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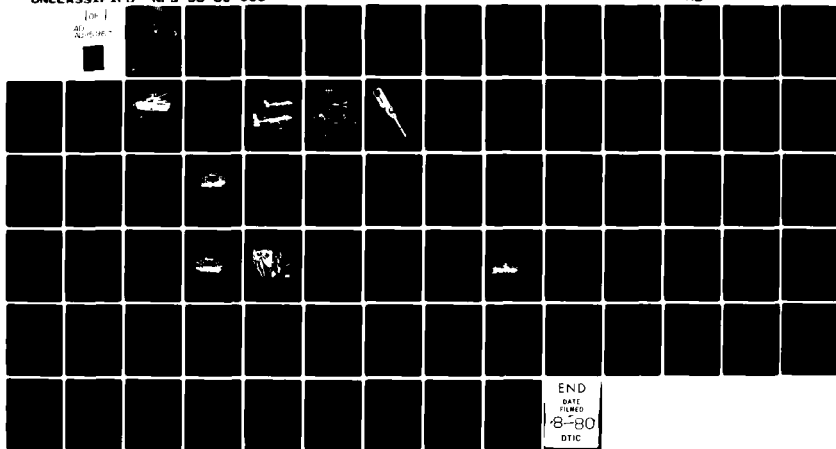
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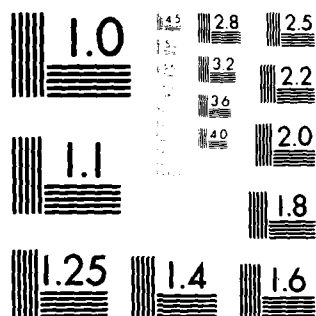
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COMBAT DAMAGE ASSESSMENT TEAM
A-10/GAU-8 LOW ANGLE FIRINGS
VERSUS
SIMULATED SOVIET TANK COMPANY (ARRAY 18)
(AEROJET LOT NUMBER AJD79A181-001)
(30 AUGUST 1979)

R.H.S. STOLFI
R.R. McEACHIN

MAY 1980

Approved for public release; distribution unlimited.

Prepared for: A-10 System Program Office
Wright Patterson Air Force Base
Ohio 45433

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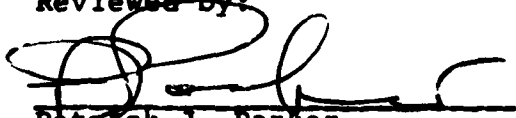
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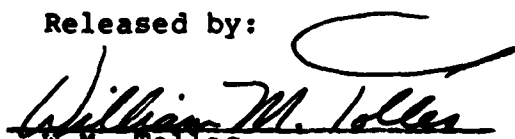
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes firings of the A-10/GAU-8 weapon system on 30 August 1979 against a Soviet tank company simulated by 10 combat loaded M-47 tanks. The pilots making the firing passes attacked at low altitude and used correspondingly low dive angles in order to simulate movement through a hostile air defense system. Ammunition used in the attacks comprised LAVP Lot Number AJD 79181-001, Aerojet 30mm armor piercing incendiary (API) rounds, which proved to be effective damage agents against substantial areas.		

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of the U.S. MK 47 tanks used as targets. The pilots in eight successful firing passes (two targets were not attacked) fired a total of 484 rounds of which 143 impacted the targets. The projectiles impacting on targets achieved 13 perforations of the armored envelopes. Significant results include:

4 tanks immobilized and
1 tank silenced.

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COMBAT DAMAGE ASSESSMENT COMMITTEE (CDAC) EXECUTIVE SUMMARY

Under the technical direction of the Combat Damage Assessment Committee (CDAC), the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted firings at low altitudes and low dive angles which simulated attack below the altitude of effective engagement for opposing air defense networks employing acquisition and fire control radar. The purpose of the test was to evaluate the effects of the Aerojet 30mm API anti-tank ammunition (lot Number AJD 79A181-001) of the GAU-8 gun under challenging conditions of engagement for the A-10/GAU-8 system against realistically simulated Soviet main battle tanks.

The CDAC assessed the results of the low angle cannon firings of the A-10 aircraft against the simulated Soviet tank company as follows:

1. Attack Parameters: The pilot of the A-10 aircraft attacked the simulated Soviet tank company for 19 minutes 54 seconds at low altitude and dive angles. The GAU-8 cannon has a ground selectable nominal fire rate of either 4200 rounds per minute or 2100 rounds per minute. The system was set to fire at the 4200 round per minute rate during this test. The pilot made a total of eight passes, each at a primary target tank. The passes resulted in projectile impacts on eight primary target tanks. The attack open-fire dive angles averaged four degrees for the eight passes against the targets. Open-fire slant ranges averaged 2791 feet. The pilot fired 484 rounds in eight bursts averaging 60.5 rounds and 0.88 seconds each.
2. Weapons Effects: The A-10/GAU-8 weapon system achieved 143 impacts on the array of target tanks. The ratio of direct impacts to total rounds fired was 0.20. Ricochet hits are also capable of causing damage. If the ricochet hits which can cause damage are added to the direct impacts, the overall ratio of impacts to rounds fired becomes 0.30. The weapon system achieved 13 perforations of the armored envelopes of the tanks with a ratio of perforations to total impacts of 0.09. The ratio of perforations to direct impacts was 0.13. Many projectiles, which did not perforate armor, severely damaged exterior track and suspension components of the tanks.
3. Damage Assessment: Two tanks were immobilized and silenced. One tank was immobilized and seriously degraded in firepower. One tank was immobilized. One tank was silenced and seriously degraded in mobility. Two tanks were not attacked and three others, though impacted or perforated, were not damaged sufficiently to degrade either mobility or firepower. The simulated Soviet tank company's overall combat capability was diminished by 50%.

4. Test Conditions: The target tanks were sited in open, flat desert terrain with no cover and little concealment. Aerial weather conditions were ones of unlimited ceiling and visibility. Shortly after the initial firing, clouds of white dust from projectile impacts were evident. Such conditions effectively simulated the actual obscuration which would have been presented to the pilots in combat.

5. Results: The overall results of the test are summarized in Table I. Appendix A contains graphical and summary information for this firing and Appendix B contains definitions of the terms used in this publication.

TABLE 1. Array 18 Summary of A-10 Aircraft in Low Angle Gun Attack versus
Simulated Soviet Tank Company
(30 AUGUST 1979)

Tank No.	A-10 Primary Pass*	A-10 Approach		A-10 Attack		Gun Effects		Damage		Tank Immob ?	Attack Aspect (degrees)
		Speed (fps)	Alt (ft)	Open Fire Range (ft)	Dive Angle (degrees)	Round Impacts (each)	Perfs (each)	M %	F %		
27	1/1	555.6	383	2666	-3.5	35	6	---	---	No	220
29	1/2	532.0	312	**	-2.0	53	5	---	---	No	215
41	1/3	540.4	366	**	-4.0	47	31	100	95	Yes	211
38	1/4	545.5	308	2677	-5.0	62	19	100	---	Yes	210
7	1/5	564.1	323	2688	-5.0	70	24	100	100	Yes	163
4	1/6	555.7	305	2955	-4.5	62	32	100	100	Yes	145
35	1/7	560.7	333	2967	-4.5	85	25	95	100	No	141
34	1/8	574.2	332	**	-4.0	70	1	---	---	No	165
33					NOT ATTACKED						
31					NOT ATTACKED						
*** Totals:					-4.1	484	143			4	
***Averages:		553.5	333	2791		60.5	17.9				

Right Rear
Left Rear

2 100% M & F
1 100% M
1 100% M, and
Seriously
Degraded
in firepower
1 100% F, and
Seriously
Degraded
in mobility

* 1/1 means pilot 1, pass 1; 1/2 means pilot 1, pass 2, etc.
** Position Uncertain
*** Based on HUD film

NOTE: Tanks 31 and 33 were not attacked. All ammunition expended.

BACKGROUND

Since February, 1978, the Armament Directorate, A-10 System Program Office, Wright-Patterson Air Force Base, Ohio, has conducted firing tests using the A-10/GAU-8 system in low-level, air-to-ground engagements of armored targets. The tests have been conducted within the framework of the GAU-8 30mm ammunition Lot Acceptance Verification Program (LAVP) - Airborne. The LAVP has the following objectives which apply to the present tests:

- A. To evaluate the performance of existing production lots of GAU-8 ammunition when fired from the air under operational conditions.
- B. To evaluate the lethality of GAU-8 ammunition against armored targets when fired at low level from A-10 aircraft using operational tactics.

To conduct the LAVP program, the Armament Directorate has cooperated with Headquarters, Tactical Air Command, Langley AFB, Virginia and, in turn, with the Tactical Fighter Weapons Center, Nellis AFB, Nevada. Within the framework of that cooperation, the Armament Directorate has set up a Combat Damage Assessment Team (CDAT) to plan and execute the firing tests and evaluate the results. The CDAT functions under the direction of a Combat Damage Assessment Committee (CDAC) which has prepared this report of the firing test of 30 August, 1979.

TEST PHILOSOPHY

To generate realistic data, the CDAC determined to use a highly empirical technique of destructive testing of actual tank targets. Tests have involved firings at individual tanks in November, 1977 and February - March, 1978, and, more recently, arrays of tanks in tactical formations. The experimental setup for the firings of 30 August, 1979 involved the use of a multi-target, tactically arrayed tank formation for attack by the A-10/GAU-8 system. The CDAT elected to simulate a Soviet tank company, as organized within a tank division, as the target array for two attacking A-10 aircraft. As few constraints as possible were placed on the attacking pilots in an attempt to develop as much realism as possible. Table II shows the test factors which would have been ideal in the test of 30 August, 1979 and the practicable setup which was achieved.

Table II. Comparison of Ideal and Practical Test Situations

<u>Ideal Test Parameters</u>	<u>Practical Test Parameter</u>
1. <u>Air Attack Realism</u> a. Actual A-10/GAU-8 b. 30mm API c. European weather & terrain d. Optimum open-fire ranges (2000 ft) e. Low altitude attack angle (< 6 degrees) 2. <u>Air Defense Realism</u> a. Automatic cannon firing at aircraft b. Missile systems firing at aircraft c. Small arms firing at aircraft d. AD suppression by aircraft 3. <u>Threat Targets and Doctrine</u> a. T62/T64/T72 high fidelity targets b. Stowed combat loads (in T62/T64/T72) c. Realistic crew station postures d. Dynamic combat formation e. Maneuvering evasive targets	1. <u>Air Attack Realism</u> a. Actual A-10/GAU-8 b. 30mm API c. Nevada weather & desert terrain d. Average open-fire range: 2791 feet. e. Low altitude attack angle (< 6 degrees) 2. <u>Air Defense Realism</u> a. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system b. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system c. Low-altitude, low-angle, minimum-exposure attacks versus assumed AD system d. No suppression simulation in test 3. <u>Threat Targets and Doctrine</u> a. Simulated Soviet tanks b. Stowed combat loads (in US M-47) c. Wooden crew manikins d. Static combat formation e. Stationary targets

SIMULATED GROUND COMBAT SITUATION

The firing test of 30 August, 1979 simulated the attack by two A-10 aircraft on a Soviet tank company. The CDAC hypothesized the Soviet tank company to be the lead march security detachment for its battalion, which in turn, is the advance guard of a larger mobile formation. The lead detachment operates approximately five kilometers in front of the Soviet battalion column. The mission of the advance company is to ensure the uninterrupted advance of the battalion and provide security against attack. Upon meeting heavy resistance, the company deploys into an appropriate combat formation to reduce the resistance, or form a base of fire for offensive action by the remainder of the battalion.

A Soviet tank company, which is simulated in the firing test, would probably have other units attached to it for its support. Attached units might include any one or all of the following elements: (1) motorized rifle platoon; (2) engineer detachment; (3) chemical defense specialists; (4) 122mm howitzer battery; (5) air defense element. The lead detachment simulated in the firing test consisted of tanks alone. The pure tank formation was arranged with two platoons up and one back, simulating an assault posture. The tanks used in the firing test were US M-47 tanks, largely intact, containing crew manikins, and stowed with ammunition, fuel, and oil. The tanks were not maneuvered during the firing test and the formation remained essentially a snapshot of the company at a single point in time.

TARGET TANKS

The most effective tanks available in sufficient numbers to simulate Soviet T-55 and T-62 (Figure 1) tanks were the US M-47 tanks. Both of the Soviet tank models are similar in armor protection to the M-47. With the appropriate purging of the gasoline fuel system of the US tanks, the CDAT managed to field a tank similar in survivability to the T-55 and T-62 tanks from the viewpoint of ignitable internal material. Few data are available on the Soviet T-64 and later model tanks from the viewpoints of armor protection and the arrangement of internal material. The decision was made, accordingly, to simulate the earlier model Soviet tanks with the readily available US tanks.

The M-47 tanks used for targets were in excellent condition from the viewpoint of damage assessment. The exterior components were complete and the tanks have proven to be effective targets for the collection of exterior mobility damage. Interior components were less complete in the target tanks. All of the most essential items were present, e.g., main gun, engine, transmission, fuel tanks, ammunition racks, etc., but other items such as oil coolers, range finders, vision devices, and radios, have not been present in all tanks.

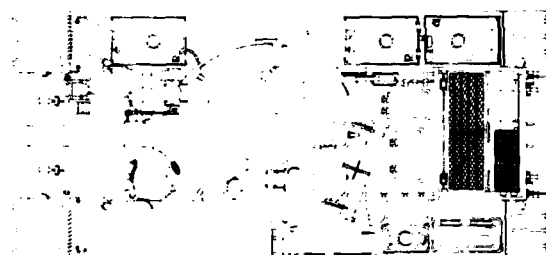
The most sensitive internal items from the viewpoint of catastrophic kills and high percentage Mobility (M) and Firepower (F) kills are the following, which were placed in the test tanks as noted:

<u>Generic Sensitive Item</u>	<u>Test Item</u>
1. Ammunition -----	US Cartridge, 90-mm TP-T
2. Fuel -----	Number 2 Diesel
3. Oil -----	Oil in Engine, Transmission and Drive Components.
4. Personnel -----	Articulated Plywood Manikins

The tanks were static during the test and their engines were not running, with the result that the fuel and oil were much cooler and more inert than would have been the case with a moving tank or a static vehicle with its engine running. The kill ratio achieved in the firing test of 30 August, 1979, therefore, is probably conservative from the viewpoint of fires resulting from ignited fuel and oil.

TEST PERFORMANCE AND RESULTS

Conduct of the test consisted of bringing together the ammunition, gun, aircraft, pilots, and combat arrayed and loaded tanks into a several minutes simulation of combat. In essence, the

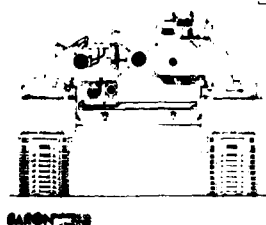


Russian T62 Medium Tank

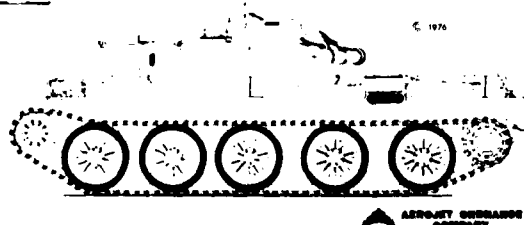
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FIGURE 1. Russian T62 Medium Tank

decisive elements which were fed into the test immediately prior to the firing were the following:

1. Aerojet 30mm API ammunition, Lot Number AJD 79A181-001.
2. General Electric GAU-8 Gatling gun.
3. Fairchild Republic A-10 attack aircraft.
4. USAF Fighter Pilots.
5. US Designed M-47 main battle tanks.

The combat simulation itself comprised the aerial fire and maneuver of the attacking A-10 aircraft. A realistic way of presenting the combat simulation is to outline the sequence of pertinent events in each firing pass. These events and the pertinent data which the CDAT attempted to collect, in order to reconstruct the simulated combat firing of 30 August, 1979, were as follows:

<u>Sequence</u>	<u>Event</u>	<u>Data</u>
1.	Aircraft Approach	Speed, Altitude
2.	Aircraft Attack	Open-fire Range, Dive Angle
3.	Aircraft Attack	Burst Time, Rounds Fired
4.	Aircraft Attack	Cease-fire Range, Dive Angle
5.	Gun Effects, (Accuracy)	Impacts on Tanks
6.	Gun Effects, (Lethality)	Perforations through Armor
7.	Tank Damage	Catastrophic (K-Kill), Mobility (M-Kill), and Firepower (F-Kill) Kills

The data noted immediately above were collected through the combined efforts of the CDAT and range support personnel at Nellis AFB, working together and using TSPI equipment, motion picture and still cameras, the industrial efforts required to repair, refurbish, and field the tank targets, and various systematic research techniques used to describe weapon effects and combat damage. The most basic materiel used in the test; i.e., the aircraft, gun, and projectile are illustrated in Figures 2, 3, 4, and 5. The tanks were arrayed in the tactical formation of a Soviet tank company as shown in Figure 6.

The pilots making the attack flew from the base area in a two-ship, mutually supporting element and employed operational tactics immediately before and during the firing passes. The pilots approached the target area at low altitude and simulated target acquisition with the help of a forward air controller. Upon arrival in the target area, the pilots noted that one aircraft had not been loaded with ammunition. The CDAT decided to conduct the test with the single loaded aircraft. The pilot proceeded to attack the acquired targets at low altitudes and dive angles, simulating operation below the altitudes for effective acquisition and engagement by opposing air defense missile and gun systems. The pilot with the unloaded aircraft made several diversionary passes in support of the firing aircraft.



FIGURE 2. U.S.A.F./Fairchild Republic A-10 Aircraft.

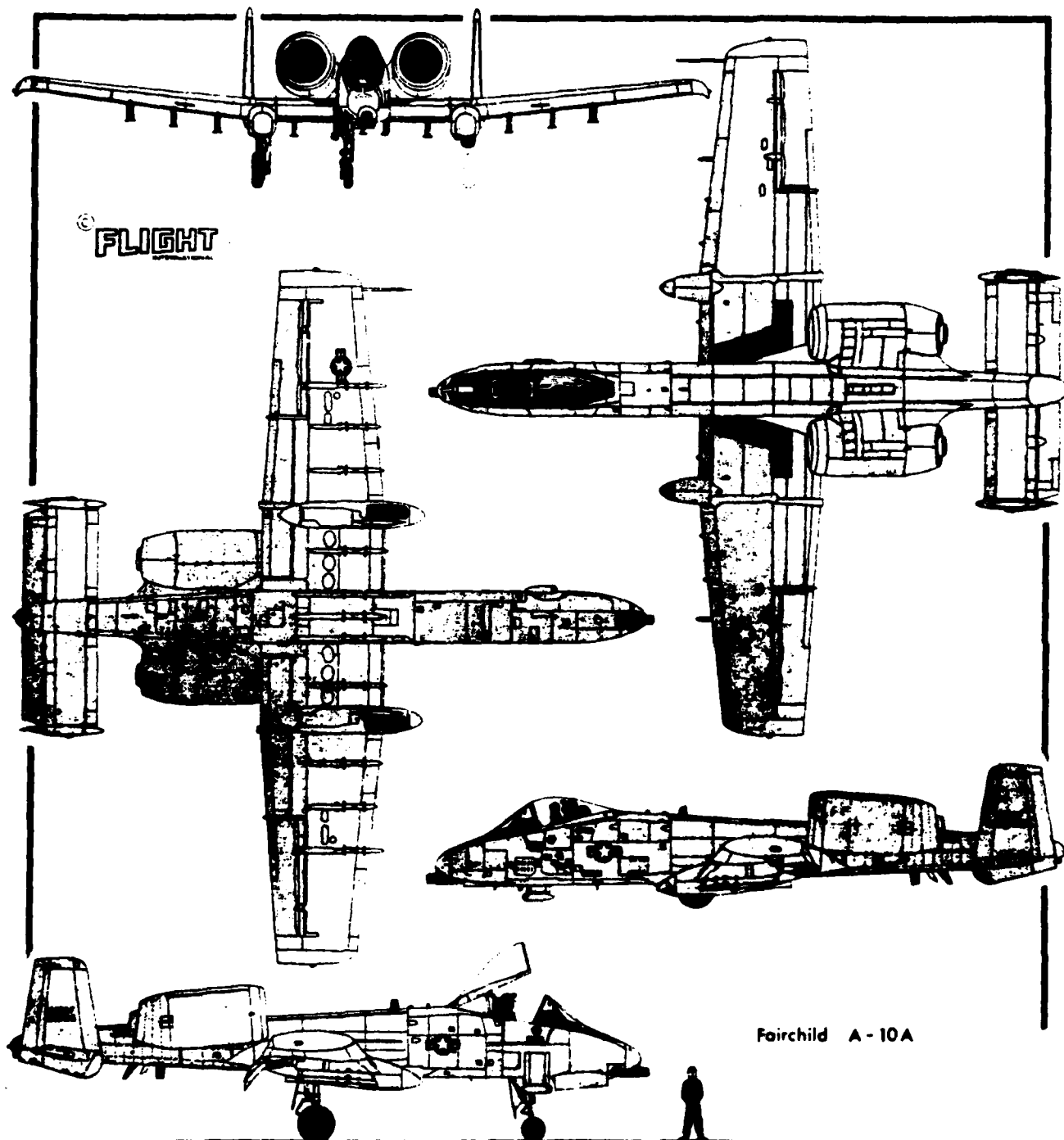


FIGURE 3. Fairchild A-10 Series Aircraft.

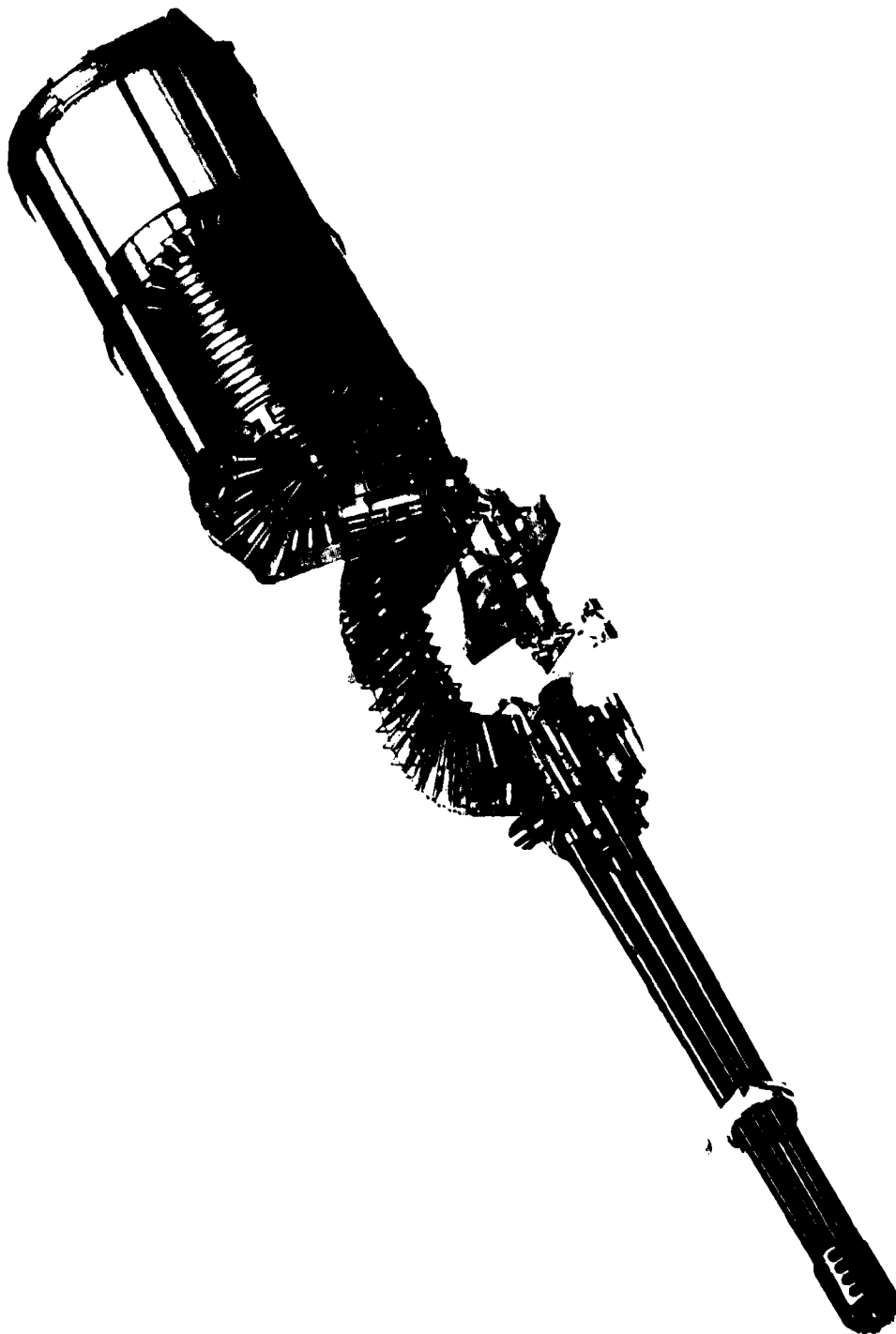


FIGURE 4. GAU-8/A 30mm Gun System

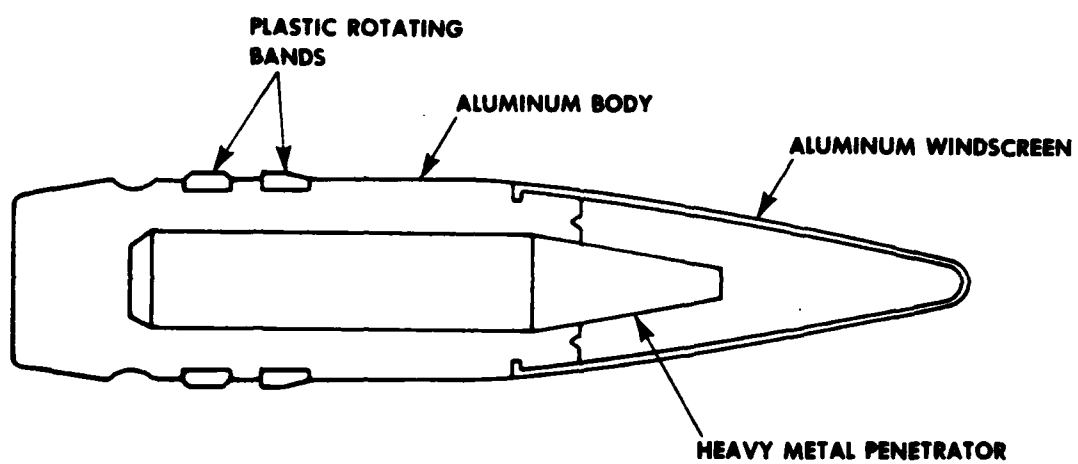


FIGURE 5. 30mm Armor Piercing Incendiary (API) Projectile.

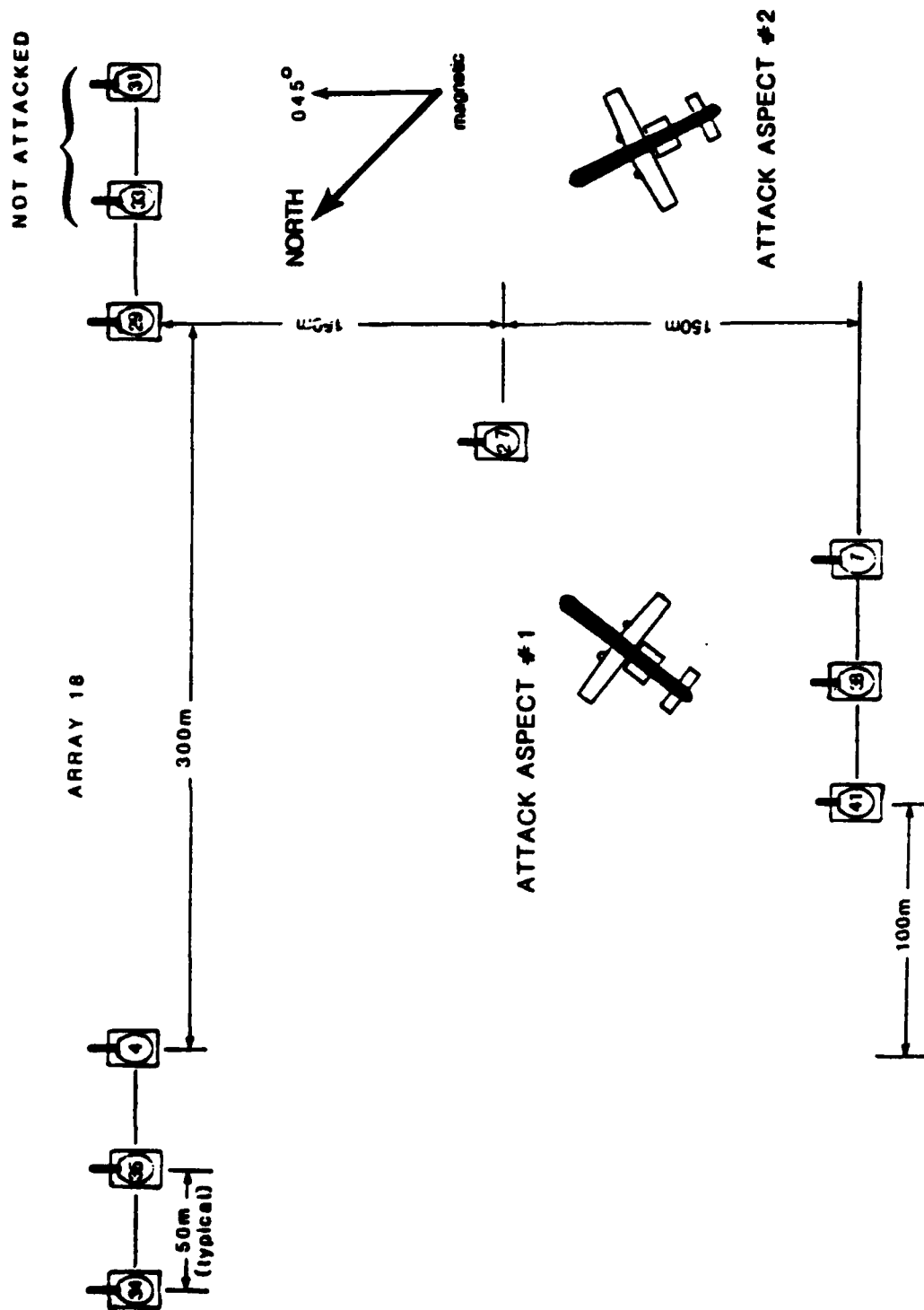


FIGURE 6. Approximate Target Layout.

DAMAGE ASSESSMENT

The damage assessment conducted by the CDAT is presented on the following pages. The attacking aircraft was loaded with enough ammunition for the originally postulated attack on five tanks and did not have enough ammunition to attack all 10 tanks in the company array. Consequently, tanks 33 and 31 were not attacked or impacted, and are not discussed further. Appendix A, following the damage assessment section contains graphical and tabular information relative to the mission in general, for example, aircraft attack parameters, weapon effects, and summaries of damage.

Terms used in the damage assessment summaries are defined in Appendix B.

Impacts on tanks were arbitrarily numbered for identification purposes. The impacts were numbered sequentially, first at the turret level, then at the hull level. If additional impacts were discovered during the combat damage assessment (as was sometimes the case) they were given the next sequential number, i.e., no attempt was made to "correct" the sequence. THE READER IS CAUTIONED THAT THIS NUMBERING SYSTEM HAS NO RELATIONSHIP WHATSOEVER TO THE ARRIVAL SEQUENCE OF PROJECTILES ON THE TANK OR TO THE PORTION OF THE BURST IMPACTING THE TANK.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 41

1. Description:

The target tank was impacted at an attack aspect of 211 degrees (left rear) during one firing pass at low attitude and low dive angle. The A-10 expended 47 rounds in the firing pass.

2. Kill Assessment:

100% M-Kill and 95% F-Kill resulting from the following observed projectile effects (Figure 7 and 8):

a. Perforations	:	2
b. Significant Impacts	:	6
c. Insignificant Impacts:		<u>23</u>

TOTAL IMPACTS : 31

3. Rationale for Kill Assessment:

- a. M-Kill: The assessment of 100% M-Kill was based on impact 29 which penetrated the left track adjusting idler hub, cumulative damage to the track and suspension system from impacts 12, 14, 24, 25, and 28, and impacts 3 and 5 which perforated the left turret and caused casualties to the commander, gunner, and loader.
- b. F-Kill: The assessment of F-Kill was based on the commander, gunner and loader casualties.

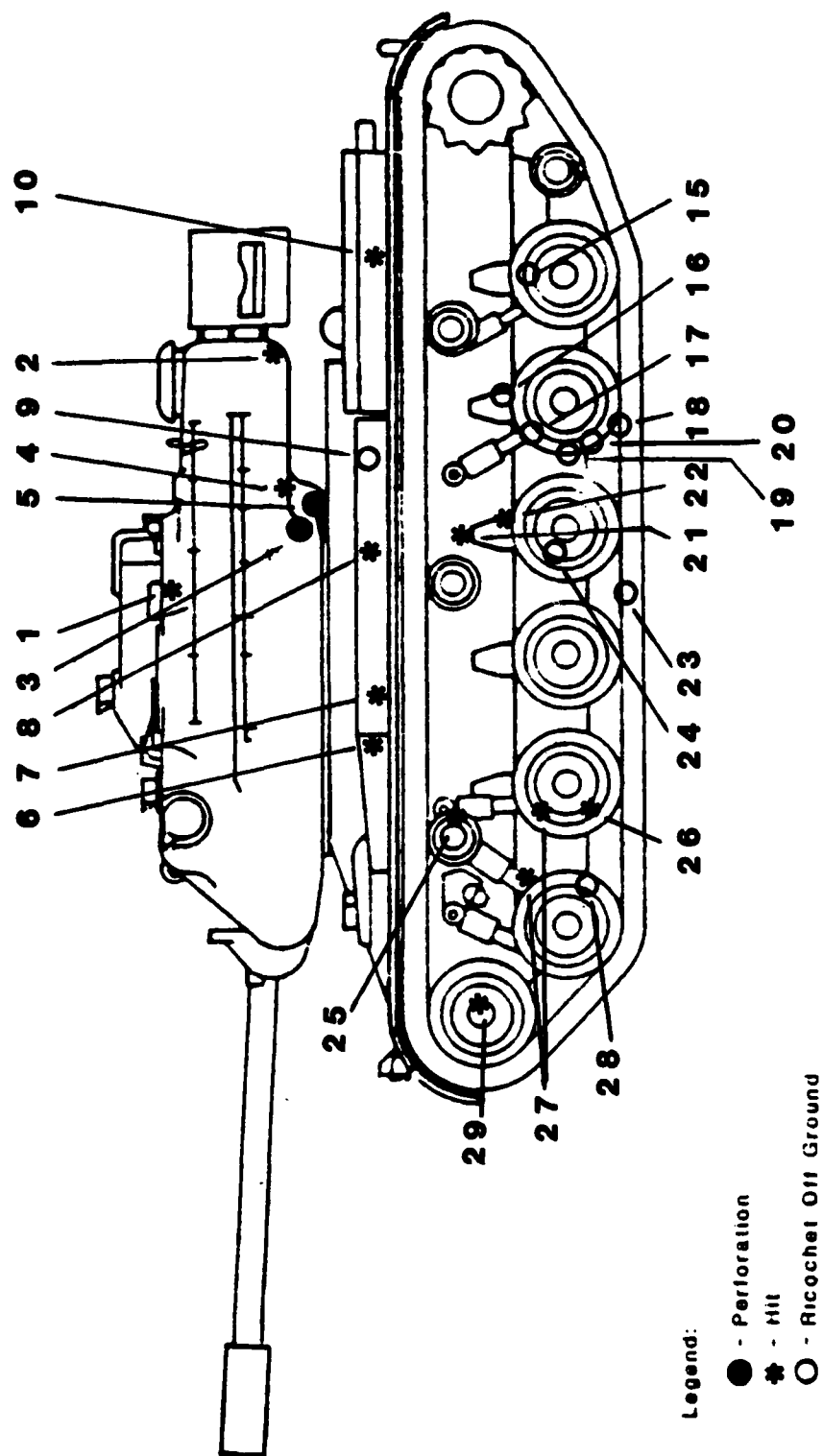
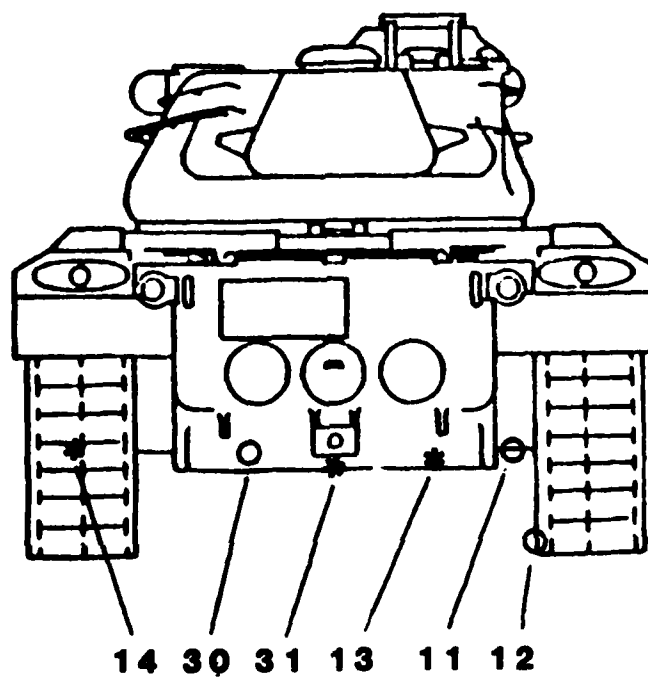


FIGURE 7. Tank 41, Impact Diagram, Left Side.



Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

FIGURE 8. Tank 41, Impact Diagram, Rear.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 38

1. Description:

The target tank was impacted at an attack aspect of 210 degrees (left rear) during one firing pass in which the attacking aircraft expended 62 rounds.

2. Kill Assessment:

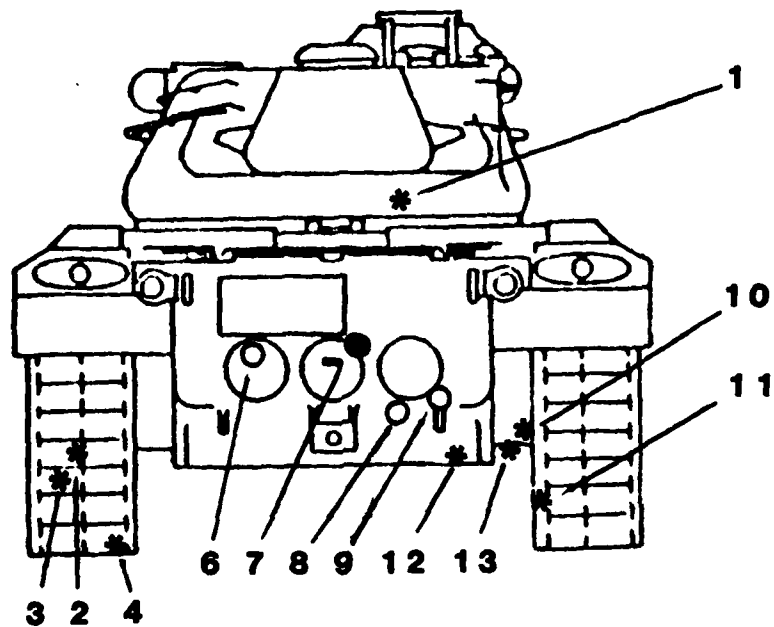
100% M-Kill based on the following observed effects (Figures 9, 10, and 11):

a. Perforations	:	1
b. Significant Impacts	:	5
c. Insignificant Impacts:		<u>13</u>

TOTAL IMPACTS : 19

3. Rationale for Kill Assessment:

100% M-Kill based on impact 7 which perforated the rear of the hull (see Figure 12) and penetrated into the transmission case; impact 10, which penetrated into the right final drive; and cumulative damage to the track and suspension system caused by impacts 4, 11, 18, and 19.



Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

FIGURE 9. Tank 38, Impact Diagram, Rear.

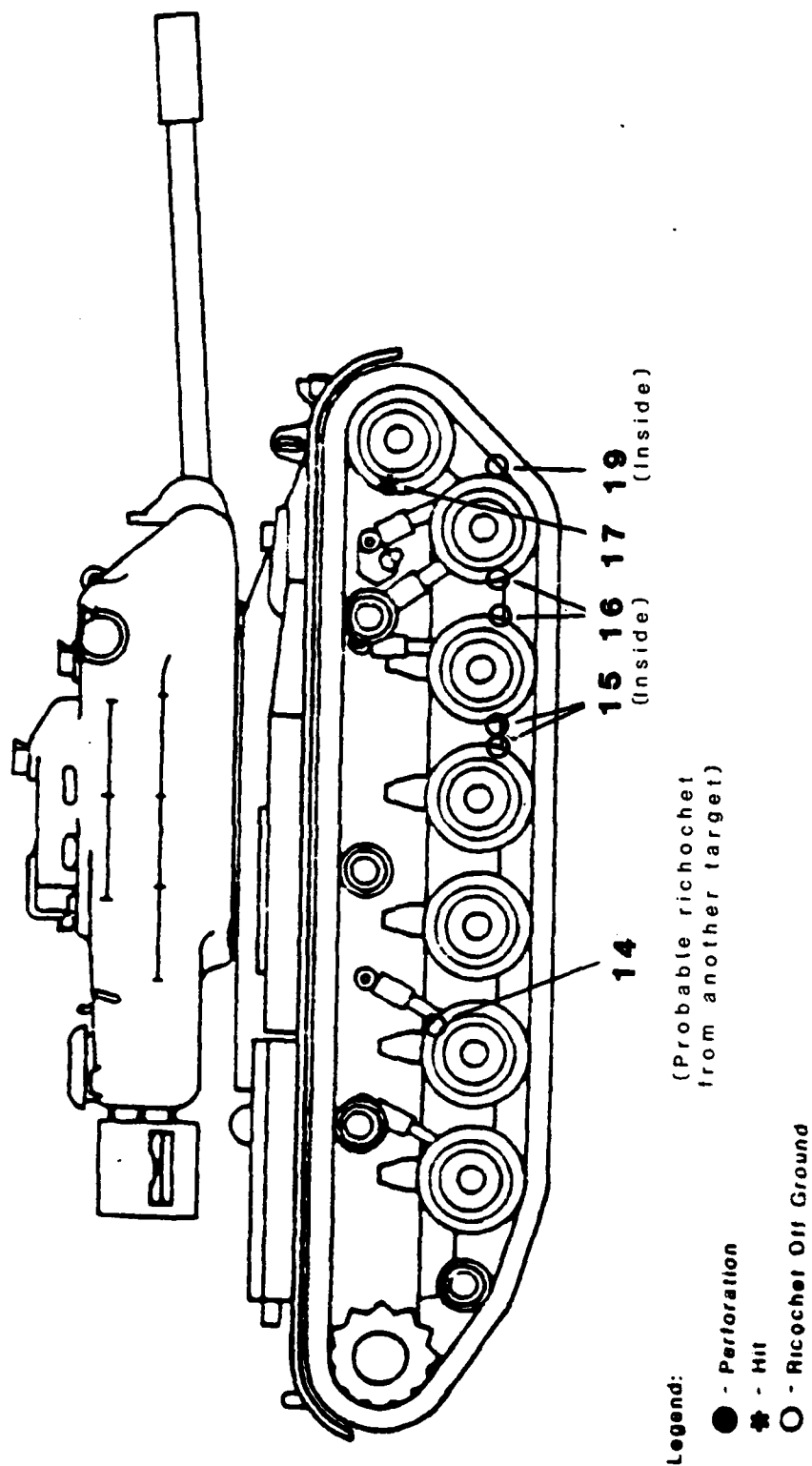
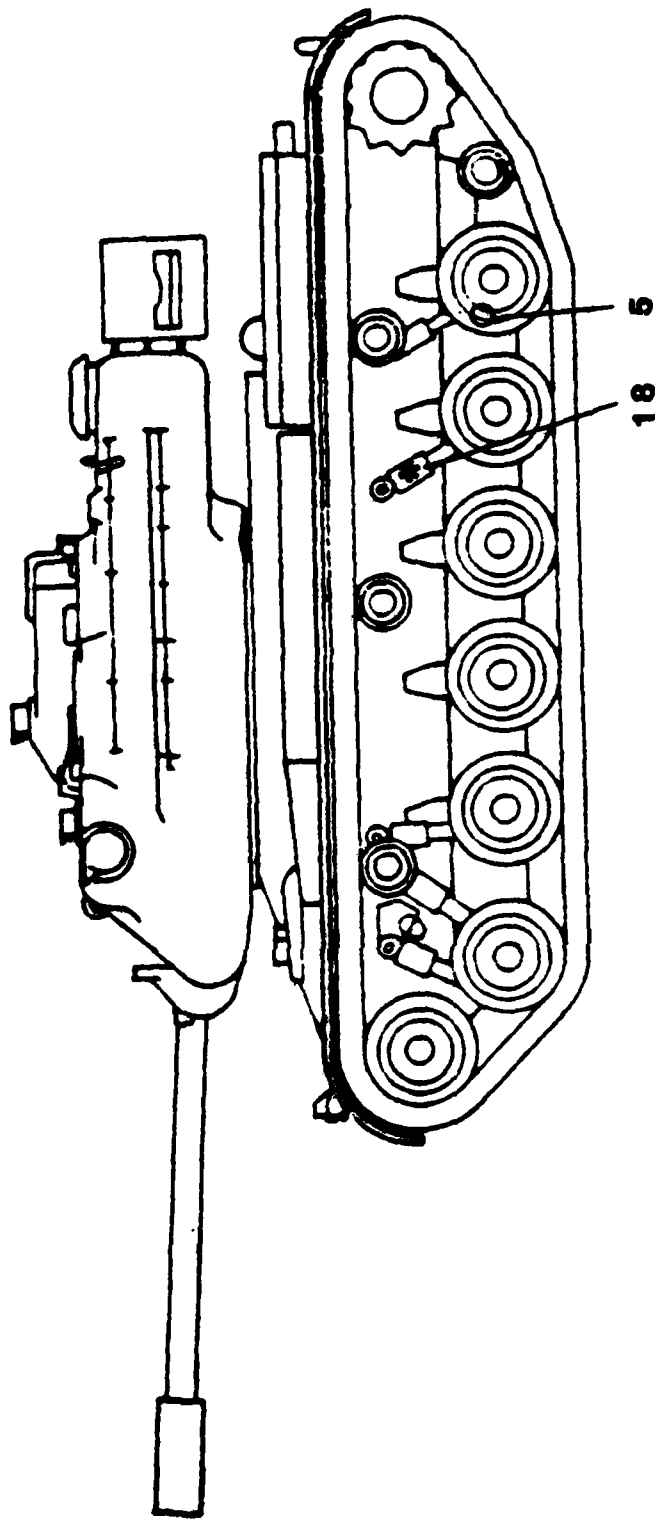


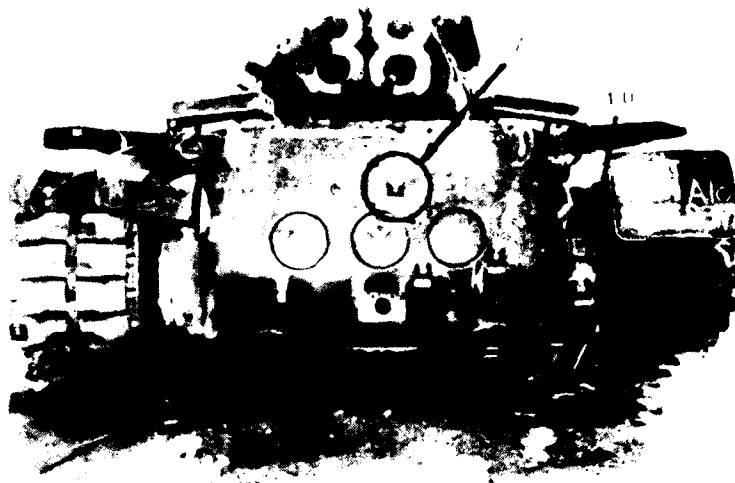
FIGURE 10. Tank 38, Impact Diagram, Right Side.



Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

FIGURE 11. Tank 38, Impact Diagram, Left Side.



Note impacts 7 and 10 which perforated the hull and the right final drive casting respectively and contributed to the assessment of 100% M-Kill.

FIGURE 12. Tank 38, Photo, Rear.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 35

1. Description:

The target tank was impacted at an attack aspect of 141 degrees (right rear) during one firing pass in which the attacking aircraft expended 85 rounds.

2. Kill Assessment:

95% M-Kill and 100% F-Kill resulting from the following observed effects (Figures 13 and 14):

- a. Perforations : 3
- b. Significant Impacts : 7
- c. Insignificant Impacts: 15

TOTAL IMPACTS : 25

3. Rationale for Kill Assessment:

a. M-Kill: A 95% M-Kill was assessed based on impacts 1, 3, and 4 which perforated the right turret causing casualties to the commander, gunner, and loader degrading mobility (90%) and on cumulative damage (5%) to the track and suspension system by impacts 13, 14, 17, 18, and 22.

b. F-Kill: A 100% F-Kill was assessed based on impact 4 which perforated the turret ring and jammed the turret so that it would not traverse, and on the commander, gunner, and loader casualties inflicted by impacts 1 and 3. Impact 24, which penetrated the bore evacuator, made a minor contribution to the kill.

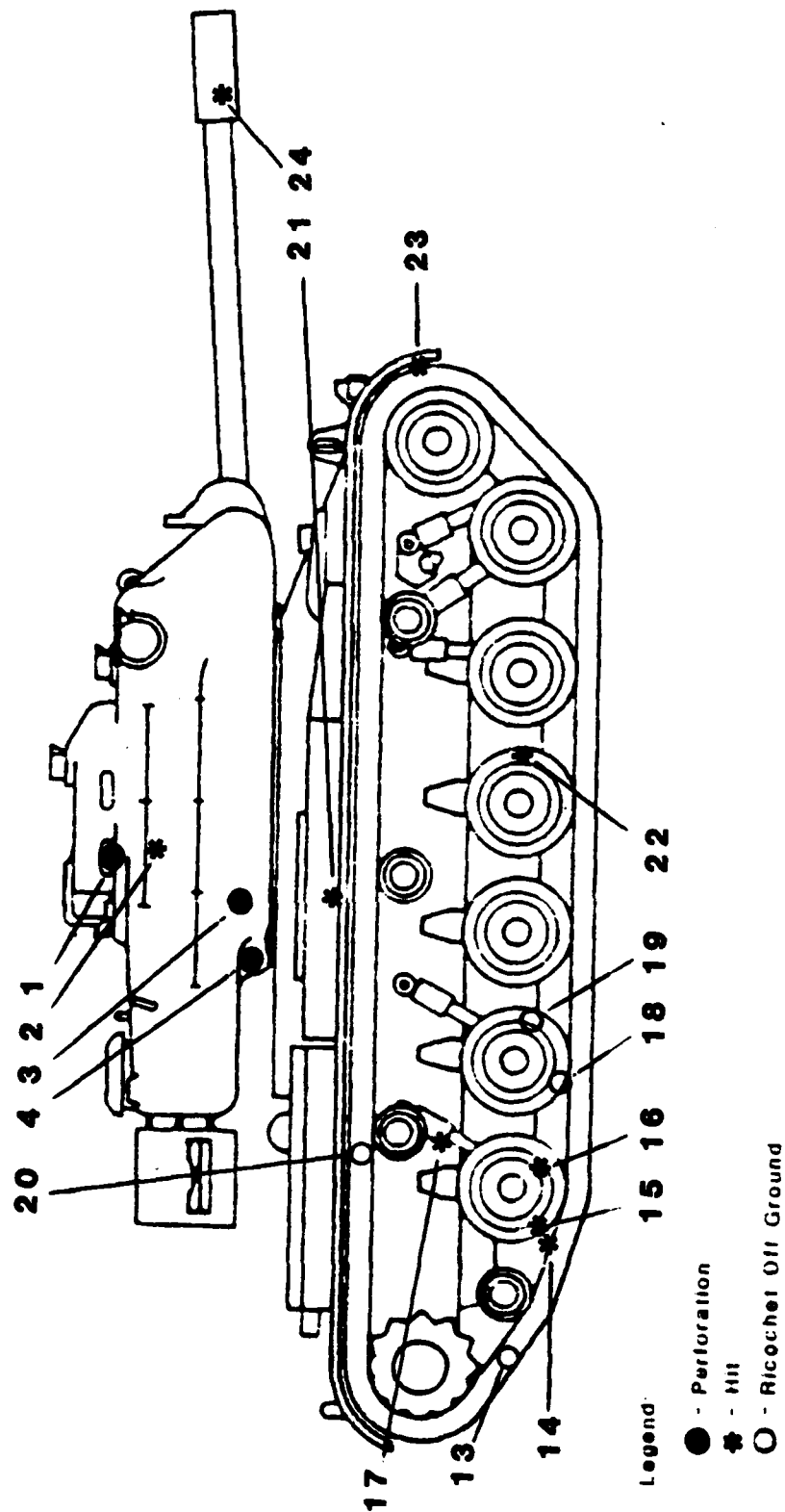
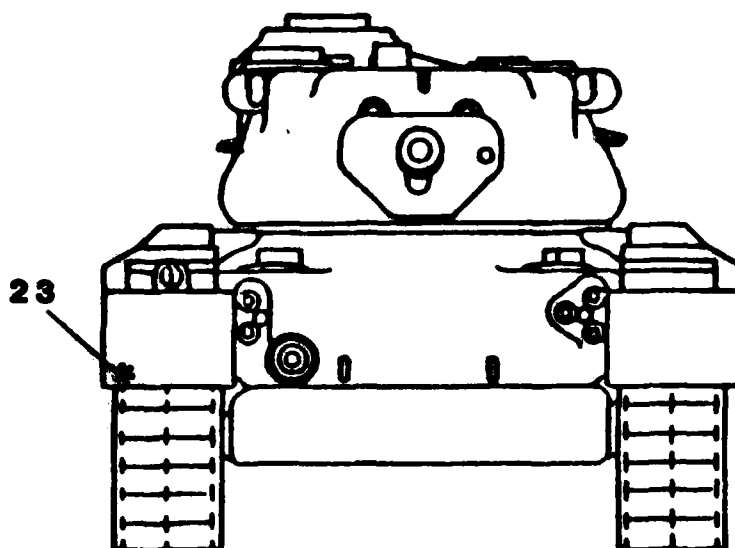


FIGURE 13. Tank 35, Impact Diagram, Right Side.



Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

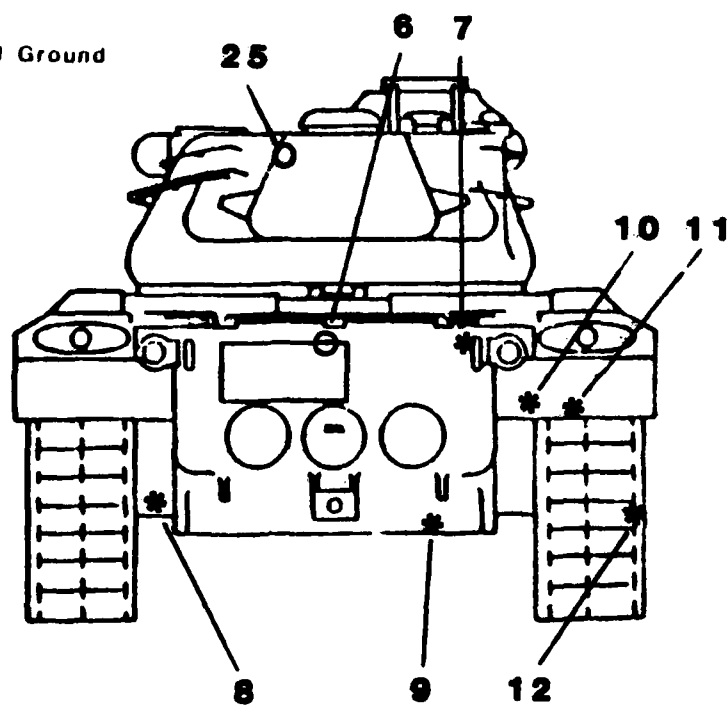


FIGURE 14. Tank 35, Impact Diagram, Front and Rear.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 34

1. Description:

The target tank was impacted at an attack aspect of 165 degrees (right rear) during one firing pass in which the attacking aircraft expended 70 rounds.

2. Kill Assessment:

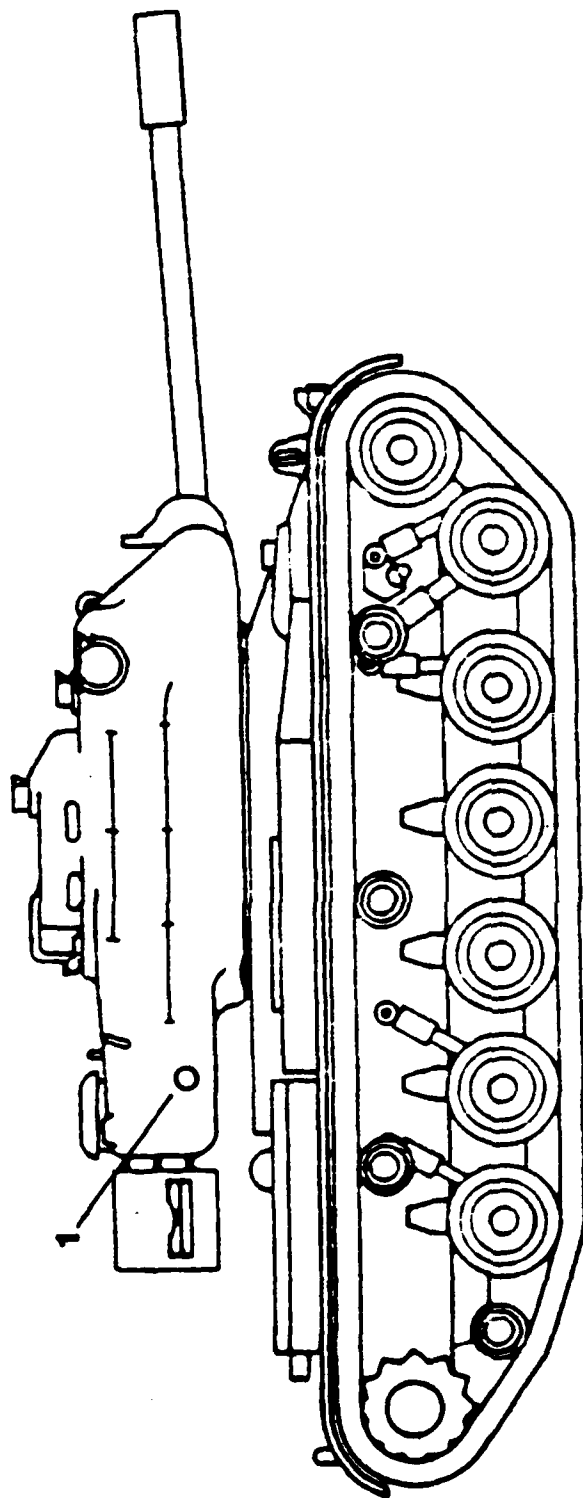
No degradation in mobility or fire-power.

a. Perforations	:	0
b. Significant Impacts	:	0
c. Insignificant Impacts:		<u>1</u>

TOTAL IMPACTS	:	1
---------------	---	---

3. Rationale for Kill Assessment:

The single impact on tank 34 partially penetrated the right side of the turret (Figure 15) with no behind-the-plate effects.



Legend:

- - Perforation
- ✱ - Hit
- - Ricochet Off Ground

FIGURE 15. Tank 34, Impact Diagram.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 29

1. Description:

The target tank was impacted at an attack aspect of 215 degrees (left rear) during one firing pass in which the attacking aircraft expended 53 rounds.

2. Kill Assessment:

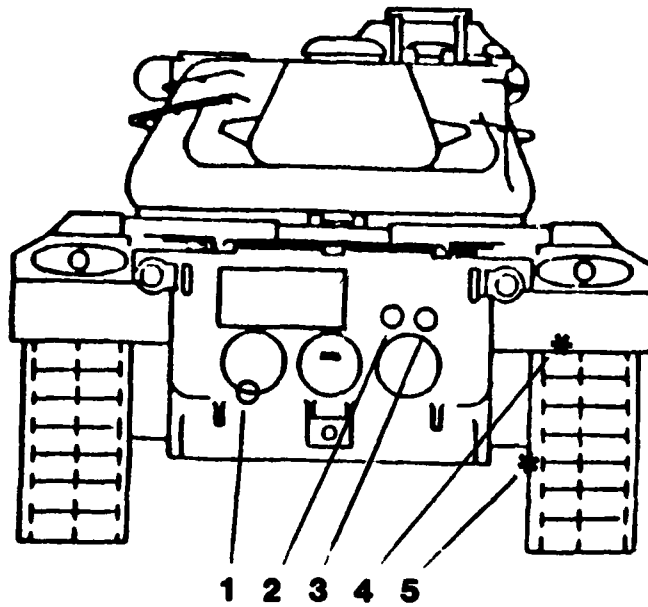
No degradation in mobility or fire-power.

a. Perforations	:	0
b. Significant Impacts	:	0
c. Insignificant Impacts:		<u>5</u>

TOTAL IMPACTS	:	5
---------------	---	---

3. Rationale for Kill Assessment:

None of the impacts on tank 29 (Figure 16) contributed to the assessment of either an M- or an F-Kill.



Legend

- - Perforation
- * - Hit
- - Ricochet Off Ground

FIGURE 16. Tank 29, Impact Diagram.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 27

1. Description:

The target tank was impacted at an attack aspect of 220 degrees (left rear) during one firing pass in which the attacking aircraft expended 35 rounds.

2. Kill Assessment:

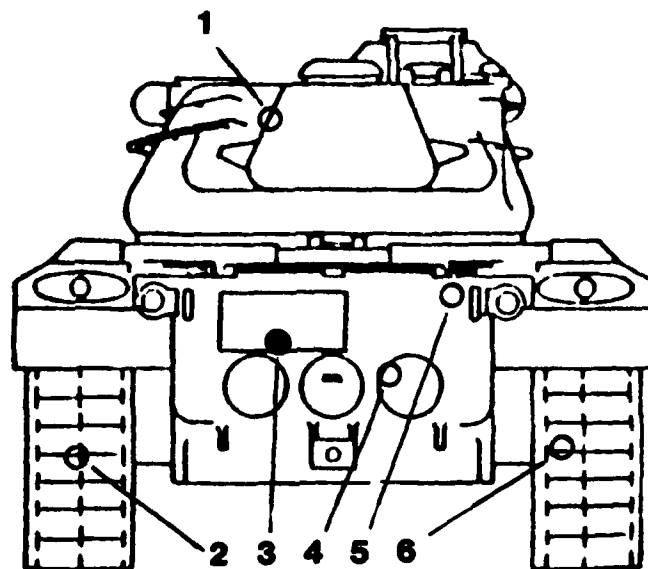
No degradation in mobility or firepower.

a. Perforations	:	1
b. Significant Impacts	:	0
c. Insignificant Impacts:		<u>5</u>

TOTAL IMPACTS	:	6
---------------	---	---

3. Rationale for Kill Assessment:

All of the impacts on the target were ricochets off the ground. Impact 3 (Figure 17) perforated the rear hull armor but did not possess enough residual energy to penetrate into the transmission case. The remaining five projectiles impacted the track and suspension system, hull, and turret with no harmful effects on mobility or firepower.



Note: Perforation resulted from ricochet off ground

Legend:

- - Perforation
- ✱ - Hit
- - Ricochet Off Ground

FIGURE 17. Tank 27, Impact Diagram, Rear.

TARGET TANK DAMAGE SUMMARY

M-47 TANK NUMBER 4

1. Description:

The target tank was impacted at an attack aspect of 145 degrees (right rear) during one firing pass in which the attacking aircraft expended 62 rounds.

2. Kill Assessment:

100% M-Kill and 100% F-Kill resulting from the following observed effects (Figures 18, 19, and 20):

a. Perforations	:	3
b. Significant Impacts	:	7
c. Insignificant Impacts:		<u>22</u>

TOTAL IMPACTS	:	32
---------------	---	----

3. Rationale for Kill Assessment:

- a. M-Kill: The assessment of a 100% M-Kill is based on impacts 15 and 16 (Figure 21) which perforated the rear hull armor and penetrated into the engine compartment, severing two oil cooler lines and penetrating the transmission case; and on cumulative damage to the track and suspension system caused by impacts 19, 25, 28, 30, 31, and 32. Crew casualties caused by impact 1 contributed to the kill.
- b. F-Kill: The assessment of a 100% F-Kill is based on impact 3 which hit in the turret ring and jammed the turret so that it would not traverse, and on impact 1 (Figure 22) which perforated the turret and caused casualties to the commander, gunner, and loader.

NOTE: Hits 19 and 20 impacted on the inside of the left compensating idler wheel and the left track respectively.

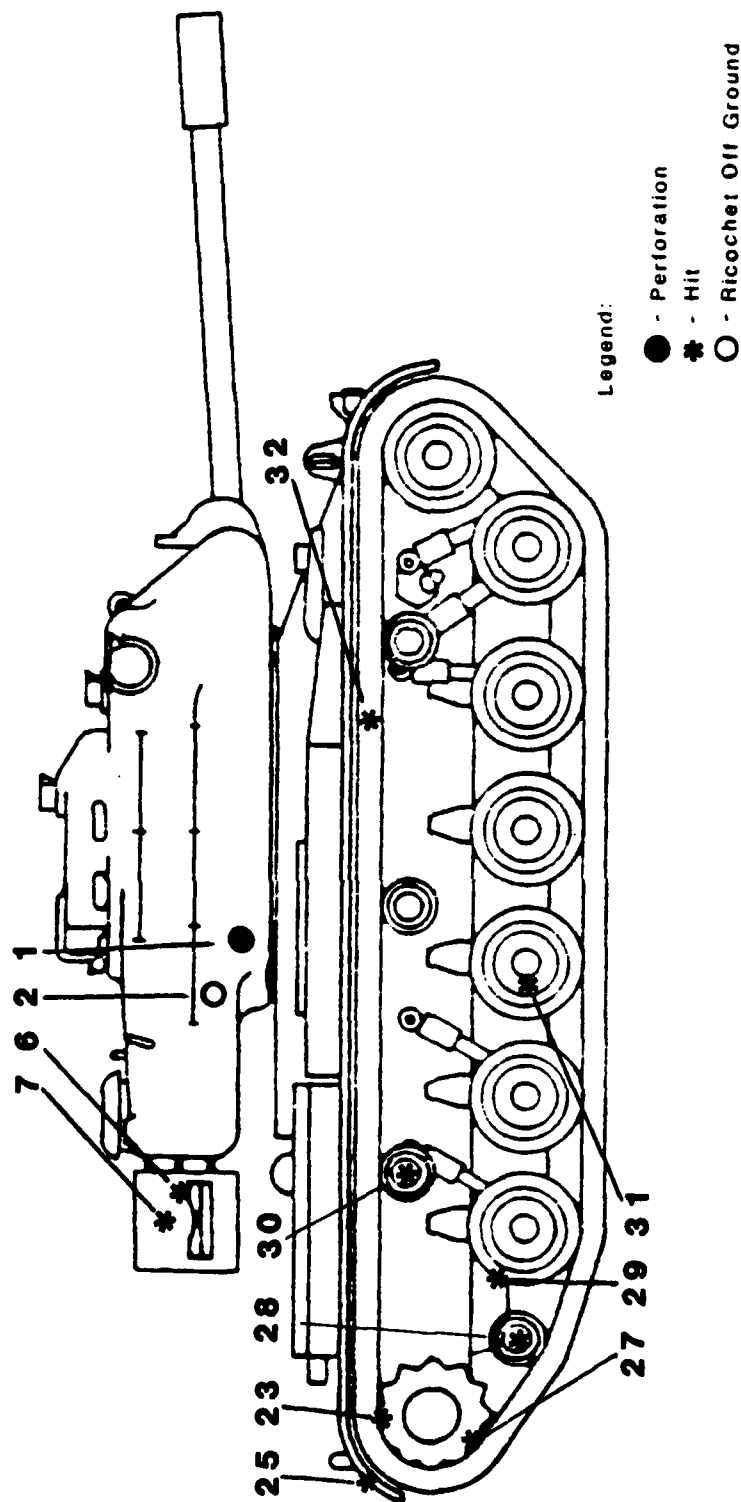


FIGURE 18. Tank 4, Impact Diagram.

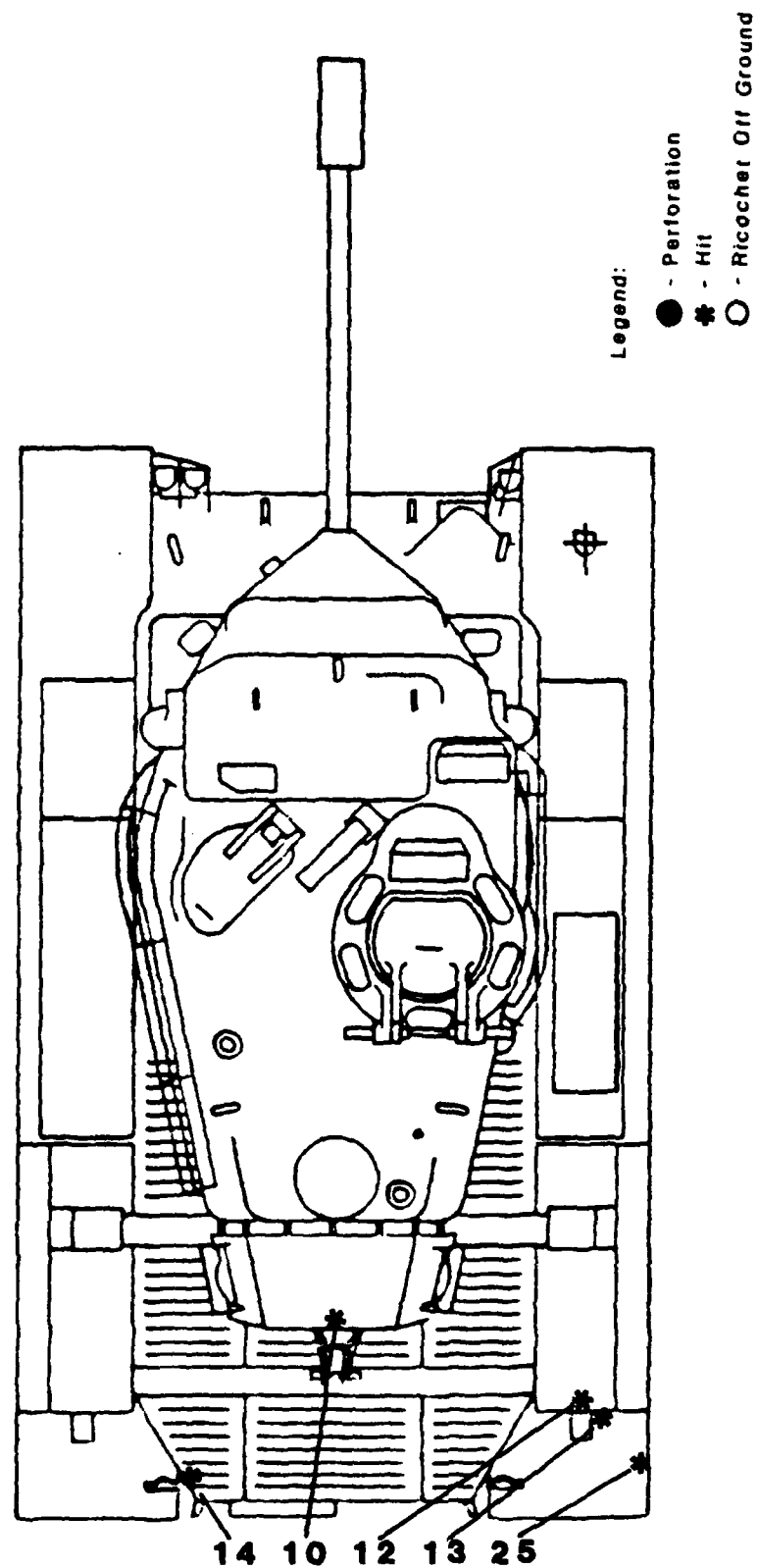


FIGURE 19. Tank 4, Impact Diagram.

Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

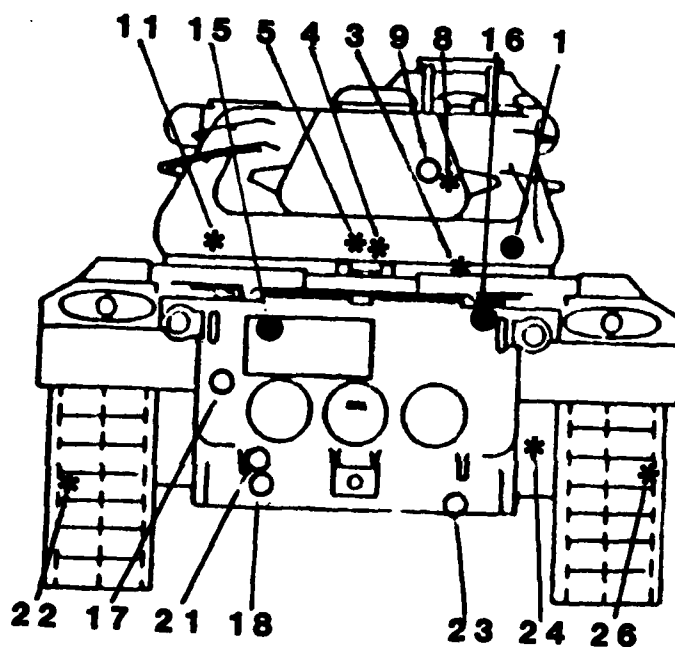
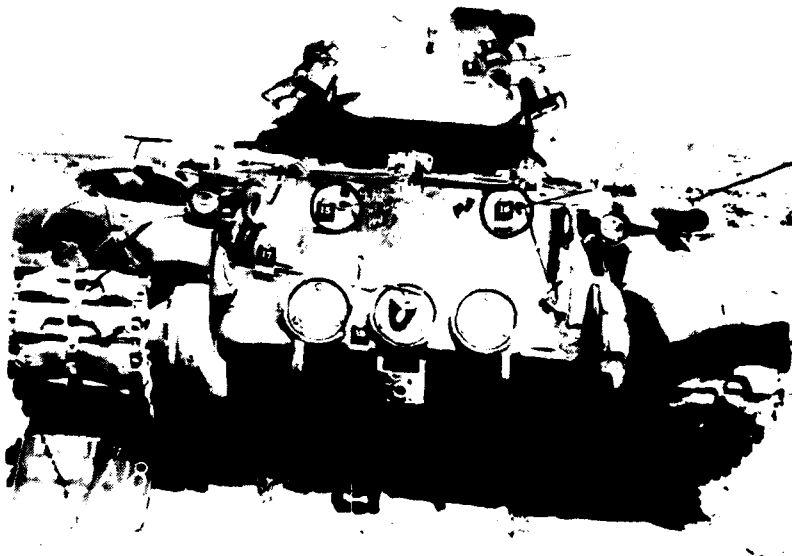


FIGURE 20. Tank 4, Impact Diagram.



Note impacts 15
and 16 which per-
forated rear hull
and penetrated
into transmission
case and oil cooler
lines.

FIGURE 21. Tank 4, Photo, Rear.



Note fragmentation effects on commander and loader manikins from impact 1.

FIGURE 22. Tank 4, Photo, Commander and Loader.

TARGET TANK DAMAGE SUMMARY

M-47 Tank Number 7

1. Description:

The target tank was impacted at an attack aspect of 163 degrees (right rear) during one firing pass in which the attacking aircraft expended 70 rounds.

2. Kill Assessment:

100% M-Kill and 100% F-Kill resulting from the following observed effects (Figures 23 and 24):

a. Perforations	:	3
b. Significant Impacts	:	6
c. Insignificant Impacts:		<u>15</u>

TOTAL IMPACTS	:	24
---------------	---	----

3. Rationale for Kill Assessment:

- a. M-Kill: The assessment of a 100% M-Kill is based on impacts 12 and 13 which perforated the rear of the hull penetrating into the transmission case, and on cumulative damage to the track and suspension system caused by impacts 14, 17, 18, 19, and 24.
- b. F-Kill: The assessment of a 100% F-Kill is based on impact 1, which perforated the right side of the turret killing the gunner and damaging the commander's main armament controls, and impact 2 which jammed the turret so that it could not be traversed (Figure 25).

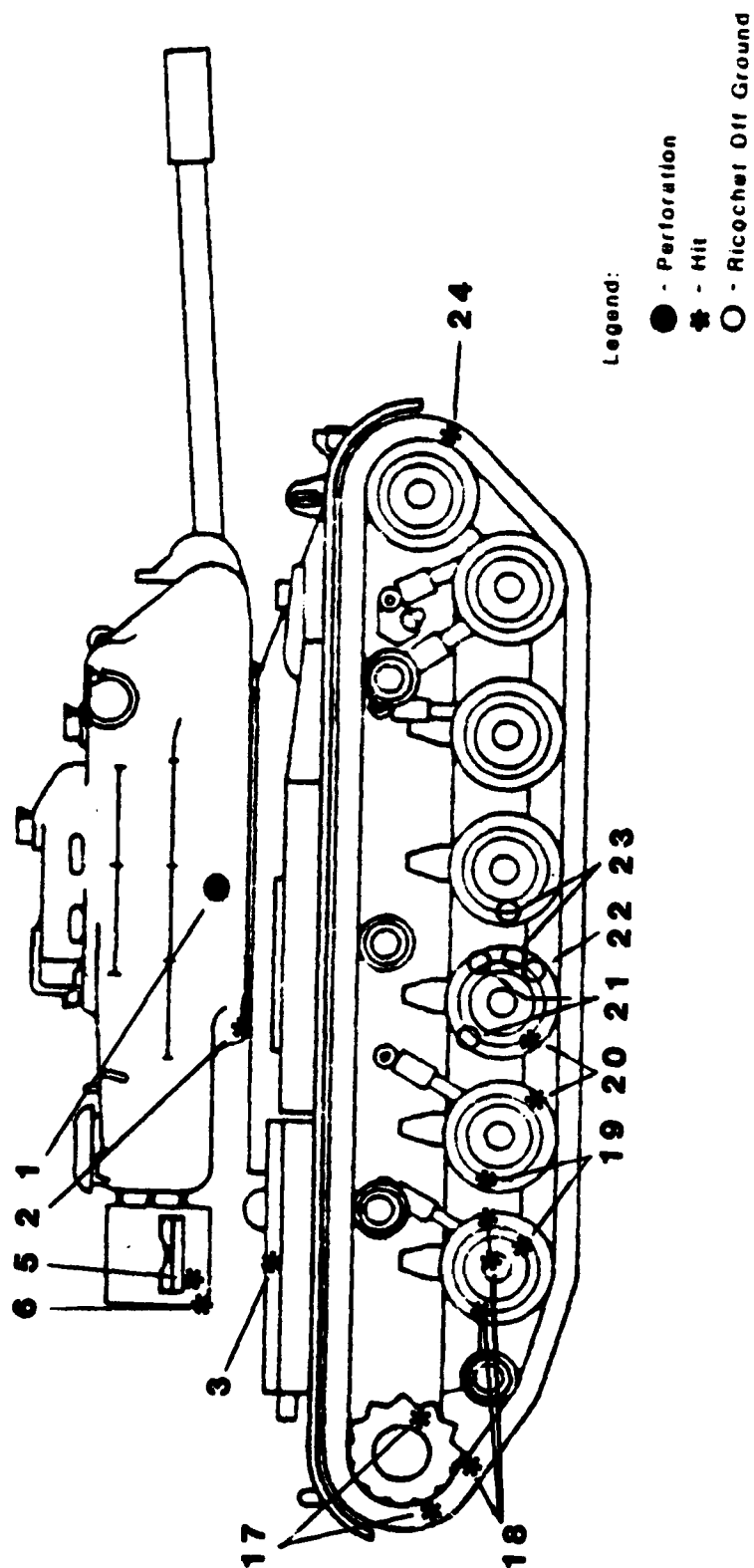
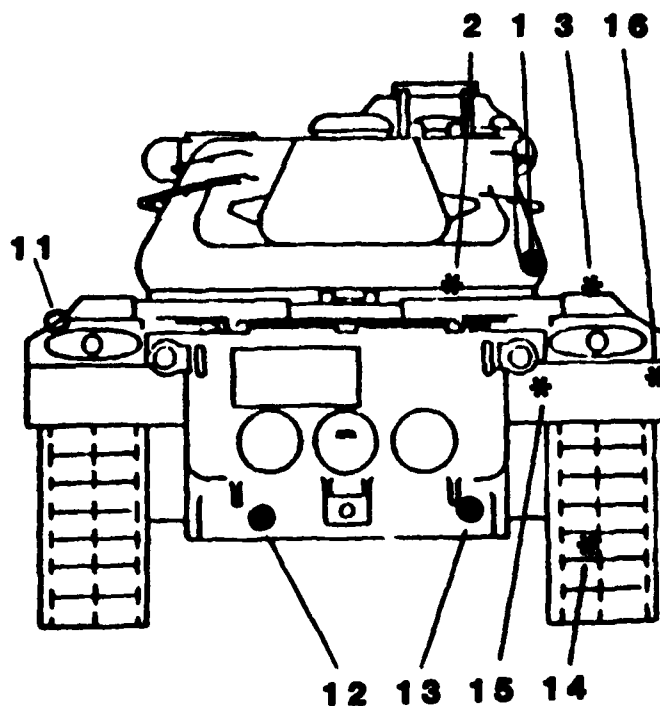


FIGURE 23. Tank 7, Impact Diagram, Right Side.

NOTE: Impacts 4,7,8,9, and 10 are not shown. These impacts struck the top surface of the tank and resulted in minor external damage.



Legend:

- - Perforation
- * - Hit
- - Ricochet Off Ground

FIGURE 24. Tank 7, Impact Diagram, Rear.



Note impacts 1
(perforation) and
2 (hit, which
jammed turret).

FIGURE 25. Tank 7, Photo, Right Side.

SUMMARY AND CONCLUSIONS

On 30 August, 1979 at Nellis AFB, Nevada, the Combat Damage Assessment Team (CDAT) conducted firings of the A-10/GAU-8 weapon system against an array of 10 tanks simulating a Soviet tank company deployed for an attack. The purpose of the firing test was to evaluate the effects of Aerojet Lot Number AJD 79A181-001 30mm API anti-tank ammunition of the GAU-8 gun under challenging conditions of engagement for the A-10/GAU-8 system against realistically simulated Soviet tank formations. The CDAT used M-47 tanks stowed with main gun ammunition, diesel fuel, lubricating oil, and crew manikins to simulate the Soviet tanks. The pilot of the A-10 aircraft used in the firings conducted the attack at low altitudes and low dive angles which simulated attack below the altitude of the effective engagement for opposing air defense systems using acquisition and fire control radar.

The firing test can be summarized in terms of the following data which were collected and/or extracted from the firings:

Aircraft Parameters

1. Speed (average)-----523 ft/sec
2. Altitude-----333 feet
3. Dive Angle (average)-----4.1 degrees
4. Open-fire Slant Range (average)-----2791 feet
5. Burst Length/Rounds (averages)-----1.15 sec/60.5
6. Number Passes (primary)-----8
7. Target Aspects (predominantly)-----right rear,
left rear

Weapon Effects

1. Rounds Fired-----484
2. Impacts-----143
3. Ricochets (off ground)-- 46
4. Direct Impacts----- 97
5. Perforations----- 13

Target Damage

1. K-Kills-----0
2. M+F-Kills-----2
3. M-Kills-----2
4. F-Kills-----1
5. Light damage--3
6. Not attacked--2

These data and the more detailed base from which they were extracted can be arranged into measures of effectiveness for the A-10/GAU-8 system under conditions similar to those in the firing test, i.e., empirical combat simulation. The following values of effectiveness are based on the firing test on 30 August 1979.

Measures of Effectiveness

Accuracy Related Ratio:

$$\frac{\text{Total Impacts}}{\text{Rounds Fired}} = 0.30$$

$$\frac{\text{Direct Impacts}}{\text{Rounds Fired}} = 0.20$$

Lethality Related Ratio:

$$\frac{\text{Perforations}}{\text{Total Impacts}} = 0.09$$

$$\frac{\text{Perforations}}{\text{Direct Impacts}} = 0.13$$

Weapon System Effectiveness Ratio

$$\frac{\text{Tanks Immobilized}}{\text{Passes}} = 0.50$$

$$\frac{\text{Tanks K-Killed}}{\text{Passes}} = 0.0$$

The eight target tanks were attacked predominately from the right rear, rear and left rear and suffered the damage shown in Table I and Table A-1.

The data and measures summarized above, and the other data contained in this report, support several conclusions:

1. The A-10/GAU-8 weapon system in realistic simulation of combat is capable of inflicting M- and F-Kills on M-47 and similarly protected main battle tanks, e.g. Soviet T-55 and T-62 tanks.

2. The weapon system, in low level attacks, can perforate specifically the side and rear surfaces of the hulls and turrets of M-47 and similarly protected main battle tanks.

3. The weapon system is an effective killing agent against the side and rear surfaces of M-47 and similar tanks when firing moderate length bursts of 0.65 to 1.45 seconds containing 35 to 85 rounds.

4. From the viewpoint of GAU-8 30mm API ammunition effects and resulting damage to combat stowed main battle tanks, the tactic of low-level attack in this firing test was shown to be a successful one.

APPENDIX A

Graphical and Summary Information

Table A-I contains a summary of the results of Mission 18 of 30 August, 1979. Table A-II contains a summary of damage assessment based on perforation locations. Table A-III contains a summary of aircraft attack parameters. Figure A-1 depicts aircraft attack aspect by tank number as a function of open-fire range.

Table A-I. Array 18 Results Summary
(30 August 1979)

Target Tank No.	Damage Assessment* (M%) (F%) (K%)	All Target Impacts	Direct Impacts	Rounds Fired	Total Perforations
27	---	6	0	35	1
29	---	5	2	53	0
41	100 95	31	18	47	2
38	100	19	12	62	1
7	100 100	24	20	70	3
4	100 100	32	26	62	3
35	95 100	25	19	85	3
34	---	1	0	70	0
33	---	NOT ENGAGED			
31	---	NOT ENGAGED			
TOTALS:		143	97	484	13

*K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill

TABLE A-II. Array 18 Perforation Location Summary
(30 August 1979)

Target Tank	Damage Assessment* (M%) (F%) (K%)		Turret Perforations (Fighting Compt)	Hull Perforations		Total Perforations
				Fighting Drivers	Engine	
				Compt	Compt	
27	---	---	0	0	1	1
29	---	---	0	0	0	0
41	100	95	2	0	0	2
38	100	---	0	0	1	1
7	100	100	1	0	2	3
4	100	100	1	0	2	3
35	95	100	3	0	0	3
34	---	---	0	0	0	0
33	---	---	NOT ENGAGED			
31	---	---	NOT ENGAGED			
TOTALS:			7	0	6	13

*K = Catastrophic Kill; M = Mobility Kill; F = Firepower Kill

TABLE A-III. Array 18 Aircraft Attack Parameters
(30 August 1979)

Acft Pass *	Tank No.	Open Fire Slant Rng (feet)	Dive Angle Open/Cease (degrees)	Altitude (feet)	Velocity Open/Cease (ft/sec)	Burst Length (seconds)	Source
1/1	27	2666 2545	-4.0/-3.0 -5.1/-4.1	138 169	555.7/555.7 557.4/557.4	.58 .5	HUD TSPI
1/2	29	** **	-2.0/-2.0 -2.9/-2.0	63 103	537.1/537.1 542.2/542.2	.83 .5	HUD TSPI
1/3	41	** **	-4.0/-4.0 -4.3/-2.5	138 135	555.7/537.1 548.9/548.9	.75 .7	HUD TSPI
1/4	38	2677 2208	-5.0/-5.0 -3.9/-2.6	138 140	545.5/545.5 554.0/550.6	.96 .7	HUD TSPI
1/5	7	2688 2471	-5.0/-5.0 -3.2/-1.5	63 125	564.0/564.0 586.1/577.6	1.08 .9	HUD TSPI
1/6	4	2955 2479	-5.0/-4.0 -3.2/-1.4	138 133	555.7/555.7 582.7/572.6	1.29 1.1	HUD TSPI
1/7	35	2967 2281	-5.0/-4.0 -3.0/-1.3	83 125	564.1/557.4 587.8/574.2	1.33 1.1	HUD TSPI
1/8	34	** **	-4.0/-4.0 -4.0/-4.0	83 122	574.2/574.2 592.8/594.5	1.08 .7	HUD TSPI
***Averages: 2823			-3.4	118.5	561.0	0.88**	

Nominal HUD film Tolerances:

Slant Ranges: Plus zero minus 300 feet
Dive Angles: Plus or minus 0.5 degrees
Velocities: Plus or minus 8.44 ft/sec
Burst Times: Plus 0. minus .083 seconds

* Pass 1/1 means pilot 1, pass 1; 1/2 means pilot 1, pass 2, etc.
** Position uncertain
*** HUD average is 1.15 seconds
**** Averages include Cinephototeodolite TSPI data. Due to TSPI camera positioning TSPI data is considered less accurate than HUD camera film data.

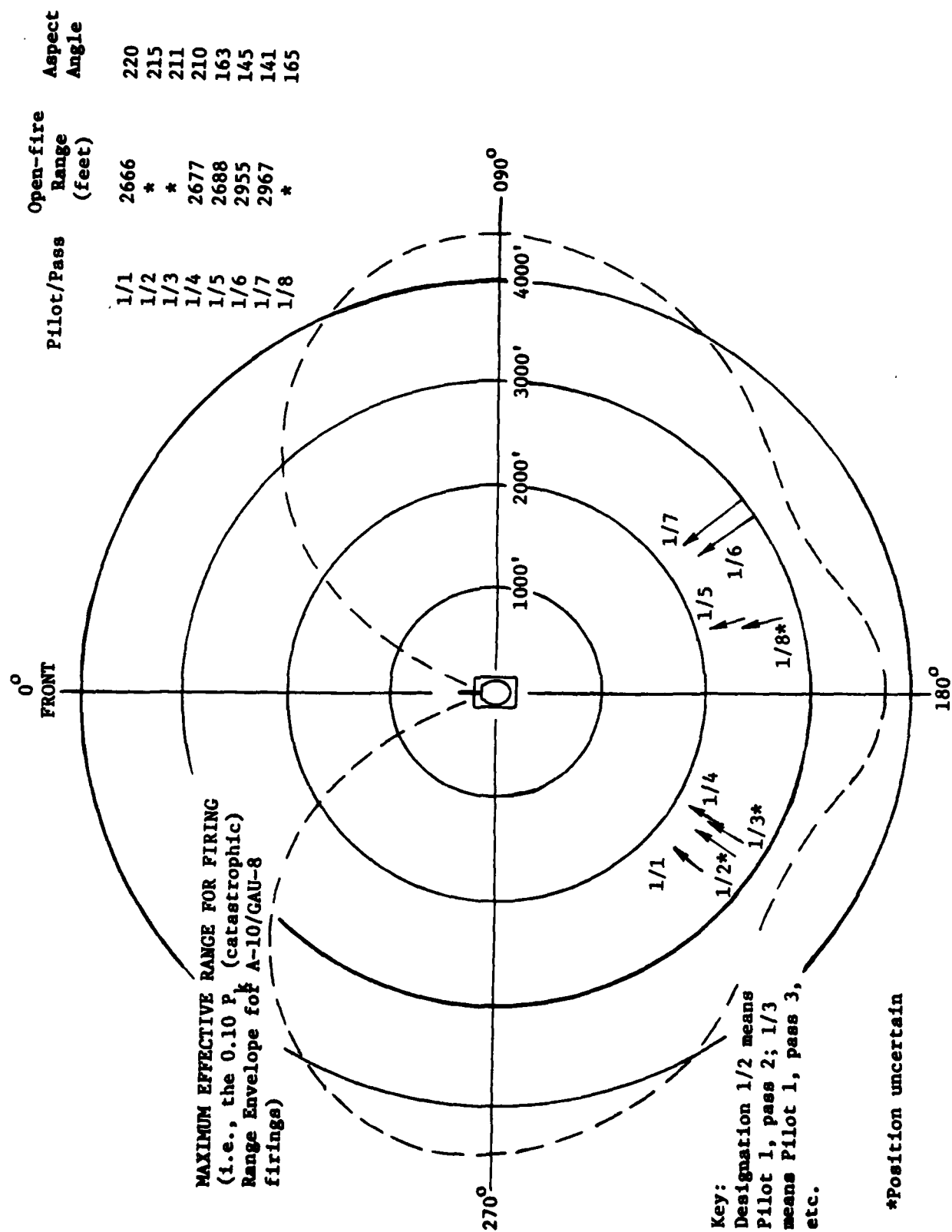


FIGURE A-1. Array 18 Attack Aspect Summary.

APPENDIX B

DEFINITIONS

The terms used in this report are defined below:

IMPACT -- Any evidence of a projectile strike against any portion of the target. Ground ricochets striking the target were classified as "impacts".

PERFORATION -- Any rupture of the armored envelope caused by an impacting projectile which results in a complete rupture of an armored surface by the projectile or spall fragments. A perforation can occur only when the armor is impacted. The word "Perforation" was deliberately selected to avoid the ambiguities which may occur through use of the word "penetration". Behind-the-plate effects may or may not result from a perforation.

HIT -- Any impact not classified as a perforation.

MOBILITY KILL (M-KILL) -- Loss of tactical mobility resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% M-Kill when it is no longer capable of executing controlled movement on the battlefield. Mobility is DEGRADED when a tank can no longer maintain position in its formation.

FIREPOWER KILL (F-KILL) -- Loss of tactical firepower resulting from damage which cannot be repaired by the crew on the battlefield. A tank is considered to have sustained a 100% F-Kill when it is incapable of delivering controlled fire from its main armament. Firepower is DEGRADED when a tank can no longer maintain its "normal" rate-of-fire, velocity, accuracy, time to shift targets, etc.

CATASTROPHIC KILL (K-KILL) -- A tank is considered to have sustained a K-Kill when both an M-Kill and a F-Kill have occurred as the result of killing fires and explosions from ignited fuel and/or ammunition. A tank which has suffered a K-Kill is considered not to be economically repairable, and, by U.S. standards, would be abandoned on the battlefield.

ATTACK ASPECT -- The angle of approach of the aircraft with respect to the orientation of the tank with zero degrees representing the front of the tank (gun forward) and 180 degrees representing the rear of the tank.

SIGNIFICANT IMPACTS -- Impacts which damage systems, components or sub-systems resulting in their destruction or partial loss of function. This type damage contributes to the assessed kill.

INSIGNIFICANT IMPACTS -- Impacts which damage non-critical structural, convenience, or accessory components and which may result in their destruction or partial loss of function, but with no impact on mobility or firepower considerations. Good maintenance practices contemplate repair or replacement of such items at the earliest opportunity consistent with accomplishment of the mission.

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60.	9 AF/DO Shaw AFB, SC 29152	2
61.	CINCUSAFE/DO Ramstein AFB APO 09012	1
62.	CINCUSAFE/DOOF Ramstein AFB APO 09012	2
63.	CINCUSAFE/DOOT Ramstein AFB APO 09012	2
64.	CINCUSAFE/DOST Ramstein AFB APO 09012	2
65.	USAF Maj. Gen. Kelly TFWC/CC Nellis AFB, NV 89191	5

66.	66 FWC/CC Nellis AFB, NV 89191	50
67.	Thomas P. Christie DASD (Tactical Air Program) PA&E Room 2E330 Pentagon Washington, DC 20301	50
68.	Maj. Davies (ASD/YXA) USAF/Aeronautical Systems Division A-10 System Program Office Directorate of Armament Wright-Patterson AFB, OH 45433	10
69.	Battelle Columbus Laboratories Tactical Technology Center Room 13-4127 Attention: Mr. J. Tuck Brown 505 King Avenue Columbus, OH 43201	5
70.	HQ USAF DSC/RDF Pentagon - 4D283 Washington, DC 20330	5
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72.	Maj. Robert. K. Redlin Commandant of the Marine Corps Code R&P Headquarters, U.S. Marine Corps Washington, DC 20380	1
73.	Lt. Gen P.X. Kelly, USMC Deputy Chief of Staff, Requirements & Programs Headquarters U.S. Marine Corps Washington, DC 20380	1
74.	Lt. Col. G. W. Keiser (Code RP) U.S. Marine Corps Requirements & Programs Washington, DC 20380	1

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78.	Maj. Gen. Thomas P. Lynch Commanding General U.S. Army Armor Center Fort Knox, KY 40121	1
79.	Lt. Col. John H. Ridge U.S. Army Armor Center Fort Knox, KY 40121	1
80.	Maj. Barry D. Watts OSD/Office of Net Assessment Pentagon - 3A930 Washington, DC 20301	1
81.	HQ TAC/CC Langley AFB, VA 23665	2
82.	Library, Code 0212 Naval Postgraduate School Monterey, CA 93940	2
83.	Dept. Chairman Dept. of National Security Affairs Naval Postgraduate School Monterey, CA 93940	2
84.	Professor R.H.S. Stolfi Dept. of National Security Affairs Naval Postgraduate School Monterey, CA 93940	30
85.	AFIT/CIP (Library) Wright-Patterson AFB, OH 45433	2
86.	AFIS/INH Ft. Belvoir, VA 22060	1

87.	Brig. Gen. Reed 355 TFW/CC Davis Monthan AFB, AZ 85707	5
88.	Col. Wayne E. Davis 1411 Gemini Circle Moody AFB Valdosta, CA 31601	1
89.	Brig. Gen. W.S. Harpe 14 TFW Columbus, MS 39701	5
90.	354 TFW/DCM Myrtle Beach AFB, SC 29577	1
91.	TAC/DR Langley AFB, VA 23665	1
92.	CIA/HQ Washington, DC 20505	2
93.	General Elwood Quesada (Retd.) L'Enfance Plaza Washington, DC 20024	1
94.	Mr. P.M. Sprey Box 264, R.D. 1 Glenn Dale, MD 20769	5
95.	Mr. Mike Mecca Fairchild Industries Germantown, MD 20767	2
96.	Industrial College of the Armed Forces Library Ft. Lesley J. McNair Washington, DC 20319	1
97.	Mr. Bernard Kornhauser System Planning Corp. 1500 Wilson Blvd. Suite 1500 Arlington, VA 22209	1
98.	Maj. Gerald H. Felix, USAF 112 TFG Greater Pittsburgh Airport Pennsylvania Air Guard Pittsburgh, PA 15180	5

99.	USMCDEC Firepower Division Air Branch/Code DP92 Attention: Ms. Kearns Quantico, VA 22134	5
100.	USAF TAWC Eglin AFB, FL 32542	1
101.	Headquarters U.S. Marine Corps Chief of Staff Arlington Annex Room 2010 Columbia Pike & Arlington Ridge Road Arlington, VA 20370	5
102.	USAF Air University Library Maxwell AFB, AL 36112	2
103.	CMDR, Naval Weapons Center Attention: Mr. Bates China Lake, CA 93555	2
104.	Col. Robert M. Gomez/DRXSR Deputy Director/Commanding Officer Ballistic Research Laboratory Building 328 Aberdeen Proving Ground, MD 21005	1
105.	GE, Armament Systems Dept. Director Lakeside Ave. Burlington, VT 05401	1
106.	HQ TAC/DO Langley AFB, VA 23665	5
107.	354 TFW/CC Myrtle Beach AFB, SC 29577	5
108.	23 TFW/CC England AFB, LA 71301	1
109.	356 TFS/DO Attention: Maj. Lt. Col. Jenny Myrtle Beach AFB, SC 29577	5
110.	USAC 4SC Ft. Leavenworth, KS 66027	1

111. 355 TFW/DOW Davis Monthan AFB, AZ 85707	1
112. 355 TFW/DO (A-7) Davis Monthan AFB, AZ 85707	5
113. 355 TFW/DO (A-10) Davis Monthan AFB, AZ 85707	5
114. 333 TSTS/CC Davis Monthan AFB, AZ 85707	1
115. 333 TSTS/DO Davis Monthan AFB, AZ 85707	5
116. OLAC 4444 OPS SQ (ISD) Davis Monthan AFB, AZ 85707	1
117. 355 TTS/CC Davis Monthan AFB, AZ 85707	1
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131. Mr. Arthur G. Hanley Central Intelligence Agency Procurement Management Staff Washington, DC 20505	1
132. 50 TFW/CC APO NY 09109	1

133. 5E TFW/DO APO NY 09109	5
134. 5E TFW/DO 496 TFS Attention: Maj. Ratley APO NY 09109	5
135. Energy Efficiency System Attention: Mr. Verdi 187 W. Orangethorpe Road Suite P Placentia, CA 92670	1
136. Col. Richard C. Head Council on Foreign Relations The Harold Pratt House 58 East 68 Street New York, NY 10021	1
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138. Col. Faybanic AWC/DAUM Maxwell AFB, AL 36112	1
139. Mr. Cobleigh Hughes Aircraft Canoga Park, CA 91304	1
140. Boeing Attention: Mr. Bud Nelson P.O. Box 3999, M/S 40-30 Seattle, WA 98124	1
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151. 92 TFS/CC/DOW 2
APO 09755
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152. Military Attache 1
U.S. Embassy (Rome, Italy)
APO 90794
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153. Military Attache 1
U.S. Embassy (Bonn, Federal Republic of Germany)
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154. Military Attache U.S. Embassy (Saudi, Arabia) APO 99697 New York, New York 99012	1
155. Military Attache U.S. Embassy Attention: Air Attache New Delhi, India	1
156. Military Attache U.S. Embassy Attention: Maj. McBaron Canberra, Australia	1
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