altitude bombing, appears to be a concomitant of all intense, protracted city fights. The disadvantages of indiscriminate destruction have been previously discussed.

GENERAL PURPOSE VS. SPECIAL PURPOSE WEAPONS FOR CITY FIGHTING

In considering ways of improving weapon effectiveness for city fighting, it is essential to keep in perspective the fact that city fighting is only one of many important forms of combat--and a relatively infrequent form, at that. Nor is city fighting uniquely different: rifle squads often engage at equally short ranges in rural fighting; heavy stone farm buildings often form strongpoints to be defended or destroyed; demolitions are as critical in the attack of fortified lines as of concrete buildings. The focus on city fighting leads naturally to the temptation to add to combat unit TO&E's weapons that are specially selected or optimized for the city environment. This temptation must be balanced by an understanding of (a) the

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*Indirect fire is considerably less efficient than direct fire in completely destroying walls and cover, because it tends to impact on roofs and then floors below rather than impacting directly on structurally critical wall areas or pillars.

**Close support in cities is almost impossible to achieve, due to the difficulties in bringing in forward air controllers and of distinguishing targets and friendly units. The Germans were able to bring Stuka close support to bear in Stalingrad, but the Soviets countered easily by moving their ground units to within tens of meters of the German forces. Only one important attempt has been made to use helicopter fire support (rockets and machine guns) in a city battle. This occurred at Hue, where it proved impossible to use helicopters due to the density of fire from machine guns and light AAA.

common features of city combat and other forms of combat; (b) the resource constraints on the TO&E of a combat unit; and (c) the cost in unit effectiveness in those combat roles that occur more frequently than city fighting.

A combat unit TO&E consists of a mix of skills and equipment intended to best accomplish a wide spectrum of combat tasks, within the constraints of a limited number of men, a limited amount of logistics support and limited funds or time available to equip, man and sustain that unit. Because of the variety of combat tasks the unit must be able to accomplish, assigned TO&E equipment is as much as, or more than, the unit can transport, learn to operate and maintain. This is confirmed by the observation that combat units, under the pressures of extended combat, always eliminate or discard a significant portion of their TO&E equipment. At the same time, experience shows that most general purpose equipment does, in fact, work well in city fighting.

Thus, special purpose equipment for city fighting--as opposed to equipment that improves effectiveness across a broad range of combat environments--added to the TO&E of, say, an infantry battalion will either be discarded or will penalize the battalion's ability to carry, operate and/or maintain equipment necessary for other combat functions. Carrying special purpose equipment outside the unit does not diminish the personnel burdens for transport and maintenance--it simply reallocates them to some supporting unit. Furthermore, it entails the risk that, when the need for employment arises, no one in the battalion will know how to operate the equipment.

Just as TO&E's are compromises to meet a variety of tasks and fixed resource constraints, so are the stock levels of ammunition items that are on hand in depots. These levels reflect anticipated ammunition mixes and combat consumption levels that are based on past experience. Amounts of ammunition that are stocked can be inadequate for city fighting needs for either of two reasons: (a) because the ammunition items are very expensive and their usage rate is based on a different use, e.g., DRAGON and TOW, which are expensive anti-tank weapons not stocked for city fighting;* or (b) because the general purpose combat consumption rate is low and no basis is seen for extra allocations for city fighting functions. An example of the latter is the 105mm artillery HEP round which is a low use anti-tank round of currently unknown wall breaching capability.

CONCLUSIONS

City fighting has been important, though considerably less frequent than other major forms of fighting, in modern warfare and probably will remain so. There is, however, little evidence to support the hypothesis that city fighting in Europe will become more important than it has been, or that dense city centers have increased significantly in number or area since WWII. The increased rate of kills and sustainability associated with improved small caliber automatic rifles, anti-tank rifle grenades, and anti-tank grenade launchers are likely to make city streets increasingly dangerous for personnel and materiel.

Fighting in suburban areas or the newer open urban areas is likely to entail considerably higher rates of movement and fewer direct building assaults than fighting in cities. Such areas have, in fact, increased substantially since WWII. The large open spaces and lighter building

*For example, the cost of a TOW round is about $6,000 or roughly 100 times the $60 cost of the 106mm round. This high cost prohibits stockpiling the hundreds of thousands of rounds that would be required to support anti-tank missile use in general purpose or city fighting applications.

construction of these areas makes it likely that this form of combat will be closer in nature to fighting along roads through farmland and rural villages than to city combat.

City Fighting Costs to the Attacker and the Defender

As in the past, initiating building-to-building city combat will entail high costs for both defender and attacker. Defense in cities implies high military and civilian casualties as well as the destruction of defended facilities. When the city is friendly but held by the enemy, the destruction of facilities or civilian populations is a cost to the attacker rather than to the defender.

In any case, the attacker faces high losses in men; he also faces high losses in materiel such as tanks and SP guns if he attempts to assist small infantry units with non-infantry weapons. In addition, he faces the necessity to commit large forces and to pay heavily in time.

City Fighting Benefits to the Attacker and the Defender

After the initial quick takeover attempt has failed, city combat historically has held few benefits for the attacker. If the city has not been rapidly invested, continued city fighting almost always has been disadvantageous for the attacker. Even when the attacker has finally prevailed, the casualties taken, facilities destroyed and time lost have seldom justified the gains in terrain, logistic capacity or political-psychological impact achieved. The defender, on the other hand, is offered the possibility of significant benefits, despite the cost in casualties and destruction: defending forces can tie up larger attacking forces for weeks or months.

These considerations lead one to the conclusion that, unless there are explicit, dominant military advantages to be gained, attacking a determined, organized defense in cities should be avoided at all costs. On the other hand, mounting such a defense may be justified.

From the NATO and U.S. strategic point of view, defending in the few cities near Warsaw Pact invasion routes may or may not be desirable. In any event, because city combat can be forced on U.S. forces in any war, keeping up city fighting skills--both for attack and defense--is necessary. Furthermore, the skills learned will improve effectiveness in a broad range of combat including fighting in built-up or fortified areas.

City Fighting Tactics and Training

In the attack of cities, as in many other circumstances, the initial tactical decisions are the most critical. The success of any attempt to quickly seize a city depends almost entirely on the success of the commander's first on-the-scene decisions in avoiding building-to-building fighting, i.e., his decisions on how to achieve surprise, how to bypass defended sectors, and how to rapidly capture key city terrain.

Another recurring theme throughout most city fights from WWII to Vietnam is that the troops had little or no knowledge of the techniques of city combat and, at high cost, learned as they fought. The contribution to city fighting effectiveness that can be made by teaching these techniques, before the onset of combat, overshadows the contributions that are likely to result from improved city fighting munitions or weapons.

The basic infantry techniques that need to be taught are defense from and hardening of buildings and barriers, assault and "cleaning out" of buildings, methods of advance through backyards and streets, wall-breaching, and demolitions. Having men in every squad trained in demolition is of particular importance for both city fighting and other forms of combat; combat experience shows over and over again that demolition-trained engineers are simply not available at many times of need.

Other than stressing the importance of these basic techniques, combat experience only teaches that there are no "best" sets of tactics for city fighting. Whether to advance through the backyards or through the streets or through the sewers, whether to attack up from street level or down through the roof or through "mouseholes" from adjacent buildings, are the choices that must be made on the scene--the specifics of each opponent as well as of each city, each block and each building make generalization impossible in this area.

Weapons Implications

There have been few significant deficiencies in effectiveness of the general purpose weapons available to infantry units when they are used for city fighting. City environments limit engagement ranges to those where infantry weapons are highly lethal. The major potential problem raised, and this was confirmed in the most recent city battles in Vietnam, is the possibility that general purpose infantry weapons which have been effective in city fighting are being discarded in favor of weapons whose city capabilities are questionable or unknown. The 3.5 inch rocket launcher vs. LAW and the 106mm recoilless rifle vs. TOW or DRAGON are examples where the older weapons have demonstrated city fighting capabilities while the new weapons may suffer deficiencies in terminal effects, mobility, cost, and/or sustainability.

Target Types and Ranges

The new and rebuilt portions of Central European cities are more lightly built than the older pre-WWII massive stone and concrete structures. On the other hand, interior and exterior construction thicknesses are significantly greater than in the U.S. and the tough, resilient, steel reinforced concrete wall is almost universal in buildings over four stories. Since the end of WWII, building construction methods and materials have been highly standardized in Central Europe. This permits the target problems and defense opportunities presented by post-war buildings to be described and prepared for. Target ranges in the heavily built-up areas will continue to be very short. The major target types, primarily people and then armored vehicles, have not changed since WWII--except for the increasing armor thickness of the vehicles, which is at least balanced by the increasing penetration of anti-armor weapons.

CHAPTER III

WEAPONS, EFFECTS AND FIRING SITUATIONS

INTRODUCTION

This chapter examines the weapon types, weapon effects, combat postures (attack or defense), and physical situations that are found in city fighting, and categorizes each of these four factors into logical classes. The possible combinations of these four factors are then systematically searched to determine (a) those combinations that are important in city fighting, and (b) which desired weapon effects in which firing situations cannot be achieved by any existing weapons. This approach provides the basis for the Chapter IV search for the major weapons information deficiencies relevant to city fighting.

FACTORS AFFECTING WEAPONS EFFECTIVENESS IN CITIES

Three aspects of the physical situation in which weapons are fired are important:

- Relative locations of firer and target
- Building structures (when these are involved in the fire situation)
- Space relationships of buildings that determine ranges and firing angles.

Each of these factors affecting weapon performance is discussed below.

Weapon Type

The types of ground force weapons that are considered to be potentially important contributors to some aspect of city fighting are those found in infantry, tank, reconnaissance, combat engineer and artillery units. An extensive list of representative weapons that could be used in city fighting was reviewed; this list of weapons, with some physical characteristics, is given in Appendix F. These weapons/munitions are categorized as follows:

- Small Arms includes man-portable, bullet-firing weapons, i.e., pistols, rifles, shotguns, submachine guns, and ground-mounted machine guns.
- Anti-Armor infantry weapons includes man-portable weapons whose primary function is defeat of armored vehicles but which have secondary capabilities as assault weapons.
- Short-Range Launched Munitions includes hand-held weapons that launch a variety of burning, smoking and exploding projectiles to ranges of a few hundred meters or less. Hand grenades, gammon-type grenades, white phosphorus (WP) grenades, thermite grenades, rifle grenades (HEAT and HE), grenade and flare launchers and flame projectile launchers are included; flame throwers are not.
- Mortars
- Artillery is restricted here to its indirect fire role. Artillery used in the direct fire role is included in the armored combat vehicle category.
- Armored Combat Vehicles includes self-propelled weapons systems possessing protection from some types of fire and possessing a mix of machine gun and/or larger caliber direct fire capabilities.

- *Mines* includes booby traps and munitions designed for anti-personnel, anti-armor, or illuminating effects that must be emplaced in advance of intended use.
- *Explosives* includes all hand-placed demolition charges, whether manufactured (e.g., engineer shaped charges) or improvised from bulk explosives (e.g., satchel and pole charges).
- *Flame Throwers* includes man-portable devices for projecting flame.
- *Smoke Pots and Smoke Generators* includes all statically-emplaced bulk smoke producers.

Weapon Effects Important to City Fighting

Many of the above weapon types can be used to produce multiple effects that are important to city fighting. Each weapon type must be evaluated, therefore, for each of the different effects that it can produce. The categories of effects which are important to city fighting are:

- *Anti-Personnel*--incapacitation or suppression of personnel.
- *Anti-Armor*--damage to armored combat vehicles.
- *Structure Destruction*--massive damaging of buildings.
- *Wall Breaching*--includes the two functions of creating holes in walls large enough to allow personnel through and neutralization or destruction of enemy firing positions behind walls.
- *Illumination*--production of artificial light to extend vision in darkness.

- Obscuration--production of vision-screening smoke. Accidental obscuration from dust, etc., is not included.
- Incendiary--setting fire to vehicles, rooms, buildings or entire blocks.
- Cratering/Denial--creation of artificial obstacles to impede men or vehicles.
- Target Designation--use of tracer or incendiary bullets and exploding, smoking, or burning grenades to mark locations and directions of targets or objectives.

Combat Posture

Weapon effectiveness is often affected by the posture of the firers and the targets. Firer posture can affect accuracy, while target posture influences weapons effects. For example, when the targets are fully exposed, as in the case of soldiers assaulting across a street, light fragmenting weapons become highly lethal. The same weapons are much less lethal against troops defending from prepared positions in buildings.

Relative Locations of Firer and Target

Buildings can limit weapon firing positions and can modify terminal effects of weapons, that is, they can provide protection against penetration or create behind-wall spall. The overall impact of relative firer-target location on weapon effectiveness in cities is categorized in terms of the following broad classes of firing situations:

- Both the firer and target are outside buildings.
- The firer is outside and the target is inside a building (or the building is itself the target).

- The firer is inside a building and the target is outside.
- The firer and target are both inside the same building.
- The firer and target are inside separate buildings.

Building Structures

Weapons effectiveness variations due to building structure are primarily a result of wall construction and, to a limited extent, of height. Wall construction strongly affects protection for targets inside buildings. Building height has some effect when the firer is in an upper story and must fire down at targets outside, or vice versa. One example of this effect is a tank trying to elevate the main cannon to knock out a machine gun position on the top floor of a tall building.

Three classes of structures are used, for the purpose of this study, to represent the spectrum of those found in cities; these can generally be described as follows:

- Concrete (steel-reinforced)--difficult to penetrate or destroy; normally multi-story.
- Masonry (bricks or cast building blocks)--provides protection against small fragments, single bullets and low velocity projectiles of nominal explosive power; normally two to four stories in Europe.
- Wood and other light materials--little or no protection against penetration; can be single story; rare in European cities.

Building Density

The arrangement of buildings and open spaces in cities dictates tactics, weapons use and target range frequency in city fighting in much the same way that terrain and vegetation do in rural combat. Building density can be represented by three classes that are expressed in terms of the incidence of open space:

- "No open space" represents the dense central business areas and old quarters of European cities--streets are narrow and only the streets themselves and a few small parking areas, courtyards or backyards are not covered with contiguous structures.
- "Few open spaces" is used to represent central city areas containing primarily contiguous structures but in which streets are wider and there are some parks, squares, or traffic circles.
- "Some open spaces" describes urban areas in which buildings may be higher but density is lower and there are wide boulevards and frequent parks and other open spaces. From a density standpoint, it can also represent higher density suburbs.

HOW WEAPON TYPES, EFFECTS, AND PHYSICAL SITUATIONS COMBINE

There are a large number of possible combinations of all the factors described above. Fortunately, many of them cannot reasonably be expected to occur, e.g., the use of small arms to produce anti-tank effects in a situation in which both sides are inside a building. Others do not affect weapons effectiveness as in the case of building density which is irrelevant when firer and target are in the same building.

As a first step, each of the combinations of desired weapon effects and physical situation factors was examined to determine whether it could reasonably be expected to occur. The tabulated results are shown in Table G-1 of Appendix G.

The next step was to consider usable combinations of specific weapon type and desired weapon effects in each of the likely situations. Tables G-2 through G-12 tabulate, for each weapon type, the combination of weapons types, desired effects, and physical situations which are usable in city fighting.

ASSESSING IMPORTANCE TO CITY FIGHTING

The final step in the systematic search of combinations of weapon type, effects, posture and physical situation is the assessment of the basic importance of each of the previously identified usable combinations to combat in cities. In this assessment, four elements were considered:

- The significance of the weapon effect based on combat experience.
- The number of weapons of the specified type available to those infantry elements directly engaged in city fighting. This includes infantry weapons at or below battalion level, as well as weapons of supporting tank, artillery and engineer elements.
- Probable weapon use frequency, considering the effect of weapon/ammunition system weight on weapon mobility and sustainability.*

*Sustainability is used to mean the ability of a weapon system's ammunition load, within the weight and/or volume limits imposed on it by given combat conditions, to sustain a desired rate of target effects. The concept applies to all systems from rifles to tanks.

- Weapon employment limitations such as long minimum arming distances and hazards to the user from launch blast effects in rooms or from short range use of fragmenting warheads.

As an example, consider the use of weapons of the anti-armor type to achieve anti-personnel effects when the weapon is inside a building, the target personnel are outside, and the area has high building density. Building structure type is not relevant in this situation because the target is outside. The use of anti-armor weapons from inside buildings is severely restricted because of portability, launch blast and depression angle considerations, particularly in this dense building situation where ranges are very short. Short ranges raise the further problem of long minimum fuze arming distances. High cost per round for missile anti-armor weapons limits availability and use frequency. For the remaining anti-armor weapons, high weight per round of ammunition leads to low sustainability except in static defensive positions. Further, few anti-armor weapons are efficient producers of personnel casualties; exceptions are weapons such as the 106mm recoilless rifle and the RPG-7 which have HE or HEP rounds in addition to the usual HEAT rounds. U.S. infantry units have few or no anti-armor weapons that could be used in buildings--except possibly the LAW, which has poor anti-personnel capabilities. Combat experience shows little use of such weapons against personnel outside buildings. Consequently, the anti-armor weapon type is not considered to be a significant producer of anti-personnel effects when fired from inside buildings in densely built-up areas.

A similar assessment process was used for each of the previously identified usable combinations.

RESULTS

The important and useful combinations of weapon type, effects and physical situation are tabulated by weapon type in Tables G-13 to G-23 and were used to guide the information search in Chapter IV.

Of the approximately 175 combinations identified as important, in only 33 cases were there no existing weapons available that could achieve the desired effect under the specified physical situation. In all remaining cases, at least one and usually more weapons were available. The cases where weapons to accomplish the function did not exist can be summarized as follows:

- Wall breaching and structure destruction when the firer is inside a building and the target is in another building (18 combinations). The backblast limitation on firing rocket launchers and recoilless rifles inside buildings prevents the anti-armor weapon type from being assessed as a currently significant contributor to this important capability. The artillery, mortar, armored combat vehicles and aerial weapons types are not normally fired from inside buildings. For cases when these latter supporting weapons are available and not masked--which may be infrequent--they can fulfill the wall-breaching function from their normal outside locations.
- Wall breaching when both firer and target are inside the same building (3 combinations). Only small anti-armor weapons and demolitions could contribute significantly in these situations, and the problem of safety to using troops limits the utility of current anti-armor weapons in these roles.

- <u>Cratering and denial in the "some open areas" level of building density (2 combinations)</u>. These cases represent a minimum level of canalization of attacker movement in a city, and the hardness of city pavement surfaces severely restricts hasty emplacement of mines or cratering explosives (except for the reported use of chains of mines pulled across the street by hand just in front of advancing vehicles). Thus, more of these munitions would be required and rapid emplacement would be difficult. When time is available, mines can and have been emplaced under pavement. However, means other than the identified weapon types can be used for denial of movement in this situation, e.g., concertina wire, rubble barricades and overturned cars.
- <u>Illumination inside buildings when open areas are other than minimal (4 combinations)</u>. Other than setting fires inside buildings with tracers or incendiary munitions, the only weapon type potentially capable of such illumination (which entails accurate delivery of flares through windows or other openings) is the short range flare launcher. The "few" and "some" open areas cases imply ranges longer than those at which accurate flare delivery could be expected from such launchers.
- <u>Illumination of outside targets by firers located inside buildings when maximum open areas exist (1 combination)</u>. The inside location of the firer limits him to the use of small, short range flares, yet the need is to illuminate large areas at medium ranges. Such targets could be illuminated by artillery or mortar flares located outside, if the supporting weapons with forward observers

and communications are available and not masked. However, flares aloft are likely to cast even greater obscuring shadows in cities than in the country. Setting fire to nearby buildings can also provide illumination.

- Obscuration of areas outside buildings by munitions launched from inside buildings in cases where open areas are other than minimal (5 combinations). No munitions capable of mass smoke production and operable from inside buildings are available, although small smoke producers such as WP grenades are widely used. This target effect can be achieved, however, by smoke pots, smoke generators, artillery and mortars located outside.

As can be readily seen, few of the above cases lead to a high priority need for weapons development. One capability described above which would be clearly useful is the capability to neutralize protected weapons positions using a man-portable weapon fired from inside buildings. Such a weapon would require minimal backblast to permit inside firing and a warhead with good effects against and behind light to medium walls. If technically feasible, such a weapon would be useful in many non-city combat situations requiring firing at tanks, buildings or bunkers from confined positions--the backblast of current infantry anti-armor weapons seriously restricts their use under these conditions.

CHAPTER IV

INFORMATION NEEDS FOR ASSESSING WEAPON EFFECTIVENESS IN CITY FIGHTING

INTRODUCTION

This chapter summarizes the results of the search for available information useful in evaluating weapon techniques and effectiveness in city fighting. The search was guided by the previously discussed list of combinations of weapon type, effects, posture and physical situation of importance to city fighting. The end result of the search is the identification of major city fighting information needs that can be filled by physical testing.

Emphasis was placed on city-unique information needs. Clearly, there are wide areas of unfilled weapon effectiveness information needs that apply to both city fighting and less specialized, higher priority forms of combat. A prominent example is the almost universal lack of combat-representative rate of target effects* data--due to the dearth of sufficiently controlled and realistic field firing tests. In these areas, testing of weapons under specialized city conditions would not be justified until after the accomplishment of the more basic and important effectiveness testing under normal combat conditions.

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*This study uses the term rate of target effects (which includes incapacitating and suppressive effects) rather than the more usually accepted measures of accuracy such as hit probability, standard deviation of error, and CEP. In fact, these latter engineering measures are usually misleading in evaluating weapon effectiveness (unless they explicitly incorporate time) because (a) in most forms of combat, killing or suppressing multiple targets <u>before</u> they can shoot back is the relevant goal, not minimum single target errors; and (b) accuracy can trade off against time to fire.

There are also numerous areas of unfilled information needs where usable basic data exists but has not been analyzed in a form useful for evaluating weapon effectiveness. When relevant to city fighting, such areas are noted in this chapter but not further addressed. These analytical tasks are best left to the user or the weapons evaluator who has a direct need for the resulting information and, in any event, analytical reduction of existing data is outside the scope of the present study.

Information in a given area was considered inadequate only if there was no confirmed combat experience or no sufficiently realistic test evidence for making choices among alternative weapons or employment techniques of practical importance.

The research for the needed effectiveness information was conducted by: (a) review of standard field and technical manuals; (b) subject-by-subject bibliographic searches including the Defense Documentation Center, the National Technical Information Service, and various archives; and (c) visits to Department of Defense laboratories and agencies where up-to-date information might be available. Documents examined are included in the bibliography (Appendix H), and those which provided useful insights are cited in the text.

In the following discussion, information needs are grouped for convenience by the weapon effects categories previously established. Within these groups, specific information needs for other than effects data (e.g., firing limitations, rate of target effects, signature, etc.) are discussed whenever relevant.

ANTI-PERSONNEL EFFECTIVENESS IN CITIES

Background

There are widespread deficiencies, not unique to city fighting, in existing information on the incapacitating effects of munitions, due to the sparseness and difficulties of testing these effects on representative animal targets and the lack of systematic, sound ballistics data from combat. These deficiencies are aggravated by the widespread acceptance of unverified computer models for estimating probabilities of incapacitation* or lethal areas. These models are constructed from (and highly sensitive to) a series of key assumptions regarding penetration, energy loss in tissues, and relationships of incapacitation probabilities to energy loss--assumptions that rest on weak or nonexistent empirical bases.

As a result of lack of validation and basic testing, large uncertainties in this area must be accepted when evaluating weapon techniques and weapon choices.

Other than the general deficiencies in incapacitating effects and rate of target effects data, the city-unique anti-personnel effectiveness information needs identified are rather narrow in scope, as seen in the following discussion.

Artillery and Mortar Anti-Personnel Effectiveness in Cities

It is generally believed that fragmenting shells impacting on city streets are more lethal, due to increased wall and pavement ricochets, than

*These models for human, as well as vehicular, incapacitation actually compute the expected value--not the probability--of an arbitrarily assigned "combat capability" reduction score (a score assigned by "judgment" to each type and location of hit on the target). Thus it appears to be mathematically as well as practically invalid to use the model results as probabilities of kill or incapacitation for effectiveness calculations and weapon comparisons.

are shells impacting on dirt. The existing test data on fragment ricochets (233: pp. 219, 237, 398; 157; 170) places little emphasis on hard surfaces; in any case, ricochet data is too sparse and too inherently variable to be of much use in predicting lethality increases due to hard surfaces.

Even if adequate prediction or testing of street and wall effects on artillery and mortar round lethality were available, it would have little or no effect on selection or design of fuzes and projectiles, since these are and should continue to be chosen for best effectiveness in general combat, with the added lethality in cities (when indirect fire can be used at all) simply accepted as a bonus.

The important anti-personnel function of direct fire artillery used to neutralize behind wall firing positions is discussed in a later section on wall breaching.

Use of Proximity (VT) Fuzes for Artillery and Mortar Shells in Cities

Proximity fuzes are, in effect, small radars; they will function prematurely if the reflected radio signal from buildings, which yield stronger reflections than earth or trees, exceeds the pre-set detection threshold for the desired detonation height over open rural terrain. Since VT fuze radiation patterns and signal reflection properties are known, at least approximately, it would be possible to estimate the burst height of a round following a known terminal trajectory over buildings of known geometry and materials. The near-infinite number of variations possible in actual city combat situations precludes any useful pre-calculated guide; artillerymen will prefer to fire a volley and see if the results are satisfactory. A quick calculation using a standard 30 meter functioning height above a reflective surface shows that, except in wide streets bordered by low buildings, proximity fuzes are likely to function too high to be useful against troops at street level.

City-Unique Anti-Personnel Effectiveness Issues for Small Arms

The elevation angles at which small arms are fired in city combat do not differ markedly from those encountered in rural combat, as can be seen from the across-street firing geometry depicted in Figure IV-1 and the tabulated angles and distances computed in Table IV-1. The highest elevation angle seen, when firing across narrow streets and at targets on the third floor, is only 30°. Ranges in city combat will be similar to, or slightly shorter than, ranges in general combat, as indicated by the map derived range tabulations described in Appendix E. It appears that, for rough estimating purposes, the rate of hit and near miss results from the one or two adequate field tests of small arms effectiveness in general combat can be transferred to city fighting problems.

In city fighting, as in other forms of combat, riflemen quickly learn to fire occasionally from the "wrong" shoulder to allow better use of cover,* e.g., firing left-handed from the right side of a doorway. "Wrong" shoulder firing entails some unknown penalty in hitting ability; a rough feel for this penalty might help riflemen decide when to use this technique. The best way to instill this feel probably is to include some "wrong" shoulder firing on the tactical training range. Including "wrong" shoulder firing in future small arms field tests appears to be of lower priority than insuring that the

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*The same is true of other shoulder-fired weapons such as rocket launchers. However, the left offset mounting of sights on several rocket launchers (e.g., RPG-7) does not permit left-handed firing, nor is it clear that one would or should accept much sighting accuracy penalty in the design of such anti-tank weapons to make left-handed firing possible.

FIGURE IV-1

SCHEMATIC DIAGRAM OF A CITY FIGHTING FIRING SITUATION

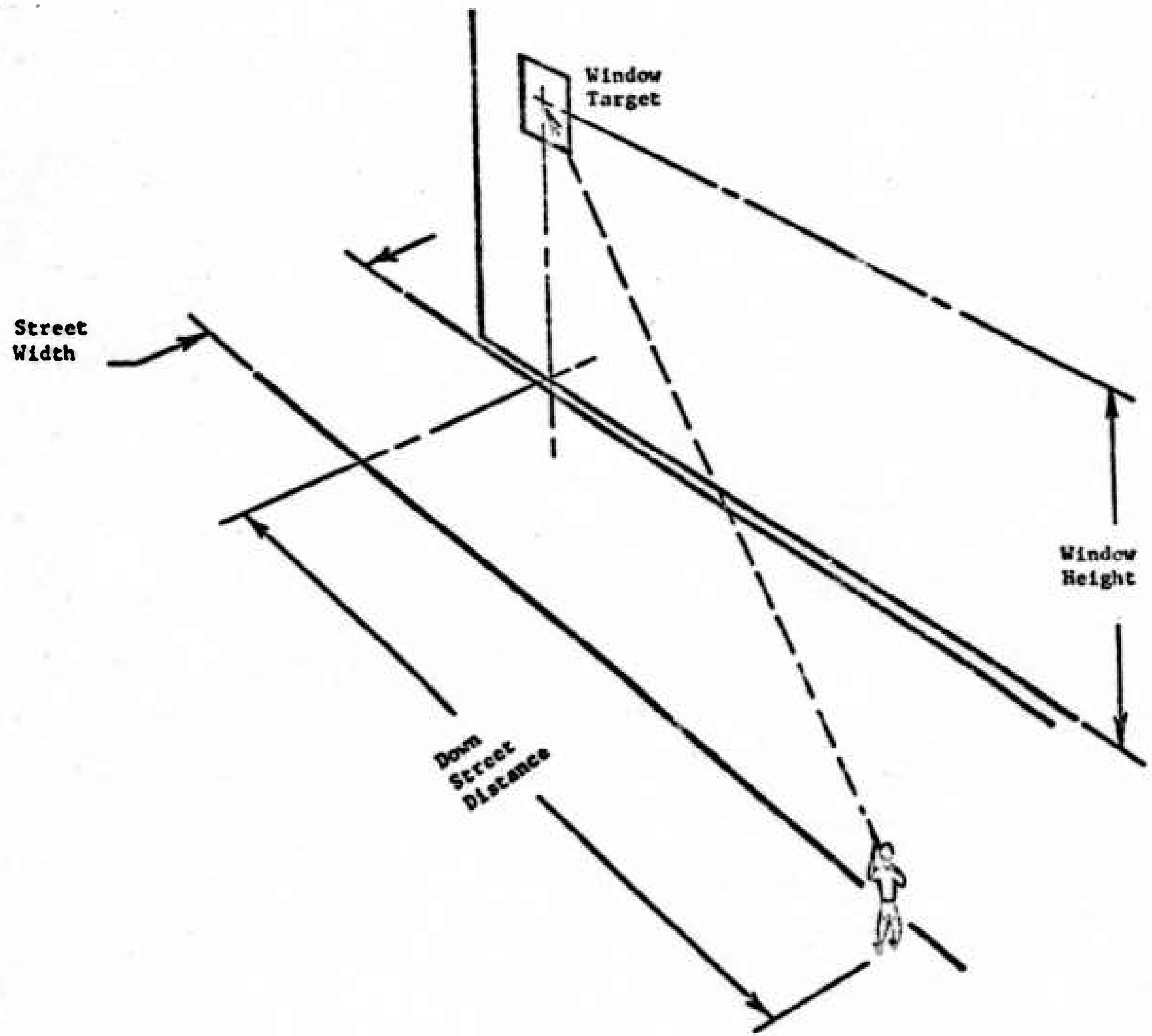

TABLE IV-1

EFFECT OF FIRING SITUATION ON VERTICAL FIRING ANGLE AND PROJECTED WIDTH OF TARGET

Street Width (Feet)	Window Height (Feet)	Down-Street Distance (Feet)	Vertical Firing Angle (Degrees)*	Projected Width of 1 Meter Window Target (Meters)
33	13	0	14	1
33	13	33	9	.7
33	23	0	29	1
33	23	33	20	.7
33	23	66	13	.5
66	13	0	7	1
66	23	0	15	1
66	33	0	23	1
66	33	33	21	.9
66	33	66	16	.7
66	33	98	13	.6
66	33	131	11	.5

*In this calculation, 5 feet is subtracted from the window height to account for average shoulder height of the firer.

small arms adopted are equally convenient for left- and right-handed firers--as is the case for the M-16.

As with fragmenting rounds, the hard surfaces encountered in cities can increase small arms lethality due to bullet ricochet. In fact, ricochet can and has been used to "bounce" bullets into otherwise covered firing positions. Due to the usually increased yaw after ricochet, these bullets may tumble faster and be more lethal than bullets impacting directly (though, as in all aspects of bullet lethality, the available data allow little or no reliable quantification). Other than the fact that about half the time bullets will ricochet off concrete at angles of obliquity as small as 35° to 55° (233: p. 395), little is precisely known about bullet ricochet from city surfaces--nor is there much need to know more than can be learned from observing bullet strikes. Even if excellent predictive formulas* for angle of departure (and post-impact velocity, yaw and lethality) were available, they could hardly be used by riflemen in combat.

The use of small arms to penetrate walls and floors is discussed in a later section on wall breaching.

Incapacitation Due to Blast in Confined Areas

Blast from fragmentation shells is a minor producer of casualties,** simply because tests have shown that many pounds of explosive are necessary

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*Attempts to develop such formulas are available (157, 170) but are inadequately verified. Ricochet is an inherently high variability phenomenon, sensitive to projectile shape, yaw, deformation, impact surface properties, velocity, etc.

**For HE explosions, about 500 psi overpressure is required for 50 percent deaths; 60-100 psi for serious injury; and 15 psi for eardrum rupture (10: p. 105). These overpressures must be achieved at the target after being attenuated by terrain folds, walls, trees or steel helmets.

to produce significant incapacitating effects at distances as small as 1.5 meters (258; 169); note that a 105mm shell has about five pounds of explosive. In a WWII sample of 217,000 casualties, only 3 percent were attributed to blast while 60 percent were due to artillery or mortar fragments (10: p. 77). Of 76 men wounded by artillery and mortar shells, 15 had ruptured eardrums, plus possible other wounds; none suffered more serious blast damage, even though nine of the 15 were within five feet of the shell burst (10: p. 543).

The pressure wave of an explosion is intensified by reflection; for a single reflection from a building wall, this amounts to an approximate doubling of peak pressure at the worst point, a not particularly significant increase since it is only equivalent to a 30 percent increase in effective radius. Somewhat greater increases can be expected inside rooms (though blast can also be significantly attenuated in rooms by mattresses or furniture used for cover). This may increase blast casualties due to large shells exploding in rooms, though fragment effects will still be dominant. Grenades are too small to have any significant blast casualty effect (except inside very small spaces), since they carry only about one half pound of explosive or less. Little or nothing is known about the claimed stunning effect of concussion grenades and other small warheads, but it probably is minimal.

The important area of blast effects on firers in rooms will be discussed in a following section on anti-armor weapons.

Grenades and Rifle Grenades

City fighting experience has demonstrated that the most important and heavily used anti-personnel weapons, besides small arms, are grenades and rifle grenades. In city assaults, grenades are tossed into windows, doors and breaches to incapacitate or suppress defenders inside buildings. Defenders use them extensively to stop close-in assaulting troops. Rifle grenades often represent the heaviest anti-personnel firepower available to squads in city combat and are fired into defended building windows and breaches at ranges beyond grenade throwing ranges. They are also used in much the same way as small mortars for short-range indirect fire into the streets. The U.S. uses the M79 40mm grenade launcher and the M203 40mm "over-and-under" attachment for the M16, much as rifle grenades were used in WWII. However, the use of 40mm grenades is restricted to two grenadiers per squad.

On hard surfaces, lethality of grenades is increased by ricochet as for other fragmenting munitions. However, when impacting into rooms prepared for defense with mattresses, furniture and sandbags piled around firing positions, their effectiveness can be greatly decreased. This problem may be even more serious for the current M25 and M33 hand grenades and the 40mm launched grenade than for the WWII Mk 2,* due to the much smaller "optimized" fragment size of the newer grenades. The Mk 2 had a wide spread of fragment sizes, with an average of 5 grains but numerous fragments of 20 to 25 grains. All current U.S. grenade fragment sizes cluster around 1 to 2 grains and may have substantially less penetration of mattresses, furniture and other barriers than the larger Mk 2 fragments.

Usable information for evaluating the effectiveness of grenades (or protective barrier materials against grenades) is not available for either general purpose or city combat. Fragment distribution data is available (184), though it does not address the question of the effects of earth or

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*The Mk 2 was a pineapple-shaped hand grenade that could be converted, by means of a small adapter, to a rifle grenade. At 21 ounces, it weighed 4-1/2 times as much as the current 40mm grenade.

pavement surfaces on the low angle fragment pattern. Penetration information is not available for city materials and is questionable for more ubiquitous materials such as helmets.* Lethality estimates are based on the unverified computer models previously discussed and may therefore have substantial absolute and relative errors, particularly in comparing the effectiveness of different fragment sizes. Testing grenades for lethality in defended rooms could provide information useful to troops on how much effect to expect, how many grenades to throw into a room, and how to protect against grenade fragments. The available fragment distribution data appears adequate for deciding safe distances, though the safety criteria presently used appear excessively stringent for combat.

Accuracy data for handthrown grenades and 40mm grenades launched from the M79 or M203 launchers is not available for combat conditions, though peacetime single-round accuracy has been tested (186; 210). Given the peacetime deflection accuracies (90th percentile is 1.5 meters as tested against horizontal targets) for handthrown grenades, it can be seen that even at 20 meters the chances of missing a 1 x 1 meter window are high enough that the "bounce-back" problem dictates a covered position for the thrower--unless the M217 impact fuze, which is inventoried but no longer in production, is used. On the other hand, 40mm grenade launchers should have no trouble getting most rounds through a window at ranges up to and beyond 50 meters, even considering the decrease in apparent window height and width for typical street geometries, as shown in Table IV-1.

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*Reference 287 states, without source, that 50 percent of 1 grain fragments will penetrate U.S. helmets at 874 m/s while reference 197 indicates a velocity twice as high is required for 50 percent penetration of mild steel thinner than the U.S. helmet. Apparently, no tests of penetration of the Soviet helmet by such fragments are available.

There is little incentive for futher testing of grenade or grenade launcher hitting ability unless acquisition of a new hand grenade or a standard rifle grenade is contemplated. From the point of view of weapon technique, infantrymen receive dummy grenade practice during individual training (horizontal targets only) and in unit training (horizontal and window targets); they thus obtain some minimal feel for grenade accuracy, although they almost never get to use live grenades on tactical ranges.

ANTI-ARMOR EFFECTIVENESS IN CITIES

Background

There is a general lack of reliable information on shaped charge or kinetic energy warhead effects on tanks, APC, reconnaissance vehicles and SP artillery across all forms of combat. Most of the anti-tank lethality estimates used today are derived from computer models of vehicle vulnerability which are likely to produce serious absolute and relative errors, for the reasons discussed in connection with personnel vulnerability models. In addition, due to the emphasis on penetration rather than lethality, there is little comparative testing available on behind-armor spall effects, anti-tank incendiary effects, or effectiveness degradation due to external vehicular equipment. Shaped charge penetration data, in general, is not reliable because it is usually based on static warhead detonations, often with the fuze removed; dynamic impact results in combat and in testing show significantly poorer results. The validity of currently used prediction formulas for kinetic energy penetrators have been placed in question by combat results. Probably the only reliable, though approximate, estimates of probability of "kill" given a hit for armored vehicles that are currently available are those derived from the 1967 and 1973 Arab-Israeli wars; these only apply to M60, Centurion, T54/55, and possibly T62 tanks and tank guns.

Similarly, there appears to be no usable rate of hit data under controlled combat-type conditions available for LAW, DRAGON, TOW or 106mm RR--despite extensive testing, including some on tactical ranges.

The deficiencies in both terminal effects and rate of hit information for all the U.S. anti-tank weapons need to be addressed as a matter of considerable priority. These issues, however, require resolution for normal combat environments before any specialized city fighting testing is considered.

In city fighting, the highest priority anti-tank weapons are those that attacking or defending squads can carry with them, without losing major portions of their anti-infantry capabilities. For the U.S. Army, the only current weapon in this class is the LAW. There is reason to expect that the LAW will be relatively ineffective against tanks in city or general combat--primarily due to lethality and accuracy problems.

Flame Weapons Effects Against Armor

The utility of flame weapons as anti-armor agents has been known since the widespread use of the "Molotov cocktail" in WWII and the Hungarian Revolution. However, no test data have been identified that could be used to predict the effectiveness of the U.S. man-portable flame thrower, 66mm flame rocket, or the Molotov cocktail. In city environments, such weapons could be expected to have frequent short-range firing opportunities against armored vehicles, including firing down at the vehicles from above. If downward projection of flame against engine compartments (and particularly air intakes) of armored vehicles proved lethal, a useful backup anti-armor capability to the LAW would then be available. Since no effects information exists in this area, testing is needed to address range, time of projection, and the effect of different impact locations for flame throwers, flame rocket projectiles, and Molotov cocktails. This information might also be useful to tank designers in protecting against these weapons, as well as against napalm.

Anti-Tank Missile Effectiveness in Cities

If more general purpose direct fire weapons alternatives are available (e.g., 106mm recoilless rifles and 3.5 inch rockets), infantry are unlikely to carry the single purpose anti-tank missile weapons (e.g., DRAGON and TOW) into city fights due to their scarcity, high ammunition weight, and low utility against people and building targets.

There may be special limitations on missile use indoors such as excessive launch blast for firing in rooms, inability to achieve sufficient depression angles for firing down out of windows, and capture or sighting problems due to obscuration in the room.

In view of the preceding, there seems to be little urgency in proceeding with testing of anti-tank missiles under city conditions.

Launch Blast Limitations on Anti-Tank Weapon Firing Inside Buildings

In city combat, it is clearly desirable to be able to fire light anti-tank weapons from protected positions in buildings, both to defend against tanks and possibly to breach walls or neutralize behind wall firing positions. There are a number of limitations on inside firings of rocket launchers, grenade launchers, recoilless rifles, and missiles associated with weapon back blast and muzzle blast. These include: (a) injury to other troops in the same room when they are in the direct path of the flame and back blast, (b) obscuration due to the plaster and plaster dust brought down by the launch blast, (c) obscuration caused by propellant smoke in the room, and (d) ear damage caused by the launch blast as amplified by the pressure reflecting effects of the room. Although the latter can be greatly ameliorated by standard earplugs that close under pressure, none of the current U.S. anti-tank weapons are suitable for safe firing from inside rooms due to their blast and smoke effects. It may be possible, using extra precautions, to fire the LAW or the 3.5 inch rocket from certain larger rooms. There are combat reports of firings of anti-tank weapons from within rooms considerably smaller than the recommended safe clearance distance behind the weapon, though nothing is known about the obscuration problems or ear damage, if any, that resulted.

Anti-tank weapons of greatly reduced launch blast and smoke would have useful applications well beyond city fighting, since restricted, narrow firing positions occur in all forms of combat. Whether it is possible to develop low blast, low smoke, light anti-tank weapons without excessive velocity and/or cost penalties is unknown.*

WALL BREACHING AND BEHIND WALL NEUTRALIZATION OF WEAPON POSITIONS

Background

Perhaps the most important single city fighting function of the heavier direct fire supporting weapons from the 106mm RR to the 8 inch SP howitzer**

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*The FRG is developing a flashless, low blast, shoulder-fired anti-tank weapon, the ARMBRUST. It is currently experiencing a number of development difficulties.

**Weapons and rounds considered for this function include the 106mm RR (HEAT, HEP); the 105mm tank gun (APDS, HEAT, HEP); the 105mm towed howitzer (HEAT, HEP, HE); the 155mm SP artillery (HE); 8 inch SP howitzer (HE); and the 165mm low velocity demolition cannon for the Engineer Combat Vehicle is the destruction or neutralization of fortified weapon positions within thickwalled buildings. This is accomplished by creating enough fragments--consisting of wall material spall or of shell fragments--to incapacitate any firers within the fortified rooms. (This may require fragments to penetrate barriers of sandbags, bedding, furniture, etc., behind the walls and around the weapon positions.) There is a wide choice of ammunition and techniques for accomplishing the task, with almost no information on how to choose among them. The few tests in the area of projectile effects against buildings have measured wall penetration; of these, even fewer have measured breaching; and none have measured behind wall anti-personnel effects.

The choice of rounds includes APDS, HEAT, HEP and HE. Fuzing choices are superquick or delay. Direct fire weapon crews can elect to put HE or HEP rounds through windows or through wall breaches they have created, or they can attempt to directly spall the wall using HEP or combinations of penetrating and fragmenting rounds. Experience at Hue has shown that putting 106mm recoilless rifle rounds through windows to detonate on the far wall is ineffective as compared with direct impacts on the adjacent wall. Under fire through windows, the enemy crouched behind the front wall for cover and suffered little attrition (see Appendix B). It is suspected the same would be true for any high velocity projectile with poor backspray characteristics.

Wall breaching per se, although important, is of lower priority than behind wall neutralization. An alternative to heavy direct fire weapons for creating breaches big enough to let men through is the use of demolitions. The most difficult walls to breach are, of course, the massive stone walls

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(HEP). Lighter weapons considered include small arms, LAW and 3.5 inch rockets (USMC standard only), plus demolitions. DRAGON and TOW should prove too expensive and too scarce for this role.

of older buildings in Europe, which may be as thick as 150 to 225 cm. In newer buildings of European construction, 30 to 50 cm steel reinforced concrete walls present particular problems because, although it is relatively easy to fracture, penetrate and clear away the concrete, the remaining "jail window" of rods, usually 6 to 8 inches apart, can be severed only by direct hits or massive steel fragments (233: p. 212).

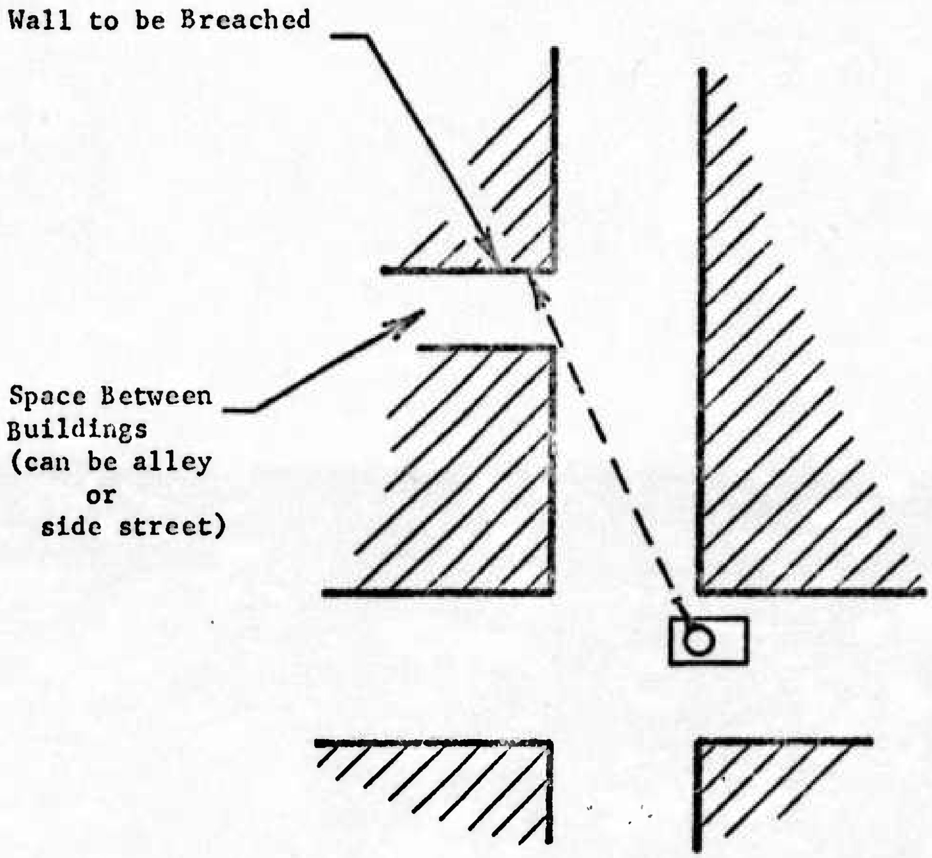
Lighter walls of brick or building block construction present much less of a problem. They can often be penetrated by long bursts of automatic small arms fire, which may or may not result in enough wall failure to create a breach. It is known that cinder blocks will practically "explode" under bursts of small arms fire. Light anti-tank weapons easily penetrate standard brick or building block walls; some may be able to create breaches with only a few rounds (depending on exact block material, mortar, loads, and supports). Combat reports from Hue assert that the 3.5 inch rocket had good breaching capabilities while the LAW had little (see Appendix B).

Firing Geometry and Obliquity

Infantry weapons, being more portable, have a larger choice of firing positions than heavy supporting weapons and thus are more likely to achieve normal impacts where necessary. Armor and artillery seeking building cover from infantry are constrained in their firing positions to corners of buildings and the like. As Figures IV-2 and IV-3 show, this means that heavy weapons firing at building walls often cannot find firing positions that offer a low obliquity shot. This is particularly true when it is necessary to achieve some desired minimum impact distance from the target building corner in order to avoid the structurally stronger corners and the extra exposure of corner breaches to enemy fire. The geometry of Figure IV-3

FIGURE IV-2

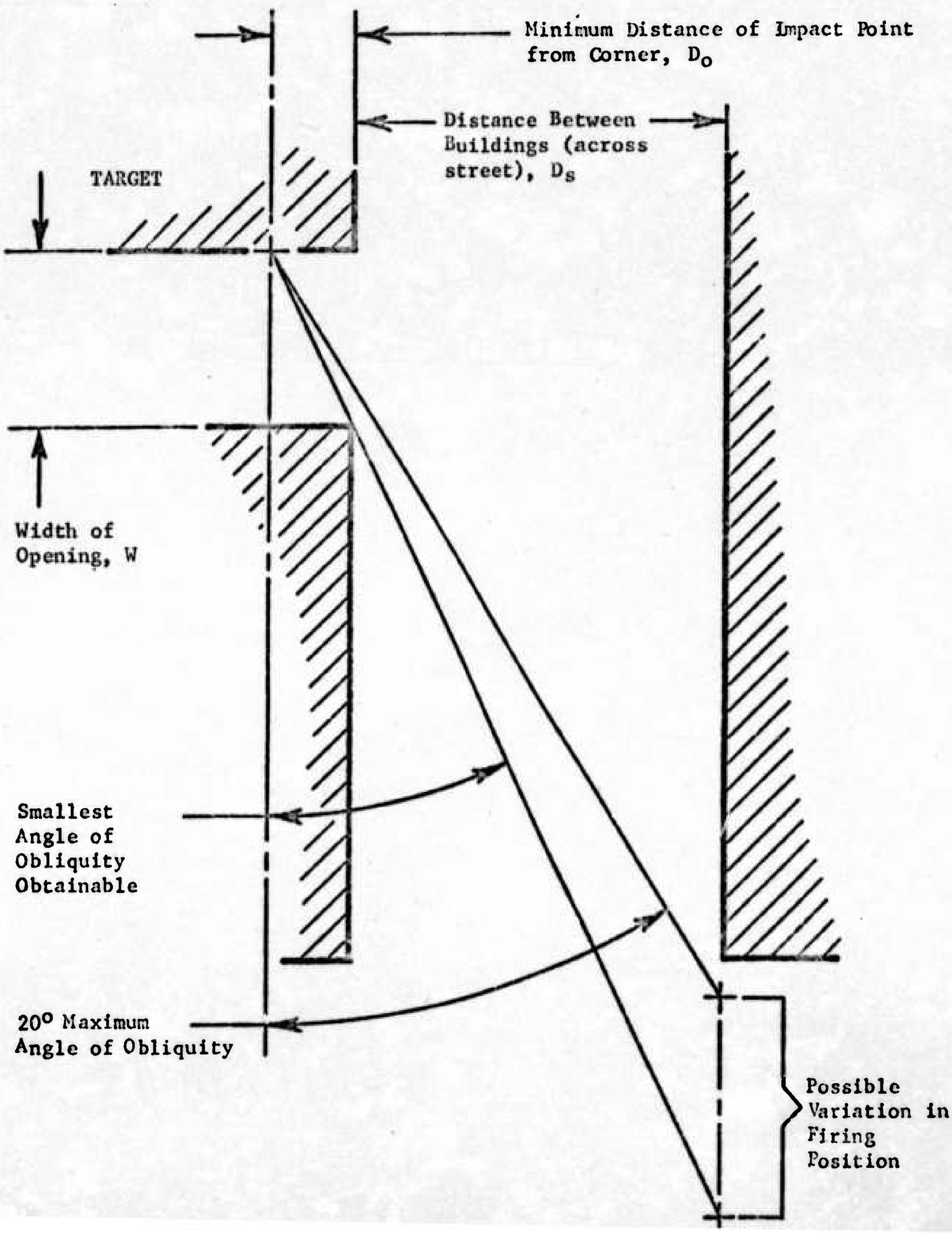
TYPICAL WALL BREACHING FIRE SITUATION FOR
ARMORED COMBAT VEHICLES IN CITIES



Plan View of Street Intersection
and Surrounding Buildings

FIGURE IV-3

THE GEOMETRY OF OBLIQUITY IN WALL-BREACHING



results in a maximum variation in feasible firing positions that is typically quite short, as shown in Table IV-2.

TABLE IV-2

FIRING POSITIONS WHEN MAXIMUM DESIRED OBLIQUITY IS 20° AND CORNER TO IMPACT SPACING IS 2 METERS

Between-Building Spacing, W (meters)	Street Width, D_s (meters)	Possible Maximum Firing Position Variation (meters)
6	20	11
6	30	16
6	40	21
8	20	33
8	30	48
8	40	63
10	20	55
10	30	80
10	40	105

In other words, finding a covered position that permits low obliquity firing is quite unlikely unless both the streets and the gaps between buildings are wide.

Despite the evident importance of high obliquity shots for both wall breaching and behind wall neutralization, little test data is available at obliquities beyond 20°.

Penetration, Breaching and Neutralization with Heavy Walls

Penetration is only a first step in breaching or neutralization. Nevertheless, most testing is limited to penetration. The bulk of available penetration tests of reinforced concrete were done during WWII by the U.K.

Road Research Laboratory, the U.S. National Defense Research Committee (NDRC) and the U.S. Army Ordnance and Engineer Corps (233; 147; 149). Only one comprehensive series of tests of the effect of obliquity has been performed. This was done by the NDRC using 37mm ammunition with limited checks using larger calibers (233: p. 198).

These tests show that any of the shaped charge projectiles from LAW up can be expected to perforate any modern reinforced concrete building wall (20 to 50cm) at low obliquity, though even the largest, i.e., TOW with a 5.8 inch HEAT warhead, will only produce a hole approximately 2 inches in diameter. At higher angles of obliquity, there is reason to doubt that the smaller warheads will perforate a 50cm wall, despite the standard tests and predictions which do not take into account dynamic impact degradations at high obliquity.

Similarly, 105mm tank APDS rounds and inert artillery projectiles from 105mm up will achieve kinetic energy penetrations of 50cm reinforced concrete walls, at least at the tested low angles of obliquity. Obliquity cannot be pushed much beyond 45°, due to ricochet. Hole diameters are somewhat larger than shaped charge holes; reinforcing rods are normally pushed aside, not severed. Inert 155mm projectiles penetrated 28 inch concrete with considerable residual velocity in a recent test.* HE artillery shells can be rendered inert either by using a shipping plug in place of the fuze or by using the M557 normal delay fuze or the M78 concrete-piercing fuze. Neither can detonate the projectile any closer to the wall than 15 feet after impact (thus eliminating enhancement of behind-the-wall spall effects) and, due to insufficient projectile case strength, these fuzes usually separate from the case

*Unpublished data from Naval Weapons Center, China Lake, California.

during penetration.* The M557 is also limited in city fighting applications due to an approximately 200-meter minimum arming distance (130 m nominal).*

The heavy European stone walls will probably not be perforated by the LAW or the 90mm RR. The stone penetrating capability of the larger shaped charges and the 105mm APDS is unknown. None of the inert artillery projectiles up through 8 inch will penetrate significant distances into stone. It is not known what combination of rounds is best for multiple round firings to "chip" through heavy stone walls.

For massive reinforced concrete walls requiring multiple round firings, a British test (233: p. 212) showed that a mix of four AP rounds to one HE round can work its way through great depths of concrete. However, no claim was made that this method was "best." The AP served to fracture and penetrate the concrete while the HE served to sever the reinforcing rods and remove the rubble. Shaped charge projectiles do not have a high enough probability of hitting and severing the rods to be useful in this role.

When the objective is to neutralize a behind-wall weapon position rather than to create a breach, there exists no available test evidence that provides any guidance on which rounds, or mix of rounds, achieves reasonable results against various wall thicknesses. It is known that shaped charge rounds (particularly under 5 inch) produce little spall and distribute it over a narrow cone. HEP remains untested for either wall breaching or neutralization, except for some limited firings of a 66mm LAW-type HEP round. Nevertheless, HEP appears to be one of the most promising projectiles for simultaneously creating spall, severing rods and penetrating concrete.

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*Ibid.

Penetration, Breaching, and Neutralization with Lighter Walls (Wood, Brick, Masonry and Concrete)

Moderately heavy residential construction can be easily penetrated by bursts of automatic small arms fire, as shown by the results of several tests. Sample results are shown in Table IV-3.

TABLE IV-3

MACHINE GUN PENETRATION OF VARIOUS MATERIALS AT 100 METERS*

Material	Number of Rounds Required to Penetrate	
	5.56mm	7.62mm (NATO)
8 inch concrete block	25	18
9 inch brick (double row)	70	45
8 spaced 1 inch wood planks**	1	1
22 spaced 1 inch wood planks**	--	1
16 inch tree stump**	1	1
3/8 inch steel plate**	1	1
24 inch sandbag wall	220	110

*Reference 291, pp. 92-100.
**Single round tests only; the effect of burst fire on these types of targets was not tested.

At best, the results of such tests can be only approximate. They vary greatly with the exact material composition and with range. Penetration may increase or decrease with increasing range, depending on the variation of bullet yaw with range and other factors. Better penetration requires highly stable, low yaw bullets or higher mass, higher recoil rounds. The former is the opposite of what is required for better anti-personnel wounding effects; the latter makes rifle automatic fire impractical and decreases sustainability and/or mobility by increasing small arms system weight. Though from time to time it is suggested that rifles and rounds of greater penetrating ability should be designed for city fighting (and dense vegetation), it can be seen that such "optimization" is disadvantageous since it leads to rounds that would degrade overall small arms effectiveness. Moreover, current 7.62mm and 5.56mm penetration performance is quite adequate.

As can be seen from Table IV-3, current small arms can fire effectively through any normal metal or wood doors and shutters, as well as plaster and lath interior walls or single row brick or building block walls. Heavier European interior concrete floors and walls would require many bursts of automatic fire to penetrate, although such penetration could certainly be achieved.

Little or nothing is known about the behind wall effects of small arms fire, though the emerging yawing bullets and their spall, once penetration has been achieved, are likely to be quite lethal. There is little reason to test these effects because: (a) the results will not change the fact that riflemen will try to fire through walls whenever an effect might be achieved, and (b) development of better penetrating small arms is not useful.

LAW and the 3.5 inch rocket have also been tested against double row brick walls backed by sandbags. Both required multiple hits to collapse the wall, though the 3.5 inch performed significantly better (247). An experimental HEP warhead version of the LAW performed about as well as the 3.5 inch rocket, both containing equal amounts of explosive. The results may not be valid due to the fact that the walls were unloaded and free standing. The LAW performed better in this test than was reported from combat experience at Hue.

Demolitions and Gammon-Type Grenades

Demolitions are essential to infantry in city combat for wall breaching and other functions. The demand for demolitions in city fighting is so widespread that sizable numbers of trained infantry are required; combat engineers are never available in sufficient numbers. Communist forces from Stalingrad to Hue have made wide use of demolition-trained assault troop units specializing in penetration of fortified areas. These units are commonly known as sappers.

The use of prefabricated or field-prepared, hand-placed explosive charges is, of course, limited by the need for troops to expose themselves while placing charges. In wall breaching, the charge must be held in contact with the vertical surface; for this purpose, pressure-sensitive adhesive backings are supplied on current standard explosive blocks. The amount of explosive needed to breach any of the types of walls under consideration can be determined from the empirical formulas developed by the U.S. Army Corps of Engineers (58). The variability of actual results relative to predicted results is not known. None of the existing formulas address explosive weights required for behind wall neutralization.

In WWII, the Germans had 25 pound and 110 pound hand-emplaced shaped charges that were designed for use against fortifications. These were first used in the famous glider attack on Belgium's Fort Eben Emael at the beginning of the blitzkrieg campaign against France.* The charges effectively crippled a number of cupolas and casements of the Fort, mostly by means of their sizable behind wall blast effects, which blew 75mm guns off their mounts and knocked crew members against walls. Machine pistols were fired through

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*J. E. Mrazek, The Fall of Eben Emael. New York: Luce Publications, 1970.

the resulting holes to further neutralize the troops inside. However, even the 110 pound charges only created man-sized breaches when used against embrasures, doors or gun ports. When used on unbroken concrete or steel armor surfaces, they did not make holes large enough for men to enter.*

There are two current standard U.S. hand-emplaced shaped charges--the 15 pound M2 and the 40 pound M3A3--using fiber spacers or extendable legs to assure proper standoff. Neither appears to have much utility in wall breaching since they have no convenient means of attachment to vertical surfaces and only produce deep, small diameter holes. The 40 pound shaped charge will penetrate 60 inches of concrete and produces a hole that tapers from 5 inches down to 2 inches in diameter. Behind wall spall and blast effects are unknown, but the blast effect may be large enough to provide useful behind wall neutralization capabilities.

It appears that a hand-placed charge that can be attached to vertical surfaces and that is especially designed for best breaching and behind wall neutralization effects--rather than for maximum small hole penetration--would provide a needed capability for general combat as well as for city fighting.

A small demolition charge of up to 3 or 4 pounds, field-prepared and impact fuzed for short range throwing, is a useful adjunct to demolitions and grenades. The British gammon grenade--an impact fuze with an attached "sock" for stuffing with explosive--served well in this role during WWII. It was also useful for dropping on tanks as a makeshift HEP munition. The need for a gammon-type grenade continues to exist, though there is none available in the U.S. inventory.

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*Penetration performance apparently was quite variable. One 110 pound charge failed to penetrate a 6 inch steel armor cupola, though it jammed the rotating mechanism.

A less convenient field-expedient substitute for the gammon grenade might consist of taping plastic explosive to an M217 hand grenade impact fuze. The M217 was used in Vietnam but is no longer issued or produced due to the reluctance to use contact-detonating hand grenades. It has a one-second arming delay for safety and a four-and-one-half-second time feature, in addition to impact detonation. The feasibility of a demolition application for this fuze could be demonstrated by means of a simple test.

The breaching capabilities of gammon-type grenades can be calculated from the Corps of Engineers formulas. Anti-tank lethality is unknown, as it is for any other HEP munition.

STRUCTURE DESTRUCTION

Background

Massive destruction of city areas has been attempted in a number of city fights (e.g., Manila, Stalingrad and Cassino) to deny the enemy protected observation and firing positions. Experience has shown it to be generally unproductive. The resulting rubble provided equally good or better cover for the defender--and became an effective barrier to movement.

Extensive structural destruction of individual buildings has frequently been used to neutralize or dislodge firers, as in the example of the defeat of the British defenders in Arnhem. In general, it appears that the more effective the capability to neutralize behind wall firing positions, the less important structure destruction becomes.

Most massive destruction of structures has been accomplished by heavy direct fire weapons, including tanks, SP and towed artillery. It generally has been found that weapons of at least 150mm are necessary against thick reinforced concrete or stone walls. Even then, very large expenditures of rounds have been required to knock down buildings of any size. Use of indirect artillery fire--where possible at all due to mask considerations--would further increase this ammunition expenditure due to the lack of sufficient accuracy to hit precisely key structural supports and undamaged sections. Heavy mortar fire (4.2 inch) appears inappropriate to the mission. Its high angle of fall leads to frequent detonations on the roof or on the floors below when delay fuzing is used (and this assumes that the delay fuzing and shell casings are durable enough, which may not be the case). Such detonations are unlikely to collapse the essential load bearing pillars and walls.

Information Needs

Since most destruction of buildings will be accomplished by heavy artillery firing directly at walls, the techniques and rounds used will be similar to wall breaching. The major difference is that the breaches needed for destruction will be larger--entire walls in many cases--and must be placed in structurally critical areas. Rough estimates of round expenditures required by size and structural class of building might be of interest to artillery planners. Extensive and expensive testing would be required to establish such round expenditure estimates. If needed, approximate factors may be derivable from artillery unit records. There appears to be little justification for the major costs required for testing in this area.

INCENDIARY EFFECTS IN CITIES

Background

Fires are commonly encountered in city fighting, although most are started inadvertently. Intentional fires can, on occasion, be used to flush out defenders. However, as was seen in Manila (see Appendix B), city fires can easily get out of hand and hinder the attacker as much as the defender. Munitions that have been commonly used to set fires, intentionally or unintentionally, include tracers, flame throwers, thermite grenades and white phosphorus projectiles and grenades.

Information Needs

Whether a given munition will set fire to a given building depends on a complex array of factors including the number and size of burning particles produced, whether they penetrate or only achieve surface contact, the temperature and heat flux achieved, the time in contact and the materials encountered.

There are available extensive flammability measurements* for common city materials (e.g., paint, fabrics, wood, furniture stuffing, plastics) in terms of minimum temperatures and heat fluxes required for ignition. However, because of the complexity of the factors involved in ignition by munitions, these engineering data cannot be used to compare incendiary effectiveness of various munitions or even to predict when self-sustaining fires can be started. There is little question about the efficacy of thermite grenades in igniting

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*Reference citing: Lehigh University Institute of Research, Bomb Damage Analysis: Terminal Ballistics (U) (ATI-73 475); Clayton Hugget et al., Investigation of Incendiaries (C) (AD 364914); R. E. Brown et al., Evaluation Techniques for Flame and Incendiary Agents (U) (AD 815648); and Warren K. Smith, Target Ignition Temperatures (U) (40604-1).

flammable materials. Flame throwers and 66mm flame rockets present a more uncertain picture, because their incendiary effectiveness will depend in large part on flame contact time and the "stickiness" of the burning liquid particles. Thus, thickened fuel in flame throwers is generally more effective in setting fires than normal liquid fuel. White phosphorus has low flame temperature and energy content relative to other incendiaries (149; p. 194); on the other hand, it produces large numbers of burning particles, many of which penetrate or "stick."

The most ubiquitous and perhaps the most important incendiary in all forms of infantry combat is the tracer bullet. Despite the fact that tracers have low energy content, automatic fire tracer bursts are effective incendiaries because they provide multiple ignition points and often stick upon impact, thus achieving good contact time. Tracers have not been tested for incendiary properties though their use in this role is commonly taught. In combat, they are frequently used to set fire to room contents and buildings. They are particularly useful in this role because occupants of the room fired upon will have great difficulty in putting out the multiple fires created, particularly in the presence of bullets ricocheting around the defended room.

Comparisons of incendiary effectiveness cannot be rated as a high priority subject for testing, since tracers are known to be effective and white phosphorus, flame rockets and flame throwers can be tried in combat, should the need arise.

CRATERING AND DENIAL

In prepared city defenses or in protracted city battles, extensive measures are taken to deny movement, including construction of obstacles or barriers, cratering, mining, setting of booby traps, and demolition of buildings and bridges. As often observed, the attacker creates some of the most effective impediments to movement by means of rubble and craters associated with heavy artillery fire and bombing. Rubble provides some of the best opportunities for mining. In prepared defenses, mines are set in holes in pavement and in sewer grates. In WWII, the Germans made wide use of railroad mines, i.e., large magnetic counter mines, placed under street surfaces. For hasty mining, pavement-camouflaged mines can be used or chains of mines can be pulled across streets by hand just in front of moving vehicles. Mine detectors are essentially useless in the city environment, due to the large number of subsurface anomalies.

It appears that little information is needed in this area over and above what has already been learned in past city combat.

ILLUMINATION, OBSCURATION AND TARGET DESIGNATION

Background

City fighting at night is rare, though infiltration at night by both attacker and defender is common. The most common use of illumination is on defensive perimeters at night. The disadvantages of parachute flare illumination (e.g., building masking, incendiary potential, inaccurate placement, and heavy shadows constantly in motion due to the swinging of flares) are amplified in cities. The increased illumination area of larger flares may well help the enemy more than the friendlies. Aircraft-delivered flares suffer from this problem, as well as from the problem of poor delivery accuracy.

Due to the importance of precisely placed illumination, the need for infantry hand-held or hand-launched flares may well be increased when night fighting does occur. Light mortar flares can be useful in this role, though mortars are difficult to emplace near defended buildings. Optical night vision devices may deceive as much as help, due to their inability to see into the dark shadows common in the night city environment.

In heavy city fighting, there is normally much "natural" obscuration due to smoke from fires and explosions, as well as rubble dust. Where more obscuration is needed to cover an advance or a withdrawal, artillery or mortar smoke is often unavailable due to mask problems or lack of forward observers. Thus, infantry-provided smoke from grenades and smoke pots becomes more important. Since the artificial roughness of city terrain significantly reduces wind velocity while increasing atmospheric mixing in the surface layer, smoke tends to persist better and give better coverage in cities than in open terrain. The smoke stream from a smoke generator tends to flow around buildings and mix more uniformly in their turbulent wake (47).

Target designation in city fighting may or may not be helped much by tracers, depending on whether lighting conditions, background, and target range permit good tracer visibility (271). On the other hand, bullet strikes on masonry and concrete are clearly visible at city fighting range, thus reducing the need for tracers in this role.

Information Needs

There appear to be no major known deficiencies requiring new information in the areas of illumination, obscuration and target designation in city fighting.

SUMMARY OF OVERALL INFORMATION NEEDS

Two important city-specific testing needs identified are:

1. Testing to determine the currently known effectiveness of direct fire weapons ranging from LAW to artillery (with emphasis on HEP rounds) in neutralizing weapons positions inside typical large city buildings and their effectiveness in breaching the walls of these buildings.
2. Testing to determine the currently unknown effectiveness of standard fragmentation grenades in clearing rooms prepared for defense.

A less important test that might be useful to conduct at some point is the following:

1. Test the lethality of the standard M9E1 man-portable flame thrower, the M202A1 66mm flame rocket, and the "Molotov cocktail" when used from above against the engine grill of current Soviet tanks.

The existence of the following major information deficiencies, important but not unique to city fighting, should also be noted:

1. Lack of reliable, test-based estimates of personnel incapacitation probabilities for small arms, larger direct fire weapons, mortars and artillery.
2. Lack of reliable, test-based estimates of destruction, immobilization or fire power incapacitation for all classes of anti-tank weapons used against tanks, APCs, reconnaissance vehicles and self-propelled artillery.
3. Lack of combat or field test data for most direct fire weapons (e.g., machine guns, anti-tank missiles, tanks) on rate of target

hits. Currently available data consist of static accuracy measures (e.g., standard deviation, single shot hit probability) taken under unrealistic, "known range" conditions.

4. Lack of uniformly-based estimates of the possibility of safe use inside buildings of each of the major infantry anti-tank weapons--or their safe use from confined firing positions. Safety considerations would include direct backblast danger to other personnel as well as inside-room obscuration effects and blast effects on people and ceiling materials such as plaster.

OTHER INSIGHTS

Based on the evaluation of weapons deficiencies, two munitions appear to have sufficient usefulness in general combat as well as in city fighting to merit exploration of technical feasibility, effectiveness and cost, and possible development. A shoulder-fired anti-tank weapon without backblast and launch flash would allow firing from confined spaces and would increase gunner survivability--both represent significant increases in effectiveness for a wide range of combat situations. A hand-emplaced shaped charge tailored for best wall breaching and behind wall effects would enhance infantry capabilities in the attack of buildings and fortifications.

In addition to these developmental munitions, a gammon-type grenade for light breaching, and anti-personnel and anti-tank rifle grenades to increase the firepower of the individual rifleman, would be useful in most forms of combat.

Outside the weapons area, the critical importance of communications in city fighting lends high priority to a test of standard infantry radios to determine whether proper siting, changed antenna configurations, or repeaters can lead to effective communications in cities.

CHAPTER V

TEST CONCEPTS

INTRODUCTION

This chapter describes general test concepts for addressing the most important city fighting weapons information needs identified in Chapter IV. These test concepts are not intended to be test plans. They constitute statements of objectives that could provide the basis for a test directive, and enough information about the possible contents and sequence of test actions to indicate the general nature of the testing required. Test facilities, instrumentation, and expendables are discussed only if they present problems or are particularly important to the overall objective.

Two test concepts are described. They deal with tests on wall breaching and behind wall damage and on hand grenade effectiveness in defended rooms.

WALL BREACHING AND BEHIND WALL DAMAGE TEST CONCEPT

Background

Forces attacking a defended building or a fortification--whether in cities or not--will frequently face the tasks of breaking into the structure via breaches in walls and/or neutralizing firers inside the structure. If direct fire artillery or tanks are to be used for either of these tasks, there is little combat experience or test information available for choosing the most suitable projectile and fuze, or for choosing best combinations of projectiles. Similarly, there is little basis for judging the suitability of the available infantry anti-tank weapons and rounds in breaching or neutralization. Much of the necessary knowledge was acquired in the course of WWII city fighting but is no longer recoverable or no longer applicable to current weapons. Current service tests and field tests of artillery, tanks and anti-tank weapons do not address effectiveness in wall breaching or behind wall neutralization.

Thus, the breaching and behind wall neutralization capabilities of direct fire weapons are not known, nor can their adequacy in these tasks be judged.

Purpose

The objective of the test program is to obtain effectiveness information, at usable ranges and obliquities, that will assist ground troops to best utilize available weapons--primarily direct fire artillery, tanks and infantry anti-tank weapons--to breach walls and neutralize firing positions in rooms prepared for defense. It can be expected to provide information indicating the existence of a need for new types of ammunition or fuzes for these functions. If the tests are correctly designed and the results adequately documented, they can aid future efforts to predict wall breaching and neutralization effectiveness of developmental weapons.

The resources required include a range where large caliber direct fire weapons can be fired safely at distances typical of city combat, samples of standard U.S. and foreign weapons and ammunition for testing, construction of a large number--perhaps hundreds--of room-type targets, and adequate time to allow any concrete used in target construction to cure thoroughly.

Test Weapon/Ammunition Combinations

The test covers the most important standard direct fire weapons available to U.S. infantry for breaching and neutralization tasks. Where additional insights are likely to be gained, potentially effective foreign weapons could be tested.

Emphasis should be placed on HEP ammunition because it is available as a standard anti-tank/anti-personnel munition* for several of the important weapons (see Table V-1) and there is reason to believe that it may have relatively high effectiveness in breaching and neutralization.

Because of the importance of the class of man-portable infantry anti-tank weapons, promising foreign anti-tank weapons such as the Soviet RPG-7, the French STRIM and the Swedish Carl Gustav could be included.

Among the larger direct fire weapons which do not have HEP rounds (e.g., 155mm and 8 inch artillery), there is a need to test HE, as well as mixes of HE and inert HE projectiles.

Since infantry frequently use field-expedient or manufactured demolitions for breaching and neutralizing, particularly when artillery is not available, it would be useful to test satchel and/or pole charges, gammon grenades, and hand-emplaced shaped charges.

Table V-1 lists the possible test weapons and rounds.

Wall and Defended Room Targets

Since defenders normally select the best wall protection available that meets their other tactical needs, the buildings of interest will be of heavier than average construction for the cities under consideration. Among pre-WWII

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*No information is available on the anti-tank effects of any of the HEP rounds. There is an urgent need for testing in this area, though such tests are outside the scope of the present study. There are limited test results available on the anti-personnel fragmentation characteristics of 105mm tank gun HEP projectiles that indicate somewhat better anti-personnel effects in grazing impacts than the 105mm HE projectile (which is no longer procured for tanks).

TABLE V-1

POSSIBLE AMMUNITION FOR BREACHING AND NEUTRALIZATION TESTS

Weapon	Ammunition Mixes for Testing
M2 15 Pound Shaped Charge	---
M3A3 40 Pound Shaped Charge	---
Gammon Grenade	2 to 4 pounds explosive
66mm LAW	HEP;* HEAT
3.5 Inch Rocket Launcher (89mm)	HEAT
RPG-7 Grenade Launcher (35mm)	HEAT; HE
STRIM F-1 Rocket Launcher (89mm)	HEAT
Carl Gustav Recoilless Rifle (84mm)	HEAT; HE/HEAT
105mm Howitzer	HEP; HE/Inert HE
105mm Gun (M60 Tank)	HEP; HEP/APDS; HEP/HEAT
106mm Recoilless Rifle	HEP; HEP/HEAT
155mm SP Howitzer	HE; HE/Inert HE
165mm Howitzer (Engineer Combat Vehicle)	HEP
8 Inch SP Howitzer	HE; HE/Inert HE

*HEP is an experimental LAW warhead and may or may not be easily available.

buildings, thick wall stone construction would be preferred by defenders over concrete or reinforced concrete or masonry. For post-WWII buildings, thick reinforced concrete would be preferred over masonry.

Targets for the large caliber direct-fire weapons should probably give some emphasis to thick, steel-reinforced concrete construction because of its ubiquity in newer city areas. Appropriate targets for the man-portable anti-tank weapons and the gammon grenade would use relatively thick masonry (cast blocks or bricks) and relatively light reinforced concrete exterior walls because these weapons are not effective against buildings of heavier construction.

If a European emphasis is desired, then West German building standards should be applied to the steel-reinforced concrete and masonry walls. In this case, the heavy reinforced concrete walls would be in the range of 30 to 50 cm; light reinforced concrete would be 20 cm or under. Such construction is probably heavier than normal for most developing countries.

The targets themselves are to represent rooms prepared as defensive firing positions for rifles, machine guns and rocket launchers. Preparations include sandbagging of the wall and stacking of mattresses and furniture around the firing positions to act as fragment barriers. Since hasty defenses may not permit sandbagging, it may be of interest to compare effects with and without sandbagged walls.

The target exterior walls must have realistic end constraints and loads, as determined by detailed structural analysis. At least for initial testing, complete rooms need to be constructed behind the exterior wall. Interior walls, floors and ceilings need to be finished with representative materials. These rooms should have typical door and window openings. If the initial tests indicate that interior wall blast and ricochet effects are small, then the remaining targets will not require construction of complete rooms behind the target wall.

It is essential that the concrete and mortar used in target construction be thoroughly cured, i.e., on the order of 12 months, in order to approximate full strength. Many recent structural target test results are unusable because the target concrete was cured for one month or less.

Firing Conditions

Firings are to be conducted at ranges representative of each weapon's use in city fighting. The target range frequency information in Appendix E, together with additional study of city topography, can be used to set ranges. Reliable fuze arming distances need to be considered in selecting firing distances.

A full range of practical obliquities needs to be tested for each weapon because opportunities for zero obliquity firings are rare in combat. Obliquities up to 70° or 75° are of interest.

Multiple Firings

Wall breaching is not a process which is highly sensitive to first-round effects--in contrast to tank duels, for example. In city combat where supporting heavy weapons can be brought up at all, there is usually opportunity to fire multiple rounds to achieve a breach or to neutralize a firing position. Thus, all weapons need to be tested for multiple round effectiveness. The criteria for the number of rounds to be fired in multiple firings should be that number which is required to achieve a specified effect (e.g., a hole large enough for a man to get through, or enough incapacitating fragment hits on possible positions for behind wall troops), providing this occurs within some reasonable number of rounds, perhaps 10 or 15.

Against thick, reinforced concrete walls, none of the APDS, HEAT or HE rounds can be expected to achieve breaches when used alone, due to the "jail window" effect discussed in Chapter IV. British tests (233: p. 212) showed that sequences of several armor piercing rounds to fracture the concrete, followed by an HE round to sever the reinforcing rods with fragments and clear away the concrete chunks with blast would eventually breach the thickest reinforced concrete. APDS, HEAT or inert HE rounds may be usable in the fracturing role and therefore HE rounds need to be tested as part of mixed round sequences. Candidate mixed round sequences are shown in Table V-1.

The most important weapons for multiple firing tests against thick reinforced concrete and stone walls are the 155mm and 8 inch self-propelled howitzers, since these are the principal artillery pieces in mechanized and armored divisions. For comparison, hand-emplaced shaped charges and field-expedient demolitions need to be tested against the same thick wall targets. The capabilities of the 105mm tank gun and the 106mm recoilless rifle need to be checked but, according to WWII experience which showed a need for at least 150mm projectiles against thick-walled buildings, they are unlikely to show high effectiveness in this role. The 105mm howitzer, issued only in towed versions, and the 175mm SP gun, in decreasing use due to user dissatisfaction, are of lower priority for testing.

Against the lighter masonry and reinforced concrete targets, the infantry anti-tank weapons and possibly the 105mm tank gun may require multiple firings to achieve a man-sized breach or to achieve satisfactory behind wall neutralization.

Effectiveness in all multiple firing tests will be dependent on the dispersion of successive impacts--although dispersion for the nonshoulder-fired weapons will be small at the short ranges under consideration. The test should attempt to reproduce dispersions representative of combat firings to the extent possible. All impact points are to be recorded.

Behind wall effects of HEAT rounds used alone--rather than as part of a mixed round firing sequence--need only be checked; little neutralization effect is likely. Spall from HEAT rounds up to 106mm (e.g., shoulder-fired anti-tank weapons, 105mm tank gun, 105mm howitzer, 106mm recoilless rifle and DRAGON) appears to be restricted primarily to the line of the jet--not much total spall is produced (281; 282). The small diameter of the 105mm tank gun APDS penetrator appears to produce similar results. The only available larger diameter HEAT projectile that might produce sizeable behind wall effects is the TOW warhead of about 5 inches. However, its use in this role would be rare in view of its cost and limited supply.

Firing Through Windows

The neutralization effectiveness of firing through walls needs to be compared with the effectiveness of firing HE or HEP projectiles through windows or breaches. Firing through windows was found to be ineffective at Hue when using the 106mm recoilless rifle, presumably because of inadequate fragment back-spray from rounds detonating on the back wall of the target room. This may or may not be true for the remaining anti-tank and artillery weapons and therefore needs testing.

Measures of Weapons Effects

The measurement of wall breaching consists of recording the size and shape of the opening, including any obstructions created by the remaining reinforcing rods. The breach is successful when it is large enough to let a man through. The principal measure will be the number of rounds required to create a successful breach.

Behind wall neutralization effects are more difficult to quantify. The desired output is an estimate, for each firing or firing sequence, of the fraction of firers or weapons crew members in the defended room that are incapacitated. This requires a quantitative description of the possible protective barriers, postures and positions of soldiers inside defended rooms. Blast effects at each position of interest can be measured by pressure recording devices; however, significant blast effects are unlikely except for the largest artillery projectiles and hand-emplaced demolitions. If spall and projectile fragment trajectory, weight, and velocity distributions, before and after penetration of the protective barrier materials, are estimated from the firing results, then it will be possible to evaluate approximately whether a soldier, in a given posture and location, would be incapacitated. It is preferable that the evaluation of incapacitation be based directly on wound information from animal experiments or combat rather than on current computer models. A number of approaches to recording the fragment distributions could be considered, ranging from witness panels to holography.

An approach that could be used in parallel with the fragment distribution collection would be the use of anthropomorphous dummies in appropriate positions to collect fragment hit, size and penetration results.

Test Resources and Replicated Firings

Since standard ammunition is being used in all cases except the HEP round for LAW, it does not appear that ammunition costs will represent a severe constraint. Range costs are not likely to be constraining, because sophisticated instrumentation and large ranges are not needed. The most serious resource constraint is probably target construction cost. This cost is likely to be dominant because of the large number of nonreusable targets needed to test the required combinations of target types, weapons, rounds, and obliquities.

The number of targets is further increased by the need for replicated firings, due to the inherent variability of projectile terminal effects and target mechanical properties. Therefore, it is essential to have enough replicates of each firing condition to be able to estimate the spread in results. This will require a minimum of three replicates, with five preferred if resources permit.

Where targets are limited, it will be preferable to eliminate low priority weapons, rounds and target types rather than reducing the number of replicates below three. Further target savings can be obtained by using prior firing results to eliminate planned firing conditions. For instance, if 155mm HE rounds prove highly effective against 50 cm reinforced concrete, there is no need to test them against lesser thicknesses--nor is there a need to test 8 inch HE rounds against the same thickness or lesser ones.

HAND GRENADE EFFECTIVENESS TEST CONCEPT

Background

Grenades are an important weapon, heavily used by defenders and attackers in city fighting. The use of hand grenades in city fighting as described in Chapter II mainly involves tossing or firing them from short ranges into streets or into confined areas, e.g., into rooms through windows, doors and breaches. To reduce their effectiveness (and that of other fragmenting rounds), soldiers defending from rooms often pile mattresses, furniture, sandbags, etc., around their firing positions to form fragment barriers. WWII grenades, with their relatively large fragments, appear to have had satisfactory effectiveness in neutralizing soldiers in such defended rooms. Current grenades, on the other hand, have much smaller fragments which may or may not be effective in this role. No tests addressing the question are available. Thus, there is a need for testing to resolve the effectiveness uncertainty.

Purpose

The primary purpose of this test is to determine the effectiveness of standard fragmentation grenades in incapacitating troops fighting from defensively prepared rooms. This, in turn, will yield information on the best techniques for using grenades and for defending against them.

The resources required include samples of standard fragmentation grenades, several rooms arranged to represent typical defensive positions, equipment for collecting fragment distributions, and test subjects representing the skill levels of riflemen in combat.

The information obtained will provide insights into the relative effectiveness of grenades of varying design and fragment sizes. It will also provide data for predicting the penetration of fragments in common materials found in building interiors.

Grenades to be Tested

The grenades to be tested cover the current standard hand and 40mm launcher grenades available to the U.S., the typical hand and rifle grenades of the USSR and its allies, and one U.S. WWII grenade, included to test large fragment effectiveness. These cover the most important grenades likely to be used by, or used against, U.S. troops. Concussion grenades are excluded because their casualty radii are too small to show good effectiveness. If desired, the most promising standard European grenades could be included for effectiveness comparisons. Grenades that need to be included in the basic test are listed in Table V-2. These grenades have widely differing characteristics with respect to the size and velocity of fragments produced and the numbers of fragments produced per grenade.

TABLE V-2

FRAGMENTATION GRENADES TO BE INCLUDED IN BASIC TEST*

Model Number	Avg. Fragment Weight (grains)	Launcher	Grenade Weight (oz)
Mk 2 (WWII)	5.1**	Hand; rifle-launched with adapter	21
M33	1.0	Hand	14
M26	1.9	Hand	16
RGD-5 (USSR)	(not known)	Hand	11
F-1 (USSR)***	(not known)	Hand	21
M406 (40mm HE round)	1-2	M79/M203	4.7
M397 (40mm bounding HE)	1-2	M79/M203	4.7

*If desired, European hand grenades and rifle grenades of promising effectiveness can be included.

**Large spread of fragment sizes with 25 grains not uncommon.

***Similar in appearance to the U.S. Mk 2; could be replaced in test by a newly standardized Soviet grenade, if and when such a new grenade is observed.

Defended Room Targets

Targets for the grenade tes are defensively prepared rooms similar to those used for the building and neutralization tests, except that thick wall structures are not needed. Interior floors, walls and ceilings need to be finished with typical materials. Rooms of several shapes with typical window and door openings are needed; these should represent rooms in both residential and commercial buildings. Typical firing positions protected by mattresses and furniture are to be reproduced in the target rooms. These firing positions can include anthropomorphous dummies in realistic postures. Postures should include those of soldiers aware of an imminent time fuzed hand grenade detonation. Equipment for collecting fragment weight, velocity and trajectory distributions, whether witness panels or more complex instrumentation, is also included in the room target.

Because almost all windows in countries using construction standards similar to those in Germany have metal shutters, it may be desirable to install such shutters and then test the effectiveness of grenades in breaching the shutters as preparation for firing into the target room.

Firing Conditions

Live hand grenades are to be thrown into target room windows from a variety of typical attack locations and ranges. They are also to be thrown into doors from typical inside-building positions; in this case, several different aim points are to be specified for the throwers so that effectiveness comparisons can be made.

Rifle and launcher grenades (as well as any hand grenades capable of being launched from a rifle) are to be fired into target room windows from a variety of typical attack locations and ranges. Variations in aim point are to be specified to compare effectiveness of different impact locations (including ceilings, where tactically feasible). If desired, rifle grenades can also be fired at closed metal shutters to determine whether they can be breached or blown open.

Test subjects should be trained and selected to represent the skill levels of riflemen in combat.

Effectiveness Measures

The effectiveness measures used would be the same as those used in behind wall neutralization testing for direct fire weapons. Pressure measurements can be taken at the firing positions to assess blast effects. However, blast effects are expected to be small since grenades have much less explosive than is required for a blast casualty radius of one meter.

CHAPTER VI

FINDINGS

The following findings apply to the primary study objectives--i.e., determining city fighting weapons effectiveness information deficiencies and suggesting general test concepts for alleviating them--and to the additional insights gained with respect to city fighting:

1. Review of the pattern of growth of dense city centers and newer, more open urban areas in Central Europe since WWII, combined with historical analysis of the reasons for city fights, provides no basis for the assertion that the incidence or importance of city fighting will be greater in the foreseeable future than it was in WWII. The growth in European highway networks bypassing cities as well as the replacement of pre-WWII heavy stone or concrete buildings in city centers (due to bombing and redevelopment) with newer, lighter, reinforced concrete structures may well decrease the incidence of city fighting.
2. The significant increase in relatively open urban and suburban areas may well increase the incidence of "suburban" fighting. Such fighting is more likely to resemble fighting along roads through farmland and villages than the building-to-building combat of WWII city battles.
3. Continuing to press a large-scale city attack through the building-to-building phase--once a quick seizure attempt has failed--is almost always a mistake, due to the resulting losses

in troops, materiel, time, city inhabitants and city facilities.

4. In most of the city battles reviewed, troops had to learn city fighting skills during combat--at a considerable cost in lives. Significant increases in city fighting effectiveness are more likely to result from better tactical training for combat in cities, built-up and fortified areas than from weapons developments or modifications. For NATO missions, city defense tactics should be emphasized at least as much as city attack tactics.

5. There is extensive overlap of combat tasks between city fighting and combat in built-up and fortified areas. In past combat, the general purpose weapons used in cities have shown few major deficiencies in accomplishing the specific functions required by city fighting. Due to the resulting penalty in effectiveness in other higher priority forms of combat, there is little reason to develop single purpose weapons that improve only city fighting capabilities. There are excellent reasons and opportunities for improving selected weapons for use across the spectrum of combat types. For instance, individual and squad anti-tank weapons need to reduce firing position restrictions by minimizing launch blast and also need to increase behind wall neutralization and behind armor effects. U.S. rifle capabilities could be substantially enhanced by adoption of effective anti-personnel and anti-tank rifle grenades.

6. The most important current city fighting weapons deficiencies result from the replacement of older direct-fire weapons (e.g., the 3.5 inch rocket and the 106mm RR) of demonstrated general purpose and city fighting utility with newer, single purpose

anti-tank weapons (e.g., the DRAGON, the TOW and the LAW) that are known to have little city fighting capability.

7. Because of the widespread need for demolitions in most forms of combat including city fighting--and because sufficient numbers of combat engineers are rarely available--insuring that a sizable proportion of infantrymen are trained and current in combat demolitions skills can significantly enhance infantry effectiveness. If hand-emplaced charges could be developed to create man-sized breaches and good behind wall effects, particularly in thick reinforced concrete walls, infantry would gain a valuable capability not provided by current hand-emplaced shaped charges. There is a continuing need for a throwable, field-expedient demolition similar to the gammon grenade--a weapon which demonstrated its utility in WWII.

8. Two information needs that are important to city fighting as well as to broader forms of combat--and that can be filled by physical testing--are: (a) determining the currently unknown effectiveness of major direct fire weapons in neutralizing weapons positions in buildings and in creating breaches, with particular emphasis on HEP rounds; and (b) determining the currently unknown effectiveness of standard fragmentation grenades in clearing out rooms prepared for defense. The test concepts presented in the study would provide a basis for more effective employment of existing weapons in performing these tasks and may provide insights for development of several munitions of increased utility for neutralizing fortified strongpoints inside and outside cities.

9. Communications are vital in city combat--however, they are frequently interrupted by radio line-of-sight problems and wire-cutting by artillery fragments. A non-weapons test that could provide information of value in city fighting would be a test of standard infantry radios in a variety of European cities to determine whether reliable communications can be achieved--with and without repeaters, rooftop antennas, and field-expedient antenna configurations.

10. Another test that might provide information of some interest would be a test of the man-portable flame thrower, the 66mm flame rocket, and the Molotov cocktail as incendiary anti-tank weapons to be used from above.

11. The most important effectiveness information deficiencies are common to city fighting and higher priority forms of combat; these deficiencies include the following:

    a. Lack of valid estimates of the anti-personnel incapacitation probabilities for most small arms, mortars, artillery and larger direct-fire weapons--due, in part, to reliance on computer models based largely on hypotheses rather than on experimental evidence.

    b. Lack of valid estimates of anti-tank lethality of current tank and anti-tank weapons--for reasons similar to those in (a).

    c. Lack of valid accuracy data on most direct fire weapons, i.e., data that address rate of target effects under combat-type conditions.

d. Lack of uniform evaluation of blast safety and obscuration limitations in firing the major infantry anti-armor weapons inside rooms or emplacements or in front of blast-reflecting surfaces.

Tests addressing the above deficiencies need to be conducted in a general purpose rather than a city-specific setting.

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13. ABSTRACT

The primary study objectives are: (a) to determine whether there are significant deficiencies in the information available for evaluating the city fighting effectiveness of standard U.S. ground force weapons, and (b) where physical testing could address such deficiencies, to develop the nature of the tests needed. The study analyzes combat experience since WWII to determine the major combat functions and weapon uses in city fighting. Existing U.S. weapons capabilities and the available supporting effectiveness data are examined. Findings related to the study objectives, as well as additional insights obtained, are presented.