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# HOW TO DESIGN WAR GAMES TO ANSWER RESEARCH QUESTIONS

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INTRODUCTION. In war gaming, to produce data for analysis, the game itself and the forms of data extraction must be designed to give outputs conveniently usable in answering the specific research questions that the game seeks to solve. This paper presents methods developed with this purpose in mind and employed in a rigidly-assessed, manually-played war game. With a brief historical sketch of the uses of war gaming from the 19th century to the present as background, present war games are classified into three groups, manual, computer-assisted, and computer-programmed, and defined. The design of manually-played war games is then considered separately in the context of a laboratory research tool. Finally, the application of the design requirements is illustrated by a description of TACSPIEL, RAC's division level war game.

Historically, war games have been developed and played to train officers and to test war plans. The former purpose was evident in the 19th century when Rigid Kriegspiel and Free Kriegspiel were developed. The testing of war plans by war games was used extensively by the Germans in the first half of the 20th century. After World War II, the technique of employing war games as an analytic tool was developed in an attempt to answer military questions pertaining to the battlefields of the future. With the advent of high speed computers, war gamers acquired a tool that permitted more comprehensive and complex games to be played. Also, the computer brought about a classification of war games by the war gaming community. A straightforward classification is to consider war games as either manually-operated, computer assisted, or computer programmed.

A manually-operated game is one in which all game orders are written, and assessments are made by people who are governed by strict or informal game rules, in essence, a rule book or an umpire.

A computer-assisted war game is a manually-operated game with the additional attribute that some of the bookkeeping and assessments are accomplished by a computer.

The third classification, the computer war game, is now in a prominent position in the war gaming field. In this type of game, after the start button is pushed, the computer plays the game without human intervention. Each and every situation thought to be important must be anticipated and simulated in the program with a suitable response.

THE DESIGN OF A WAR GAME AS A RESEARCH TOOL. Let us now consider a war game as a laboratory tool for military research. While much of what follows applies to all classifications of war games, I will be directing my words toward manual war games as a prelude to the later description of TACSPIEL.

One use of a laboratory tool is to enable the experimenter to investigate an area which would be inaccessible without the tool. For the military, the battle field of the future is the area at which attention is focused. To open this area for investigation, the war game becomes the tool. But for the experiments, or research plays, if you will, to be meaningful, the war game must be analytic. That is, it must be engineered to present a realistic environment for controlled experimental simulations with a view toward securing data for analysis.

It is not a difficult task for the military customer and the designer of war games to agree that war games can aid in the solution of military problems. However, when the research questions are directed at echelons from platoon to army, the designer must step back and take a sharp look at the design problems both obvious and subtle.

What does he see in the way of problems? First, there is the resolution problem. What is the gamet of resolution that should be considered in the game? Can the military units be played at company and battery level? Where and when can platoon, patrols, and radars be introduced? Do the research questions permit the game to be designed with divisions as the lowest echelon? To what resolution shall the unit deployments be recorded and played? How often should the game interactions be assessed?

The second problem which goes hand-in-glove with the resolution problem is the aggregation of the game models. If the basic unit is the company, then the models must reflect the capabilities of the company to move, fight, and receive casualties. There is a paramount requirement here when the designer builds the game models. Once he has chosen the resolution for the military units, he must be extremely careful to avoid constructing a game model for which no predictive data exists at the designed echelon. Should the input data to the model be lacking for the

echelon designed, the designer must re-examine the unit resolution. In short, resolution and aggregation as reflected in the game models are the two sides of the same coin.

Another problem which relates to the desired analytic nature of a manual war game is assessment of the play. A game can be played under a set of general rules with an umpire to assess battles, contacts, and other interactions. Or the game can be played under a set of rigid rules which are as detailed as the designer can make them. In this case, umpiring occurs infrequently and only when situations and capabilities arise that are not provided for in the rules. This latter method will produce the most objective and well-defined experimental conditions for a manually conducted game that can be attained.

Once the war gamer has decided on the resolution and aggregation level, he must now consider the basic tactical structure of the game. There are three characteristics which identify combat. They are the movement of units, the meeting of units known as contact, and the engagement by fire and maneuver of opposing units called battle. These characteristics are the basic tactical structure of a war game whether the game depicts ground, sea or air warfare. Any war game design must start by constructing models to represent these three characteristics.

Once the basic models of movement, contact, and battle exist, the war game is ready to consider the specific research questions of the military customer. When the research question is asked, the war gamer must ask himself three questions.

What models must be built such that the events to which the question is addressed will necessarily occur in the course of the play? What additional models must be designed to reflect the player's usual military capabilities, for example, artillery and tactical aircraft? How should all these models be constructed so that the output of each is presented in both usable form for analysis and with tactical realism for the players?

As an example relating to the first question, if the research question was to investigate the surveillance capability of a division in order to determine the detection rate of ground and airborne sensors, the war gamer would have to build, in detail, one model depicting the capability of each type of ground and airborne sensor including its associated delivery vehicle. These models would presumably allow the division commander as much flexibility as would be expected in actual combat and

would produce sufficient data for analysis. If the particular play was not directed at the surveillance question, an aggregate model depicting the intelligence acquisition capabilities of the airborne sensors could be built.

The third question concerning the presentation of the output of the models contains several requirements. The desired data for analysis must be presented in a format that can be easily manipulated manually or by a computer program. With the same format, the game assessments which contain the data for analysis should be presented unambiguously to the players and contain as much but no more information as could be expected to arise in actual combat under the same conditions that the model attempts to simulate. Without relaxing the above requirements, the recording of the assessments in a data format must not be time consuming. Otherwise the time saved during the analysis by preplanning the organization of the game data will be lost by the data recording process during the play of the game.

DESCRIPTION OF TACSPIEL. So far I have discussed the design of manually played war games pointing out the requirements for a basic tactical structure, associated sub-models, and data format.

I will now describe TACSPIEL, RAC's division-level war game, as an illustration of the application of the foregoing design principles and requirements.

The objective of TACSPIEL is ". . . to study operational problems of ground combat at division and lower echelon by analysis of play of a detailed tactical war game". The objective sets the framework within which the game was designed.

TACSPIEL is two-sided, free-play, analytic, rigidly-assessed, and manually operated. It is a free play game since after each side has been given their forces, scenarios, assigned missions, and approximate location of their respective reconnaissance elements, they are not constrained in their concepts of operation and organization other than the requirement to stay within the 45 x 200 km area of play.

It is analytic in that it is engineered to support research as a tactical environment for controlled experimental simulation of operational capabilities with a view toward securing data for analysis of their performance.

By rigid assessment it is meant that the game is conducted using a manual of rules that are as detailed as the years of operation and present ingenuity can make them, and that they limit Control as well as the players. The assessment of movement, contact, and battle are done by two ground assessors, one representing Blue, and the other Red. They must agree on the assessments that arise from interaction between the opposing forces that the game rules recognize. When unreconcilable situations, or situations and capabilities unprovided for by the rules arise, the senior controller intervenes, decides or umpires the offending assessment, and a new rule or a clarification of an old one is generated. Thus, the game manual is a living document, and some umpiring does occur. But this organization of game assessment is believed to provide the most objective and well-defined experimental conditions for a manually-conducted game that can be attained.

The game is played on 1:25,000 scale relief models of an area 44 x 90 km. The terrain selected is considered to influence but not dominate the operations at division level. The relief models depict three classes of roads, the railroads, all military streams, three classes of vegetation, all built-up areas and other limitations to movement. The relief is shown as 20 meter contour steps, with 2:1 vertical exaggeration. The interval of play is 30 minutes, and unit deployments are known to the 1 x 1 km square. The organization of units is resolved to the company, battery and armored platoon levels. This resolution at company level was dictated by the lack of predictive data at lower echelons for use as inputs to the battle model. Battery and armored platoon resolution was required to permit flexibility and realism in the employment of artillery and reconnaissance elements. The foregoing details apply to the basic tactical structure that exists in order to generate the operational environment. For research purposes, locations of point objects such as radars, OPs, minefield lanes, and boundaries can be specified to the nearest 100 x 100 m; timing of events can be reckoned to the nearest 5 minutes; and individual patrols can be assessed. The presence or absence of this latter kind of expensive detail largely depends on research objectives requiring them in any given play.

As discussed before, the basic tactical structure of a war game must contain the models for movement, contact, and battle or resolved units. These and other models developed to reflect the division's capabilities and tactical realism are shown in Figure 1. (Figures can be found at the end of this article.)

MOVEMENT MODEL. The movement model is designed to reflect a unit's maneuver capability. At the level of resolution played, this model represents in effect the movement rate of the center of mass of the unit. The movement model permits cross-country and road movement, deployed or in column for tracked and wheeled vehicles and dismounted troops. Reductions and restrictions on the rate of movement occur whenever the slope of the terrain is excessive, dense vegetation is encountered, escarpments occur, or when moving under artillery fire.

CONTACT MODEL. The contact model was developed to reflect a unit's visual and oral detection capability. In order to permit terrain to play its natural role on the battlefield, ridge lines are present on the terrain board in the Control Room. If any part of a unit's deployment area is in a terrain cell, as defined by the Control terrain model ridge lines, it is assumed that the unit exercises the full surveillance capability in that cell. Further, enough of the unit is in that cell to provide a complete sample of the unit for enemy visual surveillance and possible complete reporting.

Since in actual combat, initial visual contact does not always result in perfect identification as to the size and type of the contacted force, a distribution of possible identifications is used to determine the content of the contact report.

A three-digit code is used to report the size and type of the contacted unit. The size of the contacted unit can be reported accurately, or simply as "unknown". The type of unit may be reported accurately, i. e., medium tanks, 8-in How, etc., or given a general identification, i. e., armor, artillery, etc. or just as "enemy". The output of the assessment of contact is a contact report. The information contained in this report includes the size and type of the enemy unit as obtained from the identification distribution, its location when contacted, or its location when contact was broken, its attitude, i. e., moving halted, deployed, in column, and if moving, its direction of movement.

BATTLE MODEL. The third part of the basic structure, the battle model, is the most difficult model to design. If the battle model attempted to depict squad combat, how would one predict the behavior under a set of battlefield conditions of a squad without including the make-up of the individuals? At TACSPIEL's level of resolution, the company, group prediction is possible and feasible because of available basic knowledge from experience. This model must motivate the players to win. At the same time, the model must be as simple and quick to use as possible.

While the basic time resolution is one-half hour, battles are assessed on an hourly basis. That is, engagements are assessed once each hour of engagement. No winner or loser is declared but rather each force may accumulate casualties and the battle location can change if the attacker is successful. At the end of each hour of battle, the commanders receive reports of their own casualties, movement of the forces, and an estimate of casualties inflicted on the enemy. At that time they may attempt to reinforce or withdraw engaged units.

In the assessment of a battle, the engaged units basic combat effectiveness, their casualties at the start of the battle hour and the amount of casualties caused by enemy supporting artillery are used to calculate an attacker to defender force ratio. This force ratio is then used to determine by random number selection that hour's battle casualties on the attacker and defender, and the penetration of a successful attacker.

ARTILLERY MODEL. Since artillery has a capability which, in the real world, the division commander is able to employ with a high flexibility and effectiveness, the artillery model must be built to realistically reflect this capability. The emplacement time, rate of fire of the weapons, and the availability of the ammunition are the limitations on the employment of artillery. Since the effectiveness of rounds of different caliber to produce casualties vary, a standard unit of effectiveness called the fire unit or FU is used. One FU is equivalent in casualty production to 24 105-mm Howitzer HE rounds. The effectiveness of rounds of other calibers is equated to this measure. Thus, all fire missions are described and assessed, and a battery's basic load and resupply, computed in fire units.

The assessment of casualties is based on the number of fire units delivered, the type of target (armored, personnel) and posture of the target (exposed, attacking, defending, in woods, etc.) and the extent of observation on the target.

The results of a fire mission are reported to the side firing and the side receiving the shelling. The number of fire units expended, the type of target fired upon, and the target's location, are reported from the firing battery. If the fire is observed, an observer's report will contain the type and location of the target, an estimate of the damage inflicted, and the firing battery's designation to indicate what fire mission was being observed. For the unit receiving the fire, a shell report is generated containing an estimate of the amount of fire received and the amount of casualties suffered.

AIR OPERATIONS MODEL. The air operations model is designed to include the employment of air defense artillery, tactical aircraft against ground targets in support of engaged troops and against ground targets behind the enemy lines, airlift capability for divisional troops, and organic helicopters used in a reconnaissance role or to deliver fire from the air.

The effectiveness of the tactical aircraft's ordnance is equated to the artillery fire unit. Three stages of tactical air alert are played: No Alert, Standby, and On-station CAP. Three types of air missions are played, specific target, armed reconnaissance, and battle support. Appropriate planning times are assessed against aircraft when ordered from one of the air alert stages into one of the air missions.

Air defense artillery kill probabilities are based on their rate of fire, engagement ranges, altitude and speed of the aircraft.

The output of the air operations model is a report indicating the number of aircraft in the mission, the number surviving, and the result of the mission.

GROUND AND AIR SURVEILLANCE MODELS. To reflect the division's surveillance capability, OPs, patrols, and surveillance radars for the detection of moving personnel and vehicles are played in the ground surveillance model. The characteristics of the radars are obtained from the results of field tests.

The reconnaissance and surveillance capabilities of several air-borne devices and agencies are amenable to war game simulation. For the purpose of TACSPIEL, however, only those systems designed to concentrate in the 10-km area immediately beyond the line of contact are played.

Based on the previous plays in which each surveillance mission beyond 10-km from the LC was individually played, an aggregate effectiveness has been developed for the surveillance capability in the zone in excess of 10 km beyond the LC. This aggregated deep penetration surveillance includes information gathered by air photos, infrared devices and side-looking air-borne radars.

The output of both the ground and air surveillance models reflects the normal capabilities of each sensor.

LOGISTICS AND VEHICLE BREAKDOWN MODELS. The next model illustrates how TACSPIEL was applied to generate data to support analysis of a research question. The research question concerned an analysis of consumption and resupply in the ROAD Division of Class III and V Supplies. To generate the data, a tactical logistics model was developed.

The model assumed an infinite stock of ammunition at the Army Supply Point. Using the organic transportation available in the division, the player was required to order up the ammunition he needed under a side condition that the fuel for the divisional units must be hauled simultaneously out of the same transportation capability.

All basic loads and ordering of ammunition were reduced to one unit, the "fire unit" of effect. The POL consumption rates and basic loads of the various units were also reduced to a single "consumption unit" or CU, equal to 18 gallons of gasoline. Finally, the transport available to haul the basic loads and resupply Class III and V was reduced to a "transportation serial" equivalent to 7 1/2 tons of lift. In this manner, players could requisition ammunition, POL, and transport in a system of units that was independent of the detailed tables of equipment of the organization concerned.

TACSPIEL has undertaken on a trial basis a model to simulate vehicle maintenance and mechanical failure of combat vehicles. Vehicle maintenance in the division is simulated by assuming that the level of availability of wheeled vehicles is in a steady state during the play of the game. The level of availability is assumed to be 80 percent for units having five or more trucks over one ton carrying capacity. This 20 percent loss of hauling capacity is reflected through reduction in basic loads of Class III and V supplies available to the player, and in resupply capabilities.

The breakdown model has been developed from data from field trials on the M60 tank and M113 APC. This model simulates mechanical failure of APC, armored vehicles and SP artillery. During each interval in which these types of units move, the unit is assessed for breakdown. If breakdown occurs, the unit effectiveness is degraded 5 percent. At appropriate times during the game, vehicles repaired at the divisional support group are returned to the game.

By adding new simulation models and proving them out TACSPIEL can expect to increase its potential to produce useful data for research.

MECHANIZATION OF TACSPIEL. The method by which game data are made available for analysis is by employing IBM punch cards as a medium of exchange for the vast bulk of orders and reports and for the recording of data. A vocabulary of codes has been developed to transmit the game messages between the players and Control. The orders recognized by the game rules and the assessments are punched on IBM cards using IBM port-a-punch holders and 40-column partially preperforated cards. These 40-column cards are divided into several fields. One format is used for player orders and another for assessments (Figure 2). These formats are designed to include a three-digit order code or report code, the unit's order of battle, its coordinates, and all pertinent information in the order or assessment.

The flow of orders from the players to Control, the assessment of the interactions pursuant to the orders, and the reporting of the results to the players is called the Order-Assess-Report Cycle (Figure 3).

The player-commanders write their mission orders and organize their units for combat using overlays and mission order forms, (Figure 4). The written orders are translated into TACSPIEL order codes in the ORDERS column of this form (Figure 5). After coding the orders, the orders are punched on the 40-column IBM cards, using the ORDER format. These cards then go to Control with their ground mission order.

Upon receipt by Control of the IBM cards, the data on these cards are transferred to standard 80-column IBM cards by an IBM Summary Punch. The 80-column cards are then used to prepare a worksheet for the assessors called the Unit History Form. The format (Figure 6) groups the combat units with their initial coded orders as they are organized for combat on the mission order to provide continuity in time and to help organize the assessor's work. Additional headings (ORDER, ACTION, POSITION) are printed to permit the assessors to enter interval by interval any changes in orders from the players and assessment notes for each unit. Enough space on each page is available for listing units that become attached to an organization during the game. When the first page is filled, additional pages are produced which may reflect changes in the make-up of the combat organization.

After the Unit History Forms have been prepared, the action of the opposing forces is assessed. Reports generated by interactions are punched on the IBM cards in the Assessment Format, transferred by the IBM Summary Punch to standard IBM cards containing prepunched

military English, listed, and distributed to the players. For example, the output of an artillery assessment would use Code 801 for the firing unit's report and Code 750 for the observer's report, and the assessment by Control would be listed from the IBM cards (Figure 7). The percent casualties to the enemy unit and its order of battle would be deleted from the player's copy.

The player's response to the reports results in new orders by which a new Order-Assess-Report cycle is generated. Unless the general mission of a combat team is changed, the mission order form is not required for transmitting additional orders affecting that combat team.

By the use of the IBM cards and the mission order forms, a complete rapidly accessible record of the game is available for analysis. In addition, by the expedient of reproducing the cards, the data become accessible to any qualified study outside the gaming group itself.

SUMMARY. To summarize, in the design of a war game, a basic operational structure of movement, contact, and battle is required. Within this structure detailed simulations of the real world events to be studied are introduced in order to generate data to answer the specific research questions of the military customer.

In order to extract the data to answer the research questions rapidly and efficiently, the TACSPIEL war game has developed a method which combines a vocabulary of order and assessment codes with IBM cards. The result is a compact and complete game record for analysis and a data source on which analytic research can be based.

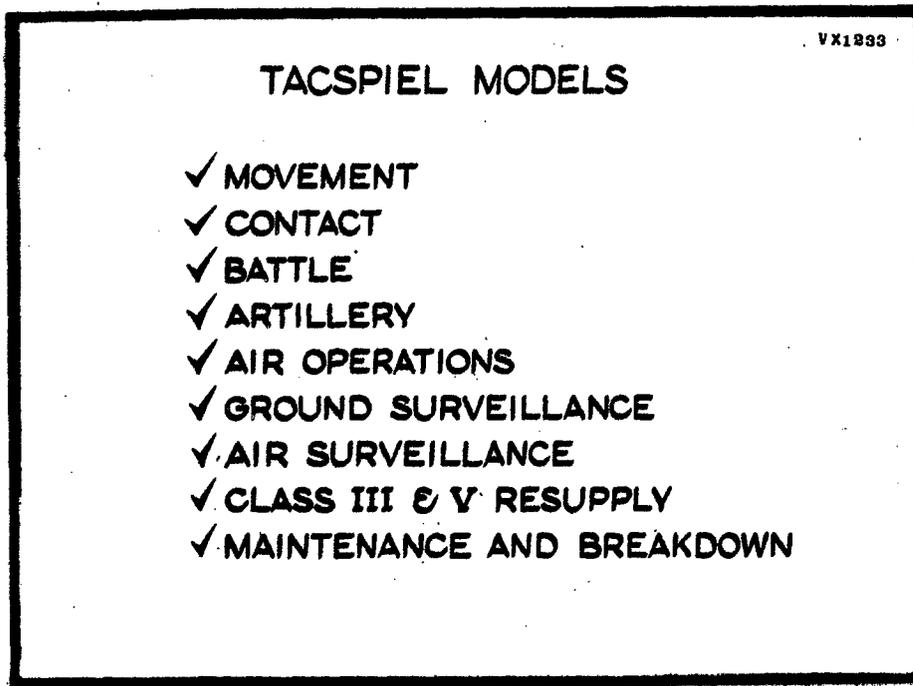


FIGURE 1- Tacspiel Models

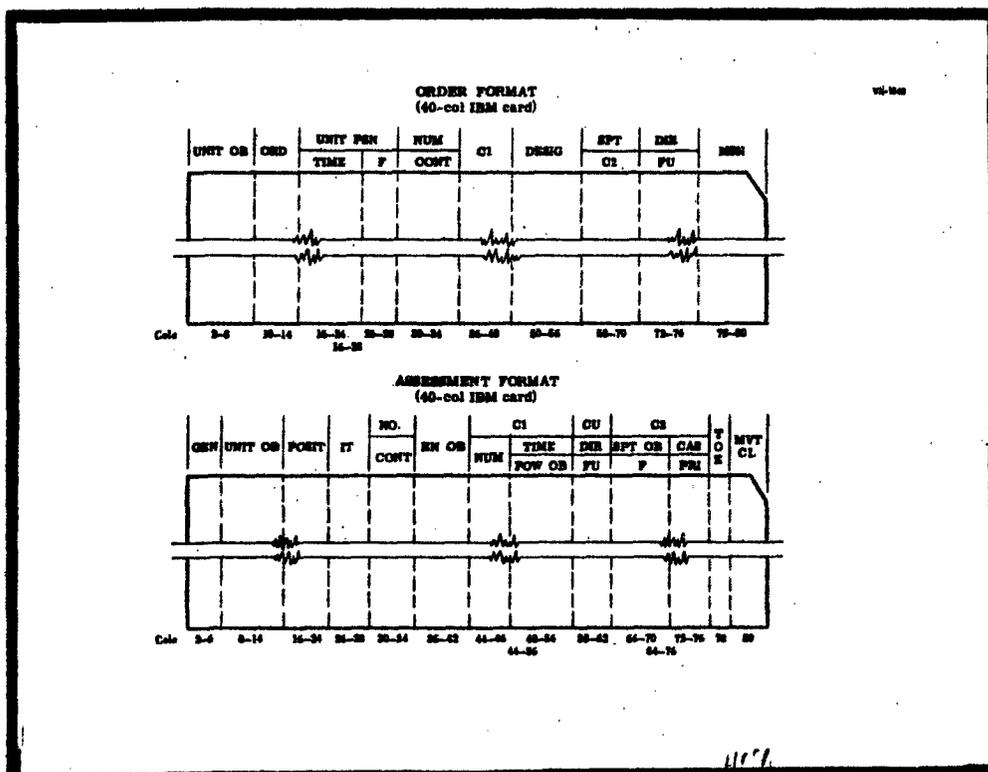


FIGURE 2- Order and Assessment Formats



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**MISSION ORDER FORM (Abbreviated)**  
with Coded Orders Added

VK-104

R B		GROUND MISSION ORDER 1		ORIGIN TIME 210600	DELIVERY TIME 210610
FROM 3		TO 22		TIME PERIOD 210610	TO 211200
ORGANIZATION		PRIMARY MISSION:			
C. S.		ORDERS		Battle Group (-) defends MAIN RIVER between (701009) and (509305) as part of Div and Corps defense.	
22H	004	22			
A22	031	1			
	020	701009			
		507305			
B22	031	1		SECONDARY MISSIONS:	
	020	700005		004	Assigned command of (designated organization) DESG
		509305		020	Assigned zone/sector of responsibility C1 to C3
C22	032	1		032	Assigned reserve role in MSN
	020	630003		033	Assigned forward defense role in MSN
		509307		121	Defend assigned sector
	131				
		SPECIAL REP:			

FIGURE 5- Mission Order Form (Abbreviated) with Coded Orders Added

VK-104

R B		GAME _____		UNIT HISTORY FORM								PAGE ____ OF ____	
												TIME ____ TO ____	
CMD ECH	UNIT	ORD	UNIT TIME	FWN F	NUM CONT	C1	DESIG	SPT C2	DER FU	MSN	TIME: ACT POS	ORD	TO ACT POS
ASBG	22H	004					22						
	A22	031				701009		507305		1			
		020						700005		509305			
	B22	031								1			
		020											
	C22	032				630003		509307		1			
		020											
		121											

FIGURE 6- Unit History Form

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## ARTILLERY ASSESSMENT CODES

VL-1547

<b>801 SPECIFIC FIRE MISSION:</b>	<b>750 OBSERVER REPORT:</b>
Expended FU Fire Units	Est. damage fr F (use OB of arty unit)
On CONT-type tgt at C1	to en tgt CONT at C1
F-type Ammo	is FU (n, l, m, h)
% caus to tgt-CAS	En Order of Battle-ENOB
En Order of Battle-ENOB	

R B ASSESSMENT REPORT TIME \_\_\_\_ TO \_\_\_\_

GEN UNIT POSIT IT

801 A12 7089 912 TGT AT 6098 RECD 10 FU, .95 CAS A61

750 B77 9197 912 VICINITY 6098 DAM REC L FR A12 A91

Note: Underlined items represent data punched from assessment.

FIGURE 7- Artillery Assessment Codes and Report

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