A HISTORICAL STUDY OF SOME WORLD WAR II AIRBORNE OPERATIONS

WSEG STAFF STUDY NO. 3

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14. ABSTRACT

**World War II saw the development of airborne operations and airborne warfare to the point where an airborne operation- that is, the forces and techniques of which it is composed and their use- could be looked upon as an additional weapons system of the armed forces or at least as a highly specialized task force combining both ground forces and air forces in a joint operation. As used in this report, an airborne operation is defined as an operation involving the movement of armed forces by air into an objective area for ground combat. The definition included the action of these armed forces on the ground as long as they are in no other contact with friendly forces except by air. During World War II airborne operations were employed on both sides in a variety of situations and with varying degrees of success. The U.S. Airborne forces in particular, experienced a considerable development both in size and technique.
 Like any new development in military thought and technique, the idea of the airborne assault has much appeal to the imagination. It is easy for enthusiasts in this direction to envisage the transport by air of entire army in the field of battle. There are others who believe that the overall cost of operations of this type, particularly on a very large scale, is out of proportion to the results that can be achieved. It would be most desirable and valuable indeed to have an accurate evaluation of military worth and effectiveness of an airborne assault.
The Weapons Systems Evaluations Group has undertaken the study and evaluation of airborne operations from the standpoint of their use in a possible future war. A very specific question to be answered in this regard is : the efficancy of which prese4nt airborne units can inpliment their portion of the current war planes.**

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I. INTRODUCTION

1. World War II saw the development of airborne operations[1] and airborne warfare to the point where an airborne operation - that is, the forces and techniques of which it is composed and their use - could be looked upon as an additional weapons system of the armed forces or at least as a highly specialized task force combining both ground forces and air forces in a joint operation.[2] As used in this report, an airborne operation is defined as an operation involving the movement of armed forces by air into an objective area for ground combat. The definition includes the action of these armed forces on the ground as long as they are in no other contact with friendly forces except by air. During World War II airborne operations were employed on both sides in a variety of situations and with varying degrees of success. The U. S. airborne forces in particular, experienced a considerable development both in size and technique.

2. Like any new development in military thought and technique, the idea of the airborne assault has much appeal to the imagination. It is easy for enthusiasts in this direction to envisage the transport by air of entire armies to the field of battle. There are others who believe that the overall cost of operations of this type, particularly on a very large scale, is out of proportion to the results which can be achieved. It would be most desirable and valuable indeed

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1/ Sometimes also referred to as vertical envelopment.

2/ The term "airborne force" will be understood to include not only the troops but also a sufficient number of troop carrier aircraft to deliver them to or in the objective area.

to have an accurate evaluation of military worth and effectiveness of an airborne assault. This would go far in enabling an estimate to be made of the proportion of the armed forces which it is desired to have with airborne capability but would involve questions of comparative military cost versus comparative military effectiveness. The discussion of these questions is outside the scope of the present report. It will be appreciated that they involve, in one way or another, most of the ideas and concepts of ground warfare as well as questions and problems of delivery by air, for which complete analytical treatments are not available at the present time.

3. The Weapons Systems Evaluation Group has undertaken the study and evaluation of airborne operations from the standpoint of their use in a possible future war. A very specific question to be answered in this regard is:

> "The efficacy with which present airborne units can implement their portion of the current war plans."

In order to start from a known frame of reference in seeking the answer to questions such as this, it is considered essential to begin by making a study of some of the historical cases that occurred in World War II. It is believed that the results of the study of historical cases will not only greatly assist in answering the specific question above but also be of significant value in the solution of any other problems related to airborne warfare. The necessity for making the historical study arises in large part from the lack of any operational analyses of airborne operations in particular, and from the great lack of analytical knowledge of ground combat operations in general. In such a study the emphasis would be placed on attempting to find the basic factors upon which the outcome of an airborne operation depends and, if possible, to what extent. From preliminary considerations and investigations one can state the following list of factors as including those which would be of basic importance in determining the degree of success of an airborne operation.

a. Command structure.

b. Time for training and planning.

c. Intelligence estimates used in planning.

d. Weather.

e. Cover plans (deceptions)

f. Tactical air support before, during and after the initiation of the airborne assault.

g. Enemy air action against marshalling area, troop carriers in flight, and against ground troops in the airhead.

h. Accuracy and concentration of the drop or landing.

i. Rate of build-up of the airhead.

j. Rate of movement of forces on the ground.

k. Communications.

l. Link-up with associated forces.

m. Logistical support.

The historical study reported herein has been carried out with these factors in mind, and the attempt has been made to show the role they played and their relative importance.

4. In the general approach to the study of the historical cases it is deemed essential to rely as much as time, personnel, and availability of records will permit -- on the original battle records and reports. The attempt has been made throughout to secure actual numerical operational data. The matter of securing original records is in itself a rather major undertaking. To get accurate data on the ground part of the operations it was found necessary to use the operational reports of units as small as battalion and company size. As far as the records of the air effort involved are concerned, the troop carrier records such as histories, after-action reports, and mission reports, are plentiful and completely adequate. The records for the tactical air support rendered by the fighters and fighter bombers is quite another story, and adequate records of these missions, particularly at squadron level, are very scarce. Equally scarce are

any Air Force records which give any clear and accurate indication of the effectiveness of the tactical air effort in support of the airborne troops on the ground. In questions of tactical air support the situation is further complicated by the fact that in some operations it is difficult -- if not impossible -- to distinguish between the tactical air effort in support of a specific airborne operation and that given generally to all forces participating in a combined major assault. In these cases the proximity of assault areas produced a condition wherein the tactical air support operations executed in certain areas actually applied and had some bearing on the ground operations of the airborne units as well as the other ground forces participating.

5. In the present report it has been necessary to limit the study mainly to the two major airborne operations of World War II -- Operation NEPTUNE and Operation MARKET. Operation NEPTUNE was the code name given to the airborne assault carried out in support of the amphibious invasion of Normandy on 6 June, 1944. Operation MARKET was the code name given to the airborne assault in Holland on 17 September, 1944, in connection with the attempted early break-through of ground forces from Belgium, through Holland, and into Germany. Maps of the areas involved in these two airborne operations are given in Figures 1 and 2 of Enclosure A. The quantitative evaluation of the effectiveness of tactical air support of ground troops is a difficult and important study in itself, and the scope of the present report has precluded anything more than some qualitative considerations of these effects. It is also pointed out that for somewhat similar reasons no attempt has been made to determine quantitatively the degree of air superiority, either temporary or local, required for the successful launching of an airborne assault.[3/] Further, the discussions concerning the troop carrier effort have been confined strictly to the role played by the troop carriers in an airborne assault. Actually, throughout the war, the troop carrier aircraft were engaged mainly in logistic support of the ground and air forces in the combat theatres. While this activity

3/ In fact one can probably go so far as to say that there does not exist at the present time a precise quantitative definition of the term "Air superiority."

was of great importance to the war as a whole it forms no part of the present study. Finally, it should be clearly understood that the historical study presented here is not an end in itself but rather an intermediate step required in order to give guiding principles and basic data for use in the study of the main problem of evaluating airborne operations. It is believed that the results obtained herein will serve the intended purpose of providing tools with which to attack the general airborne study.

II. SUMMARY OF CONCLUSIONS

The details of the historical study are contained in Enclosures A to J, included herein. The study has been carried out from the point of view of determining the main factors which influenced the outcome of the airborne operations considered and, so far as practicable, their degree of importance. Specific factors studied include the following:

A. The achievement.

B. Drop geometry - the accuracy and concentration of the parachute drop.

C. Factors in reorganization - exclusive of drop geometry.

D. The location of drop zones and landing zones.

E. The rate of movement of the troops on the ground toward their objectives.

F. The rate of build-up of the airborne forces on the ground.

G. Communications.

H. The Intelligence estimates used in planning.

I. The Troop Carrier performance.

J. The tactical air support given.

From the results found, as described in the enclosures, concerning these various factors it is concluded that some fairly definite, although qualitative, statements may be made concerning them and their importance in the scheme of an airborne operation. These conclusions are described below, and are supported by the results found in the enclosure indicated. In arriving at the conclusions the attempt has been made, whenever possible, to employ a method based on comparisons between different operations and between units engaged in the same operation.

1. It is believed that results of the study point to the existence of two general categories of basic factors which influenced the outcome of the World War II airborne operations studied: (1) those factors which taken singly could either prohibit, defeat or critically jeopardize the operation, and (2) those which could produce difficulties

when taken singly but which could not govern the outcome of the operation except by occurring in combination. These categories are referred to here as Category A and Category B, respectively. Some of the items considered in this study had no demonstrable effect on the outcome of the operations examined, either because they appear not to have been significant in themselves, or because the particular qualifications or conditions required were present to an adequate or to a generally uniform degree in all units involved in the particular operations examined. In the latter case the data studied could not be expected to show, even qualitatively, the degree of importance of such a factor. Finally, those factors which are of importance in any military action but on which no comparative analysis has been possible with respect to the airborne actions examined are referred to here as Category C, and those which it is demonstrated had no detectable influence at all are placed in Category D. The conclusions with regard to these four categories of factors are set forth in the following paragraphs in alphabetical order of category.

2. CATEGORY A: Inadequacy with respect to each of the following factors appears from this study to have been capable of either prohibiting, defeating or critically jeopardizing an airborne operation in World War II.

a. Intelligence of enemy ground strength and disposition. (Enclosure H - the unexpected enemy situation at Arnhem, Operation MARKET).

b. Weather. (Enclosures B, F, I, and J - postponement of entire NEPTUNE Operation for 24 hours, delay of 325th Glider Infantry Regiment at Nijmegen, Operation MARKET).

c. Performance of associated ground or amphibious forces in combined operations. (Enclosures A, E, and F - low rate of advance of the link-up ground forces, Operation MARKET).

d. Air superiority. (Enclosure J - complete destruction of German airborne reinforcement of forces in North Africa)

Not included

3. CATEGORY B: Inadequacies with respect to the following factors while not appearing to have directly governed the outcome of any of the operations studied when considered singly, did produce difficulties which were sometimes large. When they occurred in combination the results were often serious. These factors are listed together with such information as has been developed in this study as to the degree of effect produced.

a. Air isolation of the battle area. Information on the degree of effect is qualitative only, but it can be characterized as large. (Enclosures F and J.)

b. Anti-flak operations. Information on the degree of effect is qualitative only, but it can be characterized as large. (Enclosures B, D, I, and J.)

c. Direct air support of airborne ground operations. There is qualitative information indicating that when it was received it was beneficial. Direct air support of the operations studied, however, appears to have been generally inadequate in quantity. (Enclosures G and J.)

d. Command Structure. There are qualitative indications that for major operations, unified command was capable of producing superior results in every phase of an airborne operation. (Enclosure I.)

e. Troop Carrier Aircraft. This appears to have been a factor of considerable importance. The aircraft, including gliders, available for this use imposed limitations upon the weight, size and quantity of materiel available to airborne forces in combat in the operations studied. (Enclosure I.)

f. Navigational and homing aids for Troop Carrier Forces. These appear to have been of great importance whenever the distance flown was great or the weather was poor. Reliability of the aids appears to have been a major problem in inadequacies which did occur. (Enclosure I.)

g. Joint training and operational planning by troop carrier and airborne forces. Although the exact degree of this effect is unknown, it is indicated that best troop delivery performance was achieved as joint training and joint operational planning were increasingly employed. It is apparent that special training was required for troop carrier crews to deliver troops into combat successfully. The degree of importance is unknown but appears to have been large. (Enclosure I.)

h. Day versus night drops and landings.

(1) It was much more difficult to attain satisfactory accuracy and concentration of troop delivery at night than in daylight. Reliability of navigational and homing aids assumed major importance in night drops for this reason, as also did troop carrier training, separate and joint, and troop carrier combat experience. (Enclosures B, C and I.)

(2) Reorganization of a given percentage of unit strength took three times as long in combat night drops as in daylight. Decrease in accuracy, concentration and geometric drop effectiveness (the product of the two) caused reorganization performance to fall off twice as fast in night operations as in day operations. (Enclosure B.)

i. Drop Geometry - accuracy, concentration and geometric drop effectiveness (the product of the two). Reorganization performance, initial equipment recovery, recovery of resupply and growth of organized forces were all directly dependent upon drop geometry. This was the dominant factor in the determination of the rates associated with the above activities and was also a major factor in governing the ultimate degree of success in achieving the aims of these activities. They, in turn, determined the strength and time of initiation of the initial assaults on objectives and, in some cases, limited total available strength of troops and equipment for more extended periods. (Enclosures A, B, C, F and G.)

j. Terrain.

(1) This factor appears to have had some effect upon rate of growth of organized forces and in recovery of equipment in poor drops whenever terrain was such as to limit visibility in daylight. The degree of effect under these conditions was considerable. (Enclosures C and G.)

(2) Terrain was an important consideration in selecting landing zones (LZ's). (Enclosure C.)

k. Combat Experience. This appears to have been important to an undetermined but significant degree in reorganizing under enemy attack. (Enclosure C.) (No study was made of the effect of combat experience in executing ground combat missions.)

l. Enemy opposition on Landing Zones. This appears to have been an important consideration to the degree that high casualties could seriously interfere with performance of the ground mission. (Enclosure D.)

m. Location of Drop Zones and Landing Zones. This factor was of major importance and could seriously influence the outcome of the operation under certain conditions. Both paratroops and glider landed units enjoyed the best chance of success whenever the DZ's and LZ's were on or as close to the assigned objectives as other considerations would permit. (Enclosures D and E.)

n. Intelligence of enemy flak strength. This was important to an undetermined but significant degree. (Enclosures I and J)

o. Terrain intelligence. One example demonstrated that this factor was of major importance. In general terrain intelligence was, however, adequate. (Enclosure C.)

p. Rate of ground movement. This was a factor of major importance. Together with reorganization performance and location of drop or landing zones with respect to the objective, it determined the time required to reach objectives. Enemy opposition encountered varied directly with this time duration.

The premium on aggressiveness and high rate of movement was great. (Enclosures D and E.)

q. Rate of build-up of airborne forces delivered. This was a factor of great importance, particularly in the event of poor drops or extended airhead perimeters. It appears preferable to employ the greatest rate of build-up consistent with capabilities and limitations. (Enclosure F.)

r. Leadership. There is evidence that this factor could make a difference in reorganization performance as large as a factor of 2. Insofar as leadership was involved in governing rates of movement it appears to have had an important effect upon the execution of the entire ground mission. (Enclosures B and E.)

s. Communications. This factor was of great importance in all phases of execution of the operations studied. Serious inadequacies occurred with respect to ground to air communications, to both troop carrier and ground support aircraft. The causes included planning omissions, lack of adequately trained operators and maintenance personnel, lack of reliability of equipment and shortage of equipment due to damage or loss in drops and landings. (Enclosure G.)

t. Enemy Armor. Presence of enemy armor was of great significance to airborne troops as they seldom had adequate means at the required time and place with which to deal with it. (Enclosures F and H.)

4. CATEGORY C: This category includes those factors which are considered to be of importance in any military operation but upon which either the scope of the study or available data from the operations studied permit no comparative analysis.

a. Tactical planning of ground actions, before and during execution.

b. Relative fire power of opposing forces.

c. Training of airborne forces for ground combat.

d. Morale of Troop Carrier crews and of airborne troops.

e. Combat experience of airborne troops with respect to their performance on the ground after reorganization.

5. CATEGORY D: As far as the operations studied are concerned, the factors in this category are those which were found to have no detectable influence on the outcome of the operation.

a. Jump Casualties. Although most jump casualties are of no further use for immediate fighting, the evidence clearly indicates that jump casualties never occurred in proportions sufficient to interfere with the battle.

b. Selection of Drop Zones. There is no evidence to show that the selection of DZ's had any effect on jump casualties. The jump casualties were about the same whether the troops landed on the DZ or not, provided that they did not land in water, forest, or on rocks. No evidence was found to show that the rate of reorganization on the DZ was affected either by the terrain of the DZ or by enemy opposition on the DZ.

c. Effect of Terrain on Rate of Movement. No evidence worthy of mention could be found to show that terrain affected rate of movement of airborne forces in the operations studied. (Enclosure E.)

6. ACHIEVEMENT: Examination of this subject (see Enclosure A) leads to two general conclusions:

a. All airborne assaults in World War II did not succeed to a uniform degree from any of the possible points of view. Like all military operations, they seldom went exactly according to plan and only a few could be termed complete, unqualified successes. The two major ones, NEPTUNE and MARKET, studied in detail here, are not in this category.

b. In the present limited state of analytical knowledge of ground warfare in general, there is not available any reliable,

simple, numerical measure of degree of achievement which adequately takes into account all of the ingredients of success or failure. Neither is there available an applicable analytical method of proportional value assessment for dealing with the relative values of assigned objectives (and the time required to seize them) which would permit the realistic evaluation of the achievement of the airborne ground assault separate from all other considerations. The approach used in the examination of the degree of achievement associated with NEPTUNE and MARKET has, consequently, been qualitative and general.

7. The airborne assault in front of Utah Beach in NEPTUNE appears to have been somewhat more successful in achieving its over-all purpose than would be indicated by consideration of numbers of specific assigned objectives dealt with according to plan. Casualties, including missing and captured, were about equal in the opposing forces during the airborne phase. Casualties of airborne units from link up to ultimate relief were larger than during the airborne phase of the assault.

8. The MARKET airborne assault appears to have been somewhat less successful in achieving its over-all purpose than would be indicated by consideration of numbers of specific, assigned objectives dealt with according to plan. Enemy casualties, including missing and captured, were about twice as great as for the airborne troops during the airborne phase of the operation. Casualties to the airborne units were more than twice as high during the period of their employment in a normal ground role as during the airborne phase of the operation.

ENCLOSURE A OF WSEG STAFF STUDY NO. 3

ACHIEVEMENTS IN CERTAIN AIRBORNE ASSAULTS

I. INTRODUCTION

1. In analyzing a military operation it would be valuable to be able to measure the outcome of the action under study in concise, expressive numerical terms, such as percentage of planned performance. It would, for example, be of great assistance in the analysis of airborne operations to have had available a relative achievement scale such that it would be possible to say, "Under these conditions, against this enemy, the expenditure of this many lives, this much equipment and this much effort resulted in K per cent success for the operation." In view of the general lack of analytical knowledge of ground combat, no such numerical scale is available which can be considered reliable.

2. Military, and other, estimates have been made and will continue to be made of the degree or percentage of success achieved in military operations. They are useful for the intended purposes. Such estimates, however, differ widely in accordance with who makes them and with the purpose for which they are made. Sample points of view will suffice to demonstrate that none of these estimates are useful in an analytical approach to the problem. So far as the Air Force is concerned, success of air effort in an airborne assault is achieved if a high degree of accuracy and concentration of a large proportion of troops delivered is achieved with light troop losses and maximum air destruction and obstruction of the movement of enemy materiel and personnel. The Air Force can do no more. If all this is done in exact accordance with the plan in respect to timing, an airborne operation may still be a complete failure so far as its ground mission is concerned.

3. In the case of the ground forces as a whole, an operation may be considered successful if it accomplishes its planned purpose. In this sense, the German airborne assault on Crete would be termed a 100 per cent success. Crete was taken and that was the purpose. However, casualties to the assault force were very high. Based upon the testimony of

Generaloberst von Student, this was one of the major factors influencing Adolf Hitler in his decision not again to employ airborne forces in a major assault role.[1/] Also, although Crete was taken it was not captured in the contemplated time. It is evident that Crete is not, therefore, the symbol of unqualified success. Furthermore, this is one of the only two recorded samples of a large scale airborne operation which was completely independent of link-up with ground or amphibious forces. (One was executed in the China-Burma-India Theater.) In all other cases, the success of the operation, measured in terms of the accomplishment of ultimate purpose, was dependent not only upon the performance of the airborne forces but also upon that of the ground or amphibious forces with which they were associated. Their failure could have caused the entire operation to fail but their success might not make the operation as a whole succeed.

4. From the point of view of an airborne unit, it might be said to have achieved perfect performance if all its objectives were seized and held at the planned time. The assault operation may still fail. On the other hand, the airborne force may succeed in seizing and securing few or none of its planned objectives at planned time, or at any time, and the assault may have a high degree of success in terms of its major ultimate purpose. Witness Sicily. If some objectives are dealt with according to plan and some are not, a proportional assessment of value for each individual objective and planned time of seizure, destruction or neutralization is needed in order to permit a real and precise measure of degree of success, even within the restricted point of view dealt with here. There are as many differing assessments as assessors.

1/ Reference, "Air Staff Post Hostilities Intelligence Requirements on German Air Force," prepared 15 October 1945, by Headquarters United States Army Air Forces in Europe, Office of Assistant Chief of Staff, A-2.

5. It is apparent that none of the above described views of achievement assessment is fully developed, wholly valid, or reliable in application for analytical use. For the purposes of this analysis the point of view described in paragraph 4, objectives taken in planned time, would be most nearly applicable and most of the work done in other enclosures on individual factors in the operations studied has been done on that basis. However, until a uniform and reliable numerical method of proportional assessment of value is worked out for each objective and associated time of achievement, no valid numerical analytical measure of achievement is possible. The approach used in discussing achievement in the following paragraphs is therefore qualitative and general.

II. SAMPLES OF WORLD WAR II ACHIEVEMENT EXPERIENCE

6. The relative achievements of two World War II airborne assaults, NEPTUNE and MARKET, have been studied in considerable detail. Other operations have been given general study. The information set forth in the following paragraphs is derived from the recorded data on the operations considered.

7. NEPTUNE: In this operation the overall purpose of the U. S. airborne assault was to insure the success of the amphibious landings on Utah Beach. This was to be done by seizing causeway exits immediately behind the beaches, and all appropriate river crossings, road junctions and towns on the flanks and to the front of the beach landings so as to:

a. Destroy or neutralize the enemy in the area,

b. Shut out all enemy reinforcements to the battle area from any direction,

c. Open a wide corridor inland to high ground for the amphibious forces, and

d. Link the VII and V Corps beachheads (Utah and Omaha) firmly together.

8. The 101st was assigned the area nearest the beaches and was to provide the forces for the link-up of the two corps. The 82d was to secure the river crossings deeper to the front and block reinforcements

from further inland. Table I below shows this division of responsibility, the major groupings of physical objectives and assigned times for dealing with them, and the performance realized in terms of planned objectives taken and the times required to do so.

9. Table I shows clearly that considerably more than half of the specific D-day objectives of the airborne assault were not successfully dealt with within the planned time. From this point of view it might be expected that this operation would be considered to have had a very low degree of success in execution. The REMARKS column of Table I indicates, however, that many of the most urgent and vital purposes of the operation were achieved. No enemy reinforcements, in fact, ever reached the beachhead area. The amphibious landings were assisted greatly by the actions immediately to their front. The enemy in the area of the assault was neutralized to a great extent, so far as the beach landings were concerned. In short, the airborne assault was more successful in achieving its overall purpose than would be shown by examination of the number of specific objectives dealt with at the times intended.

10. On the other hand, it is clear that lack of success in dealing with some of the specific objectives contributed to the general delay in the combined operation, both on D-day and subsequently. The VII and V Corps were not linked firmly until D + 7 when Carentan was taken. The amphibious forces were delayed in starting toward Cherbourg and had to follow a less favorable route than was planned because of the lack of success in getting firm bridgeheads over the Merderet. The airborne assault cannot, consequently, be considered an unqualified success.

11. One aspect of the effect upon the enemy of the airborne assault in NEPTUNE, both British and U. S., is not touched by any of the considerations so far examined. The great dispersion at night of the airborne assault forces, while it created extremely difficult situations for them, confused the enemy for several hours as to the location, strength and intentions of the assault by air. By the disruption of his communications, these forces also contributed considerably to the enemy's lack of

TABLE I

PHYSICAL OBJECTIVES AND ACHIEVEMENTS - NEPTUNE (U. S.)

appreciation of the character and strength of the amphibious assaults at H-hour. Although it is believed that these contributions were significant and of substantial assistance to the total invasion effort, it is impossible to determine quantitatively the degree of their importance. It is known that part of the vacillation in commitment of heavy enemy reserves from the Calais area was probably due to the confusion described here. It is also known, however, that part was due to the enemy state of mind, his general certainty that the main attack would still come in the Calais area. Part can also certainly be ascribed to the confusion and general lack of direction resulting from the clash in basic ideas on anti-invasion measures between Rommel and von Runstedt.

12. In any event it is fair to state that the accidental dispersion which befell the airborne forces was not an unmitigated evil and, in fact, contributed to a degree to the general success of the invasion. It cannot, however, be known whether this was at all comparable to the level of success which might have been attained had the airborne forces not been scattered. There is no suggestion in the evidence examined that it would ever be justifiable to depend for the success of an operation upon the accidental miscarriage of planned execution. Neither is there evidence to show that great dispersion of forces, airborne or otherwise, should be intentionally planned.

13. In final consideration of NEPTUNE there is no conclusive evidence to show whether the beach invasion would or would not have succeeded without the airborne assault. A German authority, Generaloberst Kurt von Student, has stated that he did not consider the airborne phase of the NEPTUNE invasion to have been decisive. 5/ It is clear, however, that the airborne assault was of substantial assistance to the overall invasion even though many specific objectives were not dealt with at the times planned and the airborne operation, as such, cannot be termed an unqualified success.

14. MARKET: This airborne assault was associated with the ground operation GARDEN. MARKET-GARDEN was to produce a complete break-through

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5/ Reference is "Tactical Employment in the U.S. Army of Transport Aircraft and Gliders in World War II," Vol. I, page 201.

from the British 2d Army front south of Eindhoven, via Eindhoven, Nijmegen and Arnhem, through Apeldoorn and from there eastward into the North German plain. The force of this break-through when exploited was to have been sufficient to invite a German collapse. The general mission of the airborne forces involved was to seize, clear and secure a continuous corridor beginning with the town of Eindhoven and the bridges in the town and extending northward to a point north of Arnhem on the Arnhem-Apeldoorn road. Three airborne divisions plus one brigade were to accomplish this mission. The ground forces in GARDEN were to advance rapidly to Eindhoven, then along this corridor and continue on to the north to Apeldoorn and eastward from that point into the North German plain. This operation was to be assisted by MARKET in gaining and maintaining momentum throughout and beyond the break-through route. The advance was to be spearheaded by an armored division followed and supported by two infantry divisions.

15. Table II shows for MARKET the specific objectives and time allowances assigned to achieve the purpose of the operation and the results experienced in executing the assault. It will be seen that most physical objectives were dealt with well within the planned times and held for the intended length of time based upon the planned rate of advance of the GARDEN forces. From this point of view the airborne operation enjoyed considerable success.

16. An excellent example of the need for a method of assessment of proportional value for each objective is afforded by the experience of the 82d Airborne Division in this operation. Out of five major objectives assigned, four, including many additional secondary objectives, were taken quickly and held well beyond the time it was originally expected would be required. The fifth objective, the Nijmegen Highway Bridge, was taken some 48 hours later than had been planned and about 24 hours after it could have been in use by GARDEN forces if it had been taken. What weight should be given to the delay in taking the Nijmegen Bridge in assessing the overall degree of success of the Division, or in attempting an overall rating of MARKET achievement relative to the MARKET plan? What weight should be given to holding four out of five major division objectives for a longer period than it was expected would be necessary? No analytical method of proportional value assessment is currently available to answer these questions.

TABLE II

PHYSICAL OBJECTIVES AND ACHIEVEMENTS - MARKET

TABLE II

PHYSICAL OBJECTIVES AND ACHIEVEMENTS - MARKET

No.	Div.	Planned Assault Objectives	Planned Time Allowed	Time Required to Deal with Objectives	Objectives Dealt with at Planned Time	Objectives Held at Time Required for Use 2/	Remarks
1	101st.	Seize city of Eindhoven	6-8 hrs.	28 hrs. 05 min.	No	Yes	Garden forces were behind schedule to the extent that this degree of lateness did not affect their progress.
2	"	Seize bridge over Wilhelmina Canal near Zon.	D-Day	Bridge blown. Area taken 1 hr. 05 min.	No	No	Garden forces were delayed by necessity to build heavy vehicle bridge.
3.	"	Seize bridges over Dommel River at St. Oedenrode.	D-Day	3 hrs. 30 min.	Yes	Yes	
4.	"	Seize bridges over Ad and Willemsvoort Canal near Veghel(Vechel).	D-Day	3 hrs. 05 min.	Yes	Yes	
5.	"	Secure and maintain continuous road corridor from Eindhoven north to north of Veghel (D+1).	D+1 to end operation	D + 1	Yes	In part	Corridor was initially cleared and held for the planned time but was cut twice later, once for a period of 36 hours. Garden forces halted forward progress each time and resisted in reopening corridor.
1.	82nd	Seize and secure bridge across Maas River at Grave	D to D+1 (A.M.)	4 hrs.	Yes	Yes	Garden forces arrived at 0820 hrs., D + 2.
2.	"	Seize and hold highway bridge across Waal River at Nijmegen.	Noon D+1	75 hrs.	No	No	Garden forces arrived and participated with airborne units in unsuccessful attack on highway bridge D+2. Bridge taken D+3 by assault river crossing 504th Pir, attack from south by a battalion of 505th Pir and Grenadier Gards Group, both this objective was given priority over No. 2 in point of time.
3.	"	Seize, organize and hold High Ground between Nijmegen and Groesbeck	D-Day	3½ hrs.	Yes	Yes	
4.	"	Deny the roads in the Division area to the enemy	D-Day	4 hrs.	Yes	Yes	
5.	"	Dominate the area bounded on north by line running from Beek west through Hatert, SW to Eindschestraat, S by River Maas and Mook-Richthorst Highway, E by Cleve-Nijmegen Highway and Forst Reichswald, W by line running north and south through Eindschestract.	D to end operation	5 hrs.	Yes	Yes	This area received several heavy coordinated attacks but was successfully defended throughout the period of the operation. Enemy penetrations were reduced in all cases within a short time.
	3/						
1	1st Bn.	Seize and hold Highway, railroad and pontoon bridges at Arnhem with protective bridgeheads to north.	D+1 (night)	North End Highway Bridge.	In part	No	One company reached and took North end highway bridge in 7 hrs. Bridge demolition charges were removed. The RR bridge was blown by enemy and pontoon bridge neutralized by removal of center sections by enemy. Garden forces did not reach south side of river until small elements arrived night D+5. South side river not reached in strength until night D+7. Units at north end highway bridge were out of ammunition and food and decimated. At about 0500, D+4 survivors were ordered to attempt escape. Garden forces never crossed river in force and did not attack south end of highway bridge.

2/ The "time Required for Use" is determined for this purpose by the time at which the "Garden" forces actually first reached or were in position to use the objectives in question.

3/ Information on 1st British Airborne Division and 1st Polish Brigade objectives and their experiences are taken from a 1st Bn. Div. after action report.

17. Table II also shows that the GARDEN forces were behind their planned movement schedule from the beginning of the operation and became progressively later as the advance continued. This meant that the MARKET forces had to attempt to hold objectives four to six days longer than expected. Outstanding examples of such consequences are shown in Table II with particular reference to objectives No. 5 for the 101st and 82d and No. 1 for the British 1st Airborne Division. Total delay imposed upon GARDEN forces by MARKET operations was about 33 hours, 9 hours at the Zon bridge plus 24 hours at the Nijmegen bridge.

18. The spearhead of the GARDEN forces had planned to reach Arnhem by the night of D + 1. They did not, in fact, reach Arnhem during the MARKET-GARDEN operation. They did reach the south bank of the Neder Rijn on the opposite side of the river from the British 1st Airborne Division perimeter. A few troops reached this point late on D + 5, but the river was not reached in significant strength until the night of D + 7. It took about 175 hours to reach the Neder Rijn in force as compared to the 36 hours planned. If the delay of the advance attributable to the MARKET operations is subtracted it would seem that the GARDEN force would still have been about 106 hours, over four days, late in reaching the Neder Rijn. It might be concluded on this basis that the delays resulting from the airborne difficulties were not particularly significant in determining the outcome of the combined operation. This may be true and it is certainly evident that the greatest delay in the advance cannot be directly attributed to any part of the MARKET action. The question remains as to whether the Germans could have effectively delayed the GARDEN advance north from Nijmegen had the ground forces crossed the Nijmegen bridge on D + 2 when they arrived at that point in their advance. If the answer to this question is negative then the delay in taking the Nijmegen bridge was of major significance. No conclusive answer is available on this point. It does, however, seem likely that had the GARDEN forces crossed the Nijmegen bridge at around noon of D + 1 as planned, they would have reached the Arnhem highway bridge in time to take advantage of its north

ond being held by the airborne forces. At noon of D + 1, however, the GARDEN forces were still south of Eindhoven. On the basis of this speculation it could be said that the combined operation was most seriously jeopardized by the initial 24-hour delay of Garden forces in reaching and passing through Eindhoven and no significant part of the failure to achieve a complete break-through would then be chargeable to the MARKET actions.

19. From the point of view of the overall purpose of MARKET-GARDEN, to achieve a break-through, it is evident that the operation was not successful. What was achieved was a 70 mile penetration on a narrow front.

20. Operation VARSITY and the Allied airborne operation in Sicily demonstrate the inadequacy of considering the degree of achievement of an airborne operation divorced from the circumstances in which it may be executed. General study of VARSITY indicates that the achievement of the specific objectives assigned was of a rather high order. It may be speculated, however, that the airborne operation was not decisive even though it was of assistance to that part of the operation fronting on the VARSITY drop and landing zones. In Sicily, on the other hand, the drops were widely dispersed, some troop carrier columns were severely shot up by friendly forces with heavy losses in troops, and few of the initial assault objectives could be seized as planned by the airborne troops. Nevertheless, this operation was regarded by an enemy authority as the one decisive Allied airborne assault of the European war. 6/ Relatively small and lightly armed groups of troopers were, by hard fighting, able to confuse, disorganize and delay German armored reinforcements to their beach defenses sufficiently, in the enemy's view, to insure the success of the beach landings. That was the purpose of the airborne assault.

21. In summary, there is no single, simple and reliable numerical measure applicable to the degree of achievement of airborne operation.

6/ "Tactical Employment in the U. S. Army of Transport Aircraft and Gliders in World War II," Vol. 1, page 201.

The NEPTUNE airborne assault appears to have been more successful in achieving its purpose than the number and timing of assigned objectives seized would indicate. The MARKET operation, on the other hand, appears to have been somewhat less successful in achieving its purpose than consideration of numbers of specific objectives achieved would show. Consideration of the air actions and airborne ground actions as entities separate from each other and from associated activities of other forces involved in the same operation is valuable from the point of view of studying factors incluencing the execution of an airborne assault. This is not, however, necessarily directly related to the achievement of the overall purpose of airborne assaults.

III. AIRBORNE TROOP CASUALTIES IN CERTAIN WORLD WAR II OPERATIONS

22. In considering achievement in a military operation it is important to take into account the cost-payoff aspects in terms of casualties to the forces involved, that is, the relationship between airborne troop and enemy casualties. The following paragraphs summarize experience relative to this subject in certain world war II operations in which this aspect was studied.

23. NEPTUNE: The casualty data for the 101st and 82d during this operation are shown in Table III. Known casualties resulting from the airborne phase, prior to link-up with sea-tails and other heavy supporting forces, and those resulting from the employment of the airborne divisions in a normal ground role until relieved are shown separately. Corresponding known enemy casualties resulting from the airborne phase of the action are also shown.

24. It will be seen from Table III that enemy casualties and prisoners were considerably higher than the known battle casualties of the airborne troops during the airborne phase of the operation - roughly 6 times as high. If jump and landing casualties are included the ratio of enemy to airborne casualties is a little over two to one. If the 101st estimate of 1500 men killed or captured as a result of the scattered drop is included the ratio is very nearly one to one. It is also about one to one if the eventual

TABLE III

NEPTUNE CASUALTY DATA
(82d and 101st and Enemy in Contact)

Day	82d Area				101st Area			
	Jump + Landing	Battle	Enemy Casualties	PW	Jump + Landing	Battle	Enemy Casualties	PW
D-day	313	140	122	40	188	35 [7]	197	113
D + 1	342	73	76	739	--	91	337	755
D + 2 [8]	--	70	41	469	--	2	73	--
D + 3 [9]		75	7	101	--	--	--	--
A/B Phase	655	358	246	1349	188	128	607	868
Totals	1013		1595		316 [7]		1475	
	1853 [10]				981 [10]			
Link up to Relief	1990 [11] (1150)		--		3520 [12] (2855)			
Grand Total	3003 [11]				3836 [12]			

7/ Does not include 1500 estimated at the time to have been killed or captured as a result of scattered drop.

8/ 101st A/B phase ended this day. (See Enclosure E)

9/ 82d A/B phase ended this day. (See Enclosure E)

10/ Includes missing and captured probably attributable to the A/B phase as shown in notes 11 and 12 below.

11/ Includes 840 missing or captured, probably for the most part in A/B phase. Figures in parentheses do not include those missing and captured.

12/ Includes 665 missing or captured, probably for the most part in the A/B phase. This would indicate that about half the troops referred to in 6/ eventually rejoined their units after the A/B phase was over. Figures in parentheses do not include those missing or captured.

totals of missing and captured are included as shown by note 10. Of the jump and landing casualties shown for the 82d, 383 are glider landing casualties. Table III shows that the 82d suffered more losses during the airborne phase of NEPTUNE than during the period from link-up to ultimate relief if the missing and captured are charged to the airborne phase of the operation. The ratio is 1.6. In the case of the 101st this ratio is reversed, more losses being suffered after the link-up by a factor of almost three. Total casualties suffered by each of the U.S. airborne divisions in Normandy were comparable.

25. MARKET: Table IV shows similar casualty data for the 82d and 101st and the enemy in contact for the MARKET operation.

TABLE IV

MARKET CASUALTY DATA
(82d and 101st and Enemy in Contact)

Day	82d Area			101st Area		
	Jump + Landing	Battle 13/	Enemy 13/	Jump + Landing	Battle 13/	Enemy 13/
D-day	124	165	1079	114	95	24
D + 1	--	279	336	26	162	13
D + 2	--	206	342	70	232	615
D + 3 14/	--	420	1006	--	10	110
D + 4	--	--	--	--	16	8
D + 5 15/	--	--	--	--	68	250
A/B Phase	124	1070	2763	210	583	1020
Totals	1194		2763	793		1020
Link up to Relief	1848		2704	2107		--
Grand Total	3042 16/		5467	3301 17/		--

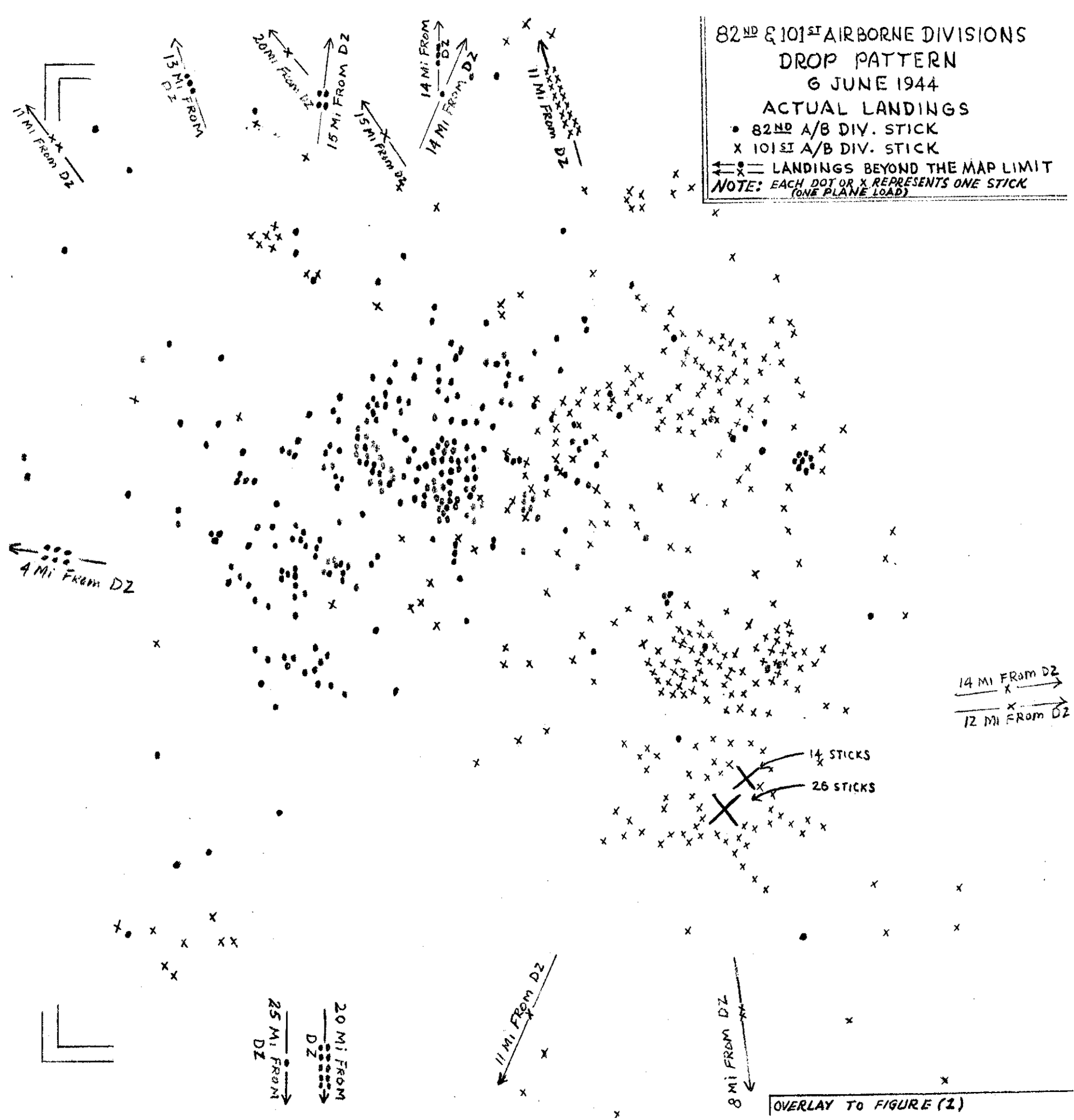
13/ Includes all causes including missing and captured.

14/ 82d A/B phase ended this day with use of GARDEN infantry, tank and artillery forces. (See Enclosure E)

15/ 101st A/B phase ended this day with use of substantial GARDEN forces in reinforcement and support. (See Enclosure E)

16/ Includes all causes. 640 missing and captured.

17/ Includes all causes. 398 missing and captured.


82ND & 101ST AIRBORNE DIVISIONS
DROP PATTERN
6 JUNE 1944
ACTUAL LANDINGS
• 82ND A/B DIV. STICK
X 101ST A/B DIV. STICK
LANDINGS BEYOND THE MAP LIMIT
NOTE: EACH DOT OR X REPRESENTS ONE STICK (ONE PLANE LOAD)
11 MI FROM DZ
13 MI FROM DZ
20 MI FROM DZ
15 MI FROM DZ
15 MI FROM DZ
14 MI FROM DZ
14 MI FROM DZ
11 MI FROM DZ
4 MI FROM DZ
14 MI FROM DZ
12 MI FROM DZ
14 STICKS
26 STICKS
25 MI FROM DZ
20 MI FROM DZ
11 MI FROM DZ
8 MI FROM DZ
OVERLAY TO FIGURE (2)

26. Table IV shows that enemy battle casualties were roughly twice those of the airborne troops for the airborne phase of the operation. From link-up to ultimate relief the 82d suffered nearly twice its losses for the airborne phase and for the 101st this ratio is more than 2.5. Total losses of the two divisions were comparable although the 82d lost about 1.5 times as many troops and caused about 2.7 times as many enemy casualties as the 101st during the airborne phase. The records of missing and captured airborne troops are much clearer for the MARKET operation than for NEPTUNE. It is indicated that, although the enemy forces engaged in MARKET by the 82d and 101st were considerably stronger than those in contact in NEPTUNE, the final missing and captured total for airborne troops in MARKET was only 70 percent of that shown for NEPTUNE. The 82d and 101st airborne forces committed in the airborne phase of MARKET were more than 15 percent greater than in the airborne phase of NEPTUNE.

27. SUMMARY: In NEPTUNE the degree of achievement of the overall purpose of assisting the amphibious invasion of Normandy at Utah Beach was apparently somewhat higher than would be indicated by consideration of the number of specific airborne objectives dealt with according to plan. Total casualties from all causes including missing and captured, to the U. S. airborne forces during the airborne phase of NEPTUNE were only a little less than those inflicted on the enemy. The 82d and 101st suffered 2834 casualties including missing and captured during the airborne phase and 6839 total casualties from D-day until they were relieved; about 41 percent of the total was sustained during airborne employment and 59 percent during employment in a normal infantry role.

28. Operation MARKET appears to have achieved a somewhat lower degree of success in relation to its general purpose than would be indicated by consideration of the numbers of specific airborne objectives dealt with as planned. Total casualties to the U. S. airborne troops from all causes including missing and captured were about 52 percent of total known casualties sustained by the enemy during the airborne phase of the operation. From link-up to relief, the airborne troops sustained 2.1 times

as many casualties from all causes as during the airborne phase. It is noteworthy that airborne losses in both NEPTUNE and MARKET were lower during the airborne phase than from link-up to relief.

29. Only 70 percent as many airborne troopers were missing and captured in the MARKET operation as in NEPTUNE, even though the airborne forces involved in the MARKET airborne phase were 15 percent greater and the enemy was about three times as numerous. It is considered probable that the higher figure in NEPTUNE is largely the result of the poor drop geometry.

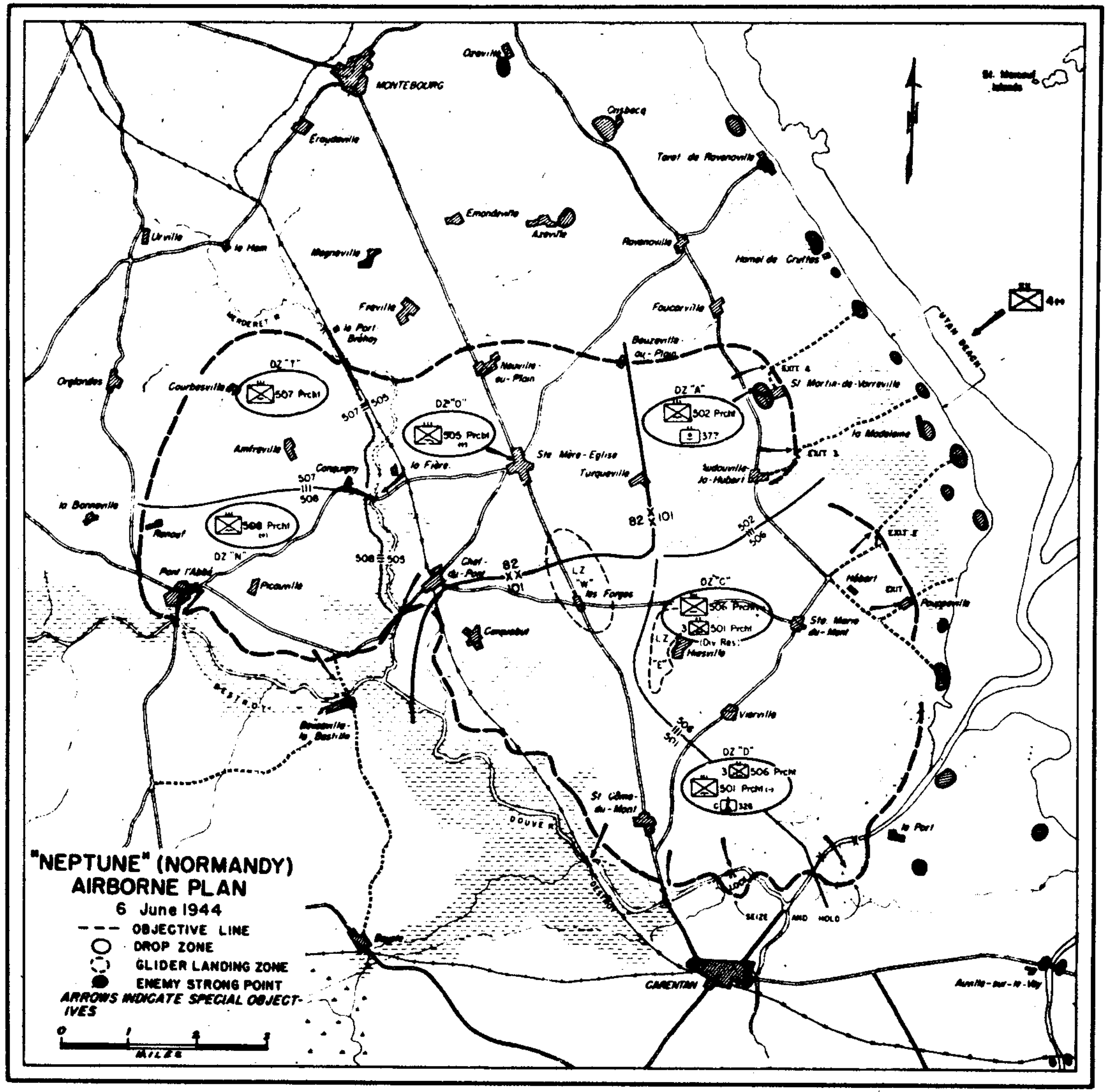

"NEPTUNE" (NORMANDY)
AIRBORNE PLAN
6 June 1944
OBJECTIVE LINE
DROP ZONE
GLIDER LANDING ZONE
ENEMY STRONG POINT
ARROWS INDICATE SPECIAL OBJECTIVES
MILES
MONTEBOURG
CARENTAN
UTAH BEACH
Ste Mère-Eglise
DZ "T"
507 Prcht
DZ "O"
505 Prcht
DZ "N"
508 Prcht
DZ "A"
502 Prcht
DZ "C"
506 Prcht
501 Prcht
DZ "D"
506 Prcht
501 Prcht
SEIZE AND HOLD
Ste Marie-du-Mont
St Côme-du-Mont
Pont l'Abbé
Picauville
Amfreville
Turqueville
Vierville
Hiesville
Foucarville
Ravenoville
Azeville
Emondeville
Fréville
Urville
Orglandes
Houesville
Hébert
Pouppeville
le Port

FIGURE NO.1

TABLE I

PHYSICAL OBJECTIVES AND ACHIEVEMENTS - NEPTUNE (U. S.)

No.	Div.	Planned Assault Objectives	Planned Time Allowed	Time Required to Seize and Hold, or Destroy, Objective	Objectives Dealt with at Planned Time	Objectives Held at Time of Link-up 1/	Remarks
1	101st.	Assist assault landing of 4th Inf. Div. by seizing the western margin of the inundated area back of Utah Beach between St. Martin-de-Varrevukke (4098) and Poupeville (4493), both inclusive. (This included exits to the 4 causeways and a gun battery and garrison vic. St. Martin-de-Varreville which dominated exits 3 and 4.)	Pridy to H-hg (About 5 hrs. total)	Exit 1 - 7 hrs. Exit 2 - 13 hrs. Exit 3 & 4 - 6 hrs.20 min. Battery and Garrison - 16 hrs.50 min.	None	All	Although none of these were seized in the planned time, exits 1 and 3 were taken soon enough to assist the landings in the expected manner. Exit 4, the battery dominating this and exit 3 and the western end of exit 2 were also either under attack or dominated in time to be of assistance to the landings. A northern defense are through Foucarville was firmly held.
2.	"	Seize crossings of the Jourdan and Groult Rivers and of the Canal du Port de Carentan at 3886, 4187 and lock at 3986 for exploitation in a southward drive to Carentan.	During D-Day (22½ hrs.)	Bridges at 4187) 4287) 5 hrs. 30 min. La Barquette Lock (3986)- 5 hrs.30 min. Bridges at 3886 - D-2	2 of 2 1 of 1 No	2 of 2 1 of 1 No	This group of objectives was precariously held, the bridgeheads had been abandoned on D-Day. Held precariously by small force on D-Day short of ammunition.
3.	"	Seize Carentan as soon as tactical situation permits and establish firm contact between VII and V Corps beachheads.	Probably not later than D + 3.	Carentan taken D + 7 (Attack began D + 3)	No	No	Enemy was strong and mobile in this sector until end of battle on D + 7.
1.	82nd.	Seize, clear and secure general area CR(261938)- CR(265958)- CR(269975)- RJ(283992)- Bridge (308987)- Neuville au Plain (340985)- Bandienville (36098) within its zone.	D-Day	4 Days (Parts of this area were secured from D-Day onward and the enemy was not in full control of most of it.)	No	Yes	
2.	"	Capture Ste. Mere Eglise (349965)	D-Day	7 hrs.	Yes	Yes	Enemy forces were stopped here from interfering with Allied activities.
3.	"	Seize and secure crossings of the Mederet River at (315957) and (321930) and a bridgehead covering them.	D-Day	4 days (La Fiere bridge taken in 11¼ hrs. but lost within one hr.)	No	Yes	Failure to secure these objectives prevented the 4th Inf. Div, from achieving its D-Day objectives and also delayed the amphibious forces reaching high ground for the planned northward advance in this region.
4.	"	Seize and destroy crossings of Douve River at Beuzeville la Bastille (309911) and Etienville (269927) also sometimes called Pont l'Abbe.	D-Day	4 days	No	No	No enemy reinforcements penetrated the 82nd Div. zone to influence the landings.
5.	"	Protect NW flank of VII Corps within Div. Zone	D-Day Onward	Neuville au Plain - 1 3/4 hrs. Ste. Mere Eglise - 7 hrs.	In part	Yes	Although this defense arc was not fully established, no enemy reinforcements ever penetrated toward the beaches.
6.	"	Be prepared to advance West on Corps Order to the line of the Douve River North of its junction with Prairies Marecageuses.	On Corps Order.	In time required.	Yes	Yes	

1/ Link-up refers to the link up of airborne forces with their own sea tails containing heavy attachments and equipment. From this point onward the airborne units are considered to be fighting a standard ground engagement. This point was reached on D - 2 for the 101st and on D - 3 for the 82nd.

ENCLOSURE A

FIGURE NO. 1

"NEPTUNE" (NORMANDY) AIRBORNE PLAN

AND

OVERLAY TO FIGURE NO. 1

FIGURE NO. 2

OPERATION "MARKET-GARDEN" (HOLLAND)

DROP AND LANDING ZONES

GROUND SITUATION AT LAST LIGHT

D-DAY 17 SEPT '44

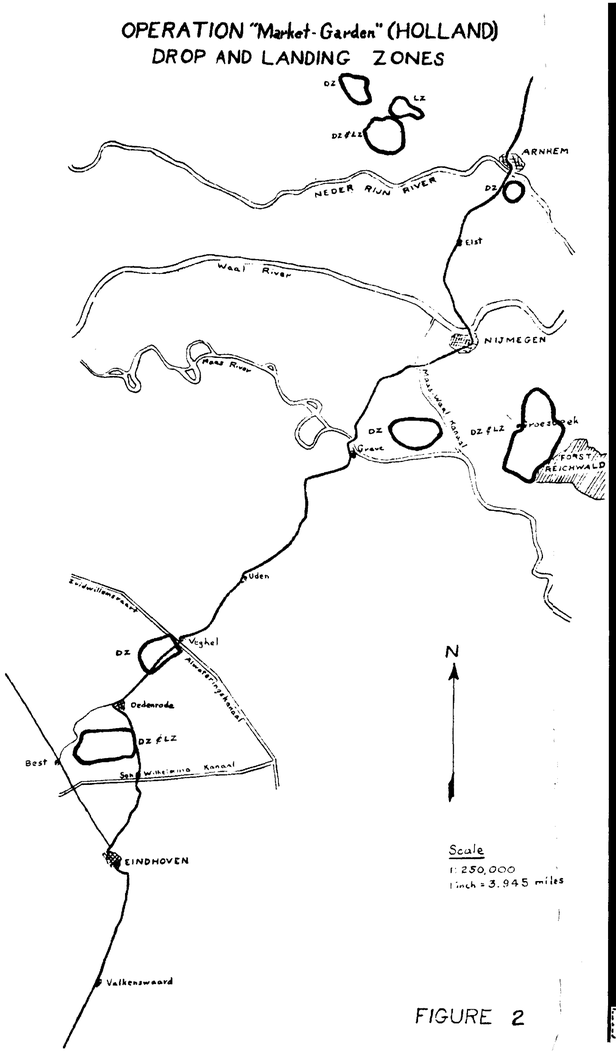
D + 1 18 SEPT '44

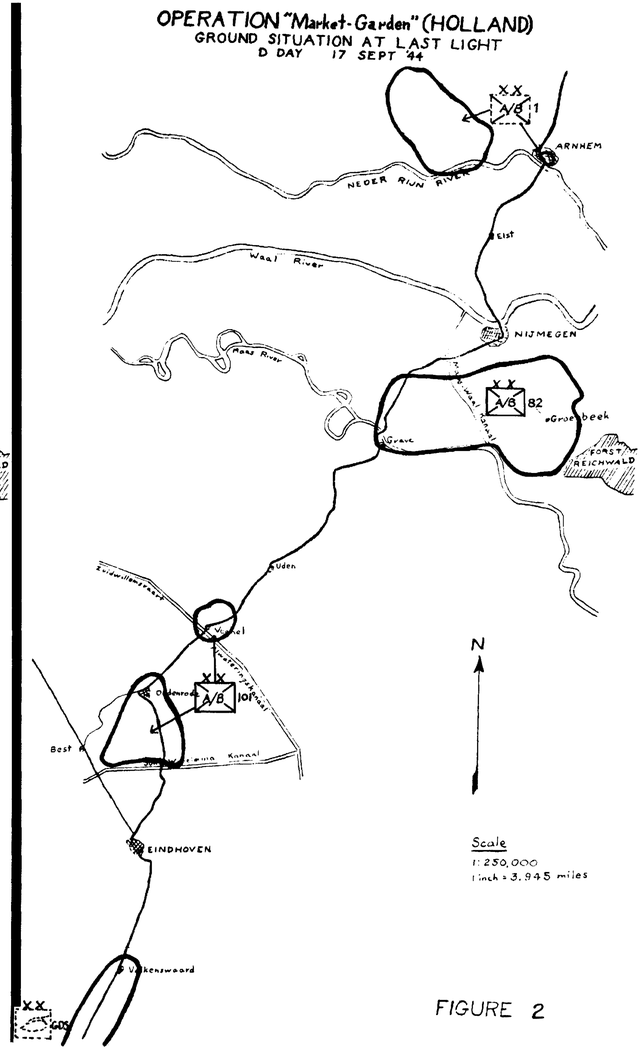
D + 2 19 SEPT '44

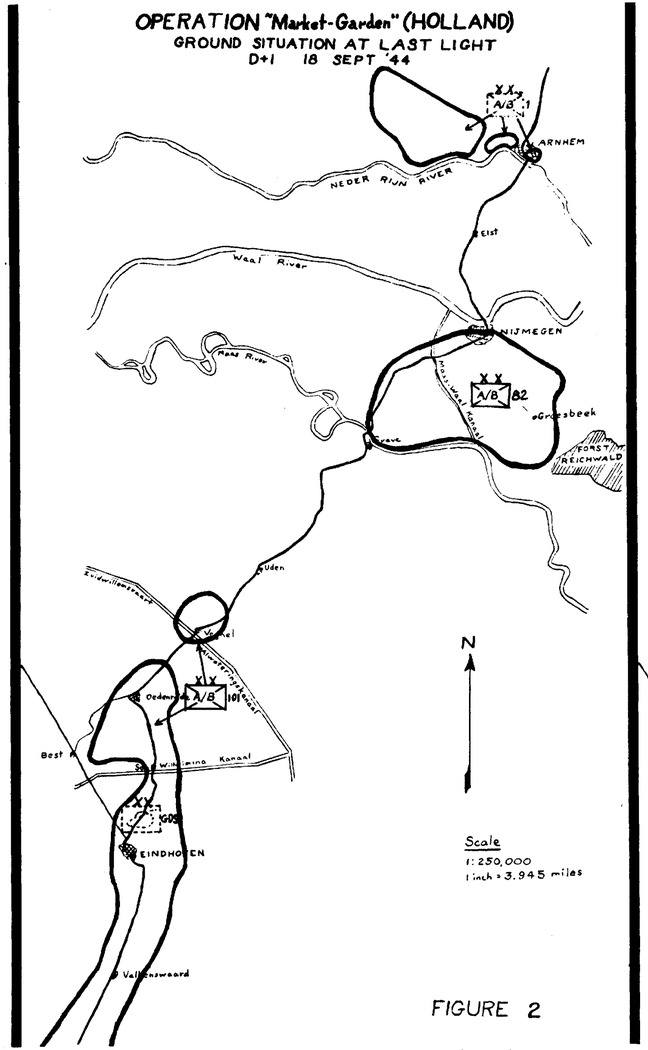
D + 3 20 SEPT '44

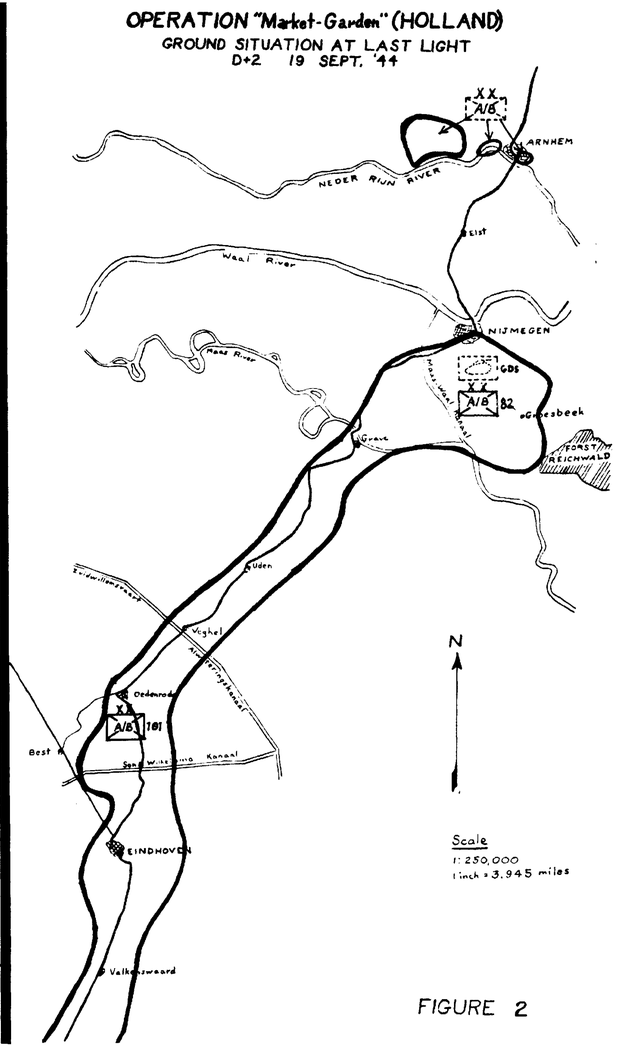
D + 5 22 SEPT '44

D + 7 24 SEPT '44


OPERATION "Market-Garden" (HOLLAND)
DROP AND LANDING ZONES
DZ
LZ
DZ & LZ
ARNHEM
NEDER RIJN RIVER
DZ
Elst
Waal River
NIJMEGEN
Maas River
DZ
DZ & LZ
Groesbeek
Gravenwaal Kanaal
Grave
FOREST REICHWALD
Uden
Zuid-Willemsvaart
DZ
Veghel
Aa-Afwateringskanaal
Oedenrode
DZ & LZ
Best
Zuid Wilhelmina Kanaal
EINDHOVEN
Valkenswaard
N
Scale
1: 250,000
1 inch = 3.945 miles
FIGURE 2


OPERATION "Market-Garden" (HOLLAND)
GROUND SITUATION AT LAST LIGHT
D DAY 17 SEPT '44
XX
A/B
1
ARNHEM
NEDER RIJN RIVER
Elst
Waal River
NIJMEGEN
Maas River
Gravenwaal Kanaal
XX
A/B
82
Groesbeek
Grave
FOREST REICHWALD
Uden
Zuid-Willemsvaart
Veghel
Aa-Afwateringskanaal
Oedenrode
XX
A/B
101
Best
Zuid Wilhelmina Kanaal
EINDHOVEN
Valkenswaard
XX
GDS
N
Scale
1: 250,000
1 inch = 3.945 miles
FIGURE 2


OPERATION "Market-Garden" (HOLLAND)
GROUND SITUATION AT LAST LIGHT
D+1 18 SEPT '44
XX
A/B
1
ARNHEM
NEDER RIJN RIVER
Elst
Waal River
NIJMEGEN
Maas River
Gravenwaal Kanaal
XX
A/B
82
Groesbeek
Grave
FOREST REICHWALD
Uden
Zuid-Willemsvaart
Veghel
Aa-Afwateringskanaal
Oedenrode
XX
A/B
101
Best
Zuid Wilhelmina Kanaal
XX
GDS
EINDHOVEN
Valkenswaard
N
Scale
1: 250,000
1 inch = 3.945 miles
FIGURE 2


OPERATION "Market-Garden" (HOLLAND)
GROUND SITUATION AT LAST LIGHT
D+2 19 SEPT. '44
XX
A/B
ARNHEM
NEDER RIJN RIVER
Elst
Waal River
NIJMEGEN
GDS
Maas River
XX
A/B
82
Groesbeek
Gravenwaal Kanaal
Grave
FOREST REICHWALD
Uden
Zuid-Willemsvaart
Veghel
Aa-Afwateringskanaal
Oedenrode
XX
A/B
101
Best
Zuid Wilhelmina Kanaal
EINDHOVEN
Valkenswaard
N
Scale
1: 250,000
1 inch = 3.945 miles
FIGURE 2

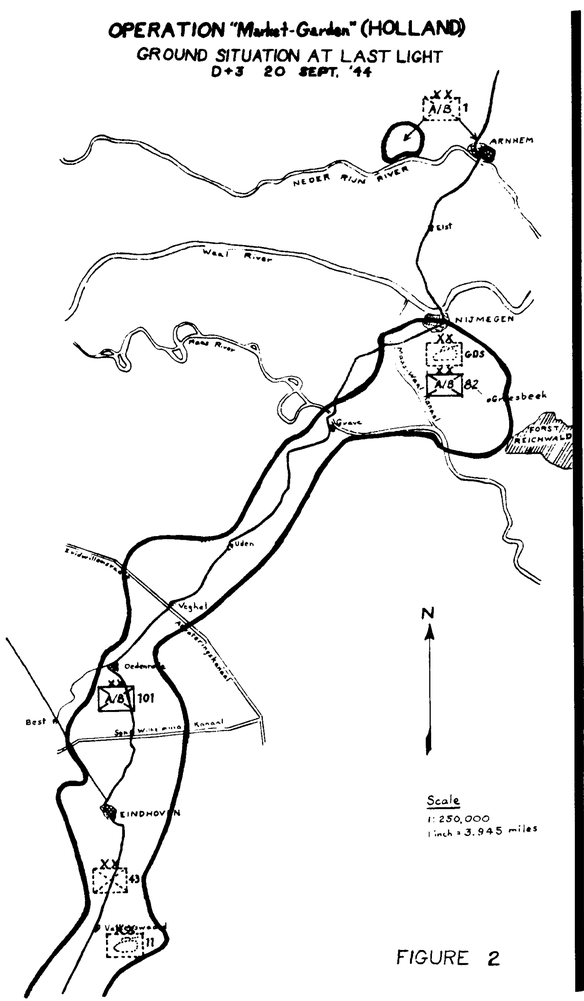


FIGURE 2

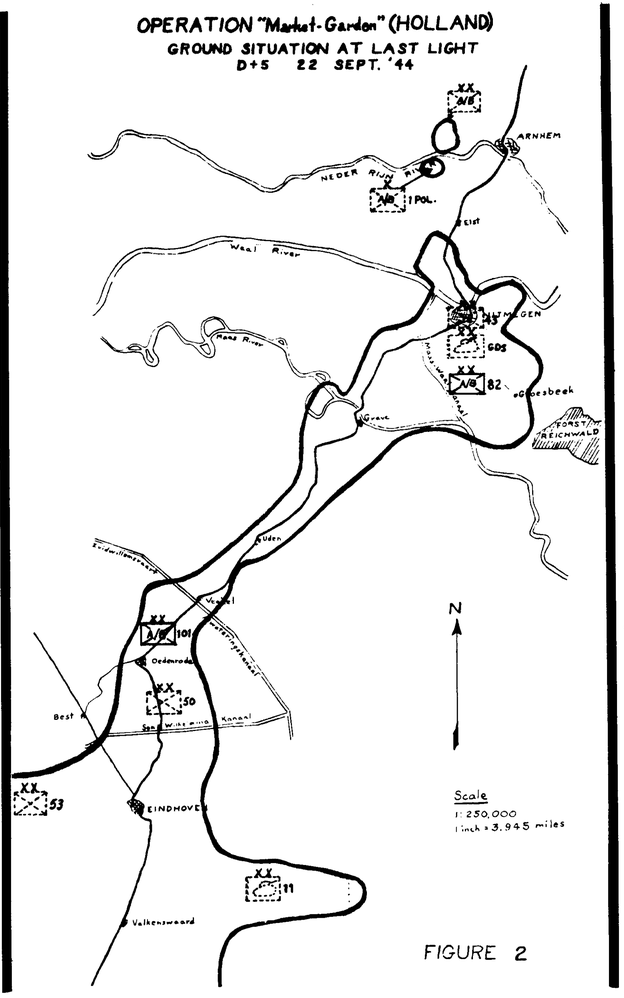


FIGURE 2

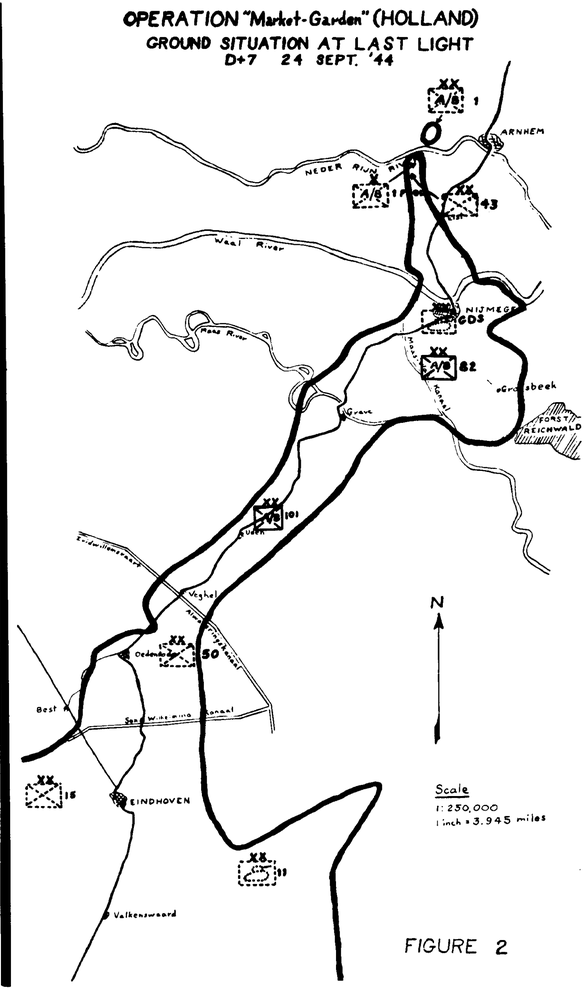


FIGURE 2

ENCLOSURE B OF WSEG STAFF STUDY NO. 3

DROP GEOMETRY

I. INTRODUCTION

1. The ground phase of a parachute assault begins the instant the assault troops have left the carrying aircraft. At this point, the conditions under which the troopers will initiate their assault are already established. They will land in some geometric and geographical relationship to their drop zones, to their objectives, to each other as individuals and to the enemy. The terrain, light, weather, equipment and other physical factors and their leadership, training, experience and similar less tangible factors are fixed. The purpose of this section of the analysis is to examine the importance to the parachuted assault forces of one of these factors, the degree of success with which they are delivered to the planned locations. It is particularly important to discover how this affects the ground phase of airborne operations because the degree of success with which troops are delivered as planned is the final and direct measure of Air Force performance in the air phase of airborne operations.

2. In the following sections the effect of drop geometry upon the parameters which determine the strength and time of initiation of the ground assault is investigated.

II. EFFECT ON REORGANIZATION

3. It is desired to determine how the geometry of a parachute drop, i.e., the degree of success with which troops are delivered to the planned locations, affects the reorganization of troops on the ground.

4. The geometry of a parachute drop is measured by the accuracy, a, with which the drop is placed with relation to the drop zone (DZ) and by the concentration, c, of the dropped troops as compared to the ideal concentration resulting when all troops are dropped within an area the same size as the DZ. The product of accuracy and concentration is defined as the geometric effectiveness, e_g, of the drop, i.e., $e_g = ac$. All three terms are dimensionless ratios showing performance relative to an accepted standard representing perfection. The definitions and methods of measurement of the three terms as employed throughout this analysis may be sum-

marized as follows:[1/]

a. Accuracy in parachute drops is defined as the distance relationship between the points on the ground on which troops actually land and the target on which they were to be dropped, the drop zone (DZ). The measurement adopted is accordingly a dimensionless ratio showing the accuracy actually achieved relative to that which was planned. This relative accuracy is denoted as a, and is referred to hereafter as accuracy. If all troops land on the DZ, the accuracy, a, is equal to one and this defines perfect drop accuracy. The form of measurement used is designed so that all troops dropped on the DZ count as perfect in accuracy. Those which drop off the DZ decrease the relative accuracy in accordance with the distance from the DZ at which they are dropped.

b. Concentration in parachute drops is defined as the distance relationship between troops as actually dropped compared to that which would occur if all troops dropped within an area the same size as the DZ. It is a measure of relative concentration and again the measurement adopted is a dimensionless ratio showing the concentration actually achieved relative to that which was planned. This relative concentration is denoted as c, and is referred to hereafter as concentration. If all troops land within an area the same size as the DZ, c equals one and this defines perfect drop concentration. The form of measurement used is designed such that full credit for concentration is given to all troops which land as close to each other as planned. Those which are dropped farther from each other than planned, i.e., occupying a larger area than planned, contribute to concentration inversely with the size of the area they occupy.

c. It should be noted that when a equals one, perfect drop

1/ For the details of the development and employment of the exact expressions used to measure accuracy and concentration, see WSEG Working Memorandum No. 44

accuracy, c, must, by definition, also be equal to one. However, c can equal one when a is very small and for intermediate ranges of a and c the two values can be completely independent.

d. The geometric drop effectiveness, e_g, is defined as the product of accuracy and concentration and is therefore a measurement of the over-all drop geometry achieved relative to that which was planned. It contains the effects of both a and c.

5. In order to discover how the geometry of the drop affects reorganization it is necessary to define and measure reorganization performance, Q. The purpose of reorganizing after a drop is to produce a controllable, coordinated, fighting unit as quickly as possible. The two basic parameters are therefore numbers of troops and time intervals. The measure of performance is, consequently, a rate. It is desirable to arrive at a dimensionless measure for Q which relates actual performance to perfect performance in both time and numbers of troops reorganized. A standard of perfection, Q_s, is established by considering the case in which the planned number of troops, N_p, is reorganized within the planned time, T_p, or

$$(5.1) \quad Q_s = N_p/T_p = 1.$$

Any actual reorganization rate Q_a, is measured by the actual number of troops, N_a, reorganized at actual time, T_a, or,

$$(5.2) \quad Q_a = N_a/T_a.$$

Then the actual rate, Q_a, may be compared with the standard Q_s, to give a measure of relative performance, Q, i.e.,

$$(5.3) \quad Q = Q_a/Q_s = N_aT_p/N_pT_a.$$

6. It can be seen that a critical factor in determining Q is the point in time selected as the end of the reorganization period, i.e., when it can be said that a unit is reorganized. In maneuvers or in training this end point is rather easily determined because in the usual case no real complications are introduced, such as by extensive scattering of troops, and units do not, in general, take off for objectives until reorganization is complete and the unit is wholly under the control of

a proper commander. There is, consequently, usually an easily discernible break between reorganization and subsequent unit movement. In many cases, training exercises constructively end with the report that the unit is reorganized. In World War II combat situations, however, such clarity can seldom be found, partly because in battle nothing so orderly very often occurs and partly because even when it does, it is seldom reported in exact terms and even more seldom recorded. In the heat of battle, actual or immediately impending, very little exact counting and clock-watching is done and even recorded times and events are often of doubtful validity. More important, under combat conditions the reorganization is only a means to an end, that of taking objectives. The unit commander, consequently, moves his forces as soon as his strength is sufficient, in his judgment, to overcome the apparent opposition or as soon as he is convinced that he will lose more in time by waiting for more men than he will gain in strength. The time of the commander's decision that he is ready to move toward the objective is the cut-off point used in this examination of reorganization performance. It appears to be the only reasonable index common to all types of units in all types of operations. Fortunately, the time that a unit starts for its objectives is fairly often recorded or can be deduced from detailed study of combat operations. The number of troops under control at the time the unit is ready to start toward its objective is taken as N_a.

7. In selecting standard values for N_p and T_p to represent perfect performance two general cases must be considered, day and night. World War II training exercises indicated that night reorganizations would require about one hour to reorganize 80 percent of unit strength under conditions of good drop geometry and use of the visual, radio and aural aids available at the time and well trained troops. This figure was substantiated in the regimental drops behind our own lines to reinforce our beachhead forces at Salerno. The drop pattern was perfect, all possible aids were used, there was no enemy opposition, terrain was generally open. All troops were in trucks ready to move to the front

in approximately one hour. There is no record of any night combat reorganization having exceeded this reorganization rate.

8. For daylight reorganization, training results under excellent conditions show that from 30 to 40 minutes is ordinarily required to secure 80 percent reorganization of a unit of regimental size and from 20 to 30 minutes for battalions. In World War II, objectives were normally assigned on a battalion or smaller unit basis in both day and night operations, and control of smaller units by regiment before departure to initial objectives was not the rule. Twenty minutes and 80 percent strength are, accordingly, the standards used in this examination. It is emphasized that whenever reorganization performance is discussed in this analysis, unless otherwise stated, it is the reorganization performance of battalions within requirements or dimensions to which reference is made.

9. Operations MARKET (Holland) and NEPTUNE (Normandy) have been studied in as much detail as available records permit and the resulting data on accuracy, concentration, geometric drop effectiveness and reorganization performance for U. S. parachute units participating are recorded in Table I.

10. Certain facts are shown immediately by Table I. Both divisions in NEPTUNE received poor drops, both inaccurate and scattered, to about the same degree. Their reorganization performance differs very little, if any. In MARKET both divisions received excellent drops with practically the same degree of accuracy in both cases but with the 101st somewhat more concentrated. There is evident in this case, however, a rather marked difference in reorganization performance between the two divisions.

11. The two drops shown in Table I and the circumstances surrounding them are as different as could be selected. The NEPTUNE assault took place at night with low cloud being met just prior to reaching the DZ areas. The terrain was cut up by hedgerows and ground visibility was limited over most of the area to the distance between hedgerows even in broad daylight. Much of the area was swampy and difficult for foot

travel and some parts were completely inundated. The MARKET assault took place in daylight in good weather. The terrain was flat with ground visibility of five to six miles in most areas and there were no serious obstacles to foot travel between the DZ's and the objectives. In NEPTUNE one U. S. airborne division was completely without prior combat experience; the other had operated extensively in the Mediterranean Theater and all or elements of it had participated in operations in North Africa, Sicily, and Salerno. In MARKET both divisions were battle experienced although the 82nd had more combat than the 101st. It is considered, in view of the range of conditions covered by the data, that any appearance of dependence of reorganization performance upon drop geometry shown is likely to be real and reliable.

TABLE I

DROP GEOMETRY VS. REORGANIZATION PERFORMANCES

Operation	Unit	a	c	e_g	Q 3/
Neptune (Night)	505 Regt., 82nd A/B Div.	0.54	0.51	0.27	0.25
"	507 " " " "	0.18	0.26	0.05	0.06
"	508 " " " "	0.26	0.23	0.06	0.08
"	502 " 101st " "	0.20	0.14	0.03	0.04
"	506, 501 DZ-D 2/ " " "	0.59	0.44	0.26	0.20
"	506, 501 DZ-C 2/ " " "	0.27	0.21	0.06	0.20
"	82nd A/B Div. mean	0.32	0.33	0.11	0.18
"	101st A/B Div. mean	0.33	0.25	0.08	0.17
	82nd + 101st mean	0.32	0.29	0.10	0.17
Market (Day)	505 Regt., 82nd A/B Div.	0.99	0.80	0.80	0.70
"	508 " " " "	0.89	0.87	0.77	0.65
"	504 " " " "	0.86	0.68	0.58	0.60
"	501 " 101st " "	0.40	0.85	0.34	0.51
"	502 " 4/ 4/ " " "	1.00	1.00	1.00	0.32
"	506 " 4/ " " "	1.00	1.00	1.00	0.33
"	82nd A/B Div. mean	0.82	0.78	0.64	0.65
"	101st " " "	0.80	0.95	0.78	0.39
"	82nd + 101st mean	0.81	0.87	0.71	0.52

2/ Elements of the 506th and 501st regiments were to be dropped on both DZ's rather than one regiment on each DZ. Each drop was of approximately regimental size, however.

3/ With the exceptions noted in 4/ below, values for Q in MARKET are considered to be accurate within 5 percent. For Normandy, although the confusion in records is so great that it is difficult to estimate the probable degree of inaccuracy, the figures shown for Q represent the best estimates which can be made and accord with the judgment of participants in the operation. It is not considered that they are likely to be inaccurate by more than 15 percent. Values shown indicate relative rate of reorganization of units within the regiments and divisions, not rate of reorganization as regiments or divisions, see paragraph 8 above.

4/ Records of both drop geometry and reorganization performance for these two units of the 101st A/B Div. are less complete and consequently less reliable than for other regiments of either division. The above figures for the 502nd and 506th are supported by such records as do exist, however, and are estimated to be, at the most, not more than 20 percent in error.

12. Figures 1, 2 and 3 are graphs of the data in Table I showing reorganization performance, Q, plotted against accuracy, concentration and geometric drop effectiveness for the two U. S. airborne divisions in NEPTUNE and LARKET.

13. Figure 1 shows that drop accuracy does affect reorganization performance, night or day, and that this effect is in the expected direction, that is, the better the accuracy the higher is reorganization performance. The line bd is the visually estimated "best fit" curve for all NEPTUNE points. The slope of this line indicates that, in general, a given change in drop accuracy alone in night drops in Normandy produced a change in reorganization performance about 0.7 as great. Accuracy did not exceed 0.6 nor Q, 0.25 in NEPTUNE and no data in a higher range than this is available for night combat drops other than the Salerno drop behind friendly lines. In the latter case, a and Q were both 1.00 and this point is plotted on Figure 1 as point s. It, therefore, seems reasonable to extend the curve bd as shown by line bg to show the probable effect of higher accuracies upon Q in night drops.

14. Figure 1 shows that in LARKET, a daylight operation, variations in drop accuracy affected Q but to a smaller extent than in a night operation in Normandy terrain. The data shown do not permit fixing curve fh with the same degree of confidence as can be placed in curve bd but, if points w and y, which are distinct anomalies, are disregarded, it is considered to be generally correct as shown. Qualitative information from VARSITY (Rhine crossing, daylight) supports this belief. Curve fh indicates that a given change in accuracy alone produced, in general, a change in Q less than half as great. The difference between NEPTUNE and LARKET in dependence of Q upon accuracy was therefore a factor of about 2. The reasons for this difference and for anomalous points w, y and z will be discussed subsequently.

15. It is considered that little, if any, importance should be attached to the fact that the curves shown in Figure 1 are straight lines on log log paper. It may be that there is actually a linear relationship

FIGURE 1
ENCLOSURE B

REORGANIZATION PERFORMANCE

vs

DROP ACCURACY

NEPTUNE and MARKET

82nd and 101st A/B Divs - by
Regiments

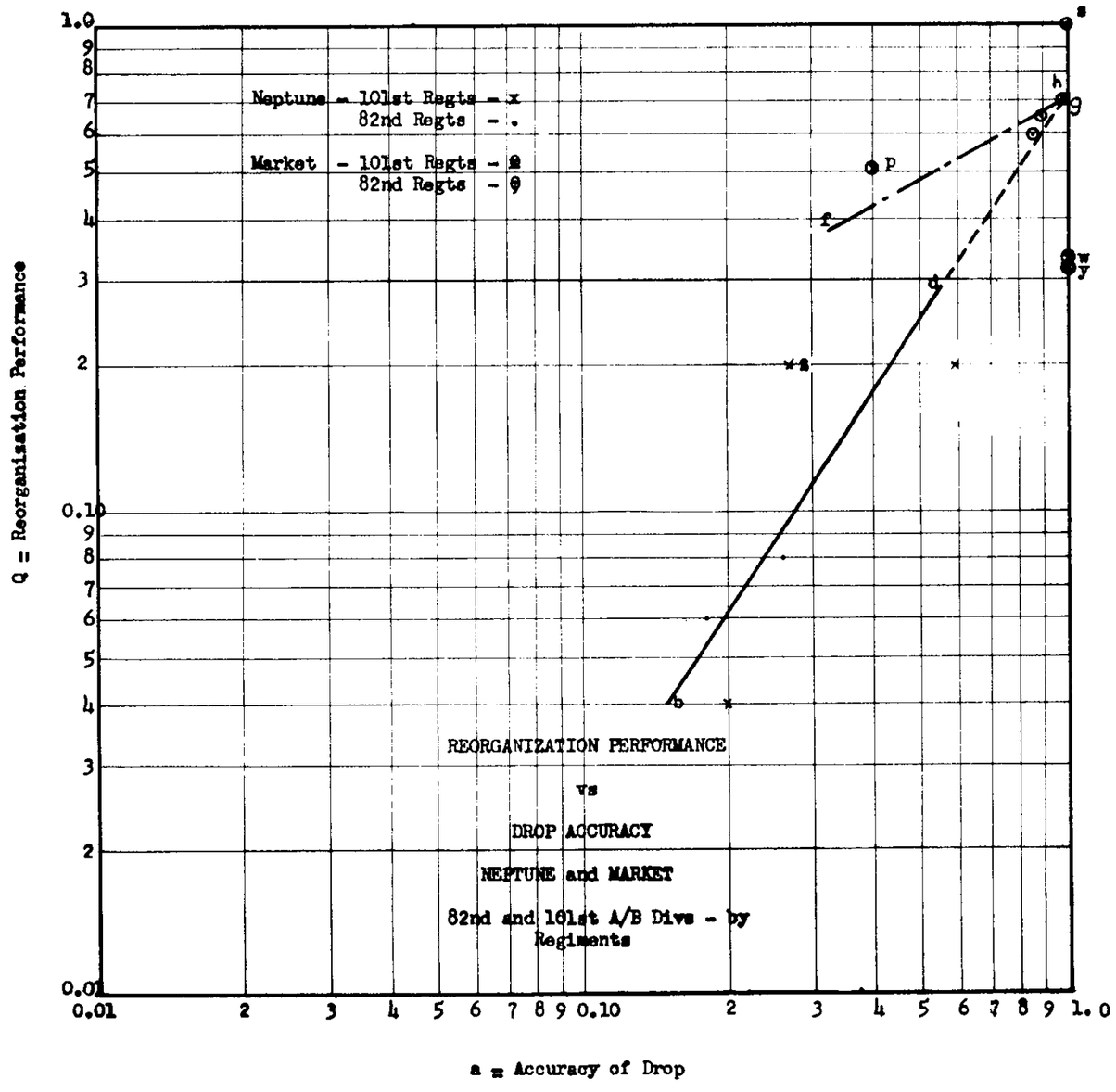


FIGURE 1
ENCLOSURE B

FIGURE 2
ENCLOSURE B

REORGANIZATION PERFORMANCE

vs

DROP CONCENTRATION

NEPTUNE and MARKET
82nd and 101st A/B DIVS. by
REGIMENTS

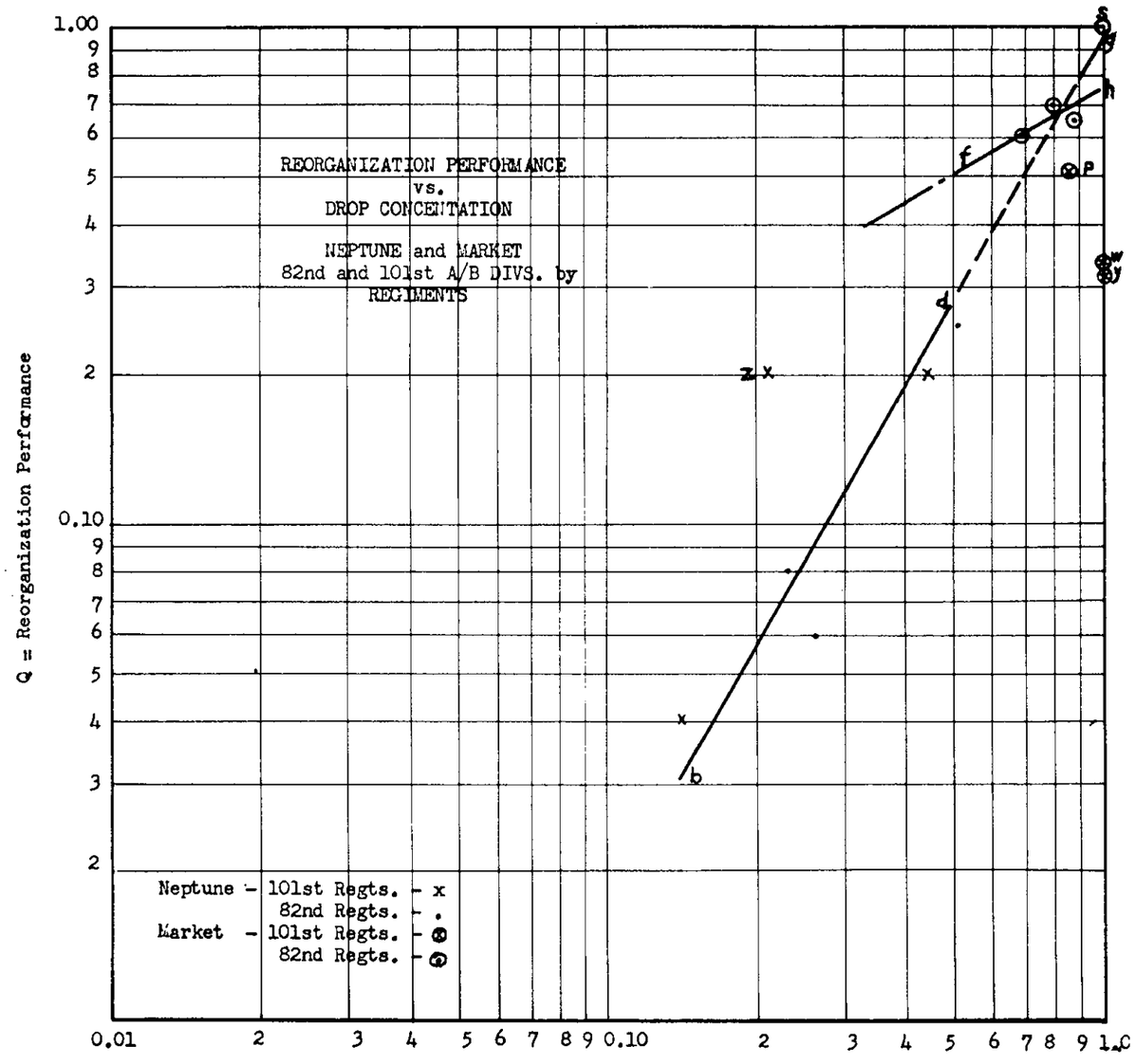


FIGURE 2
ENCLOSURE B

FIGURE 3
ENCLOSURE B

REORGANIZATION PERFORMANCE

vs

GEOMETRIC DROP EFFECTIVENESS

NEPTUNE and MARKET
82nd and 101st A/B DIVS. by
REGIMENTS

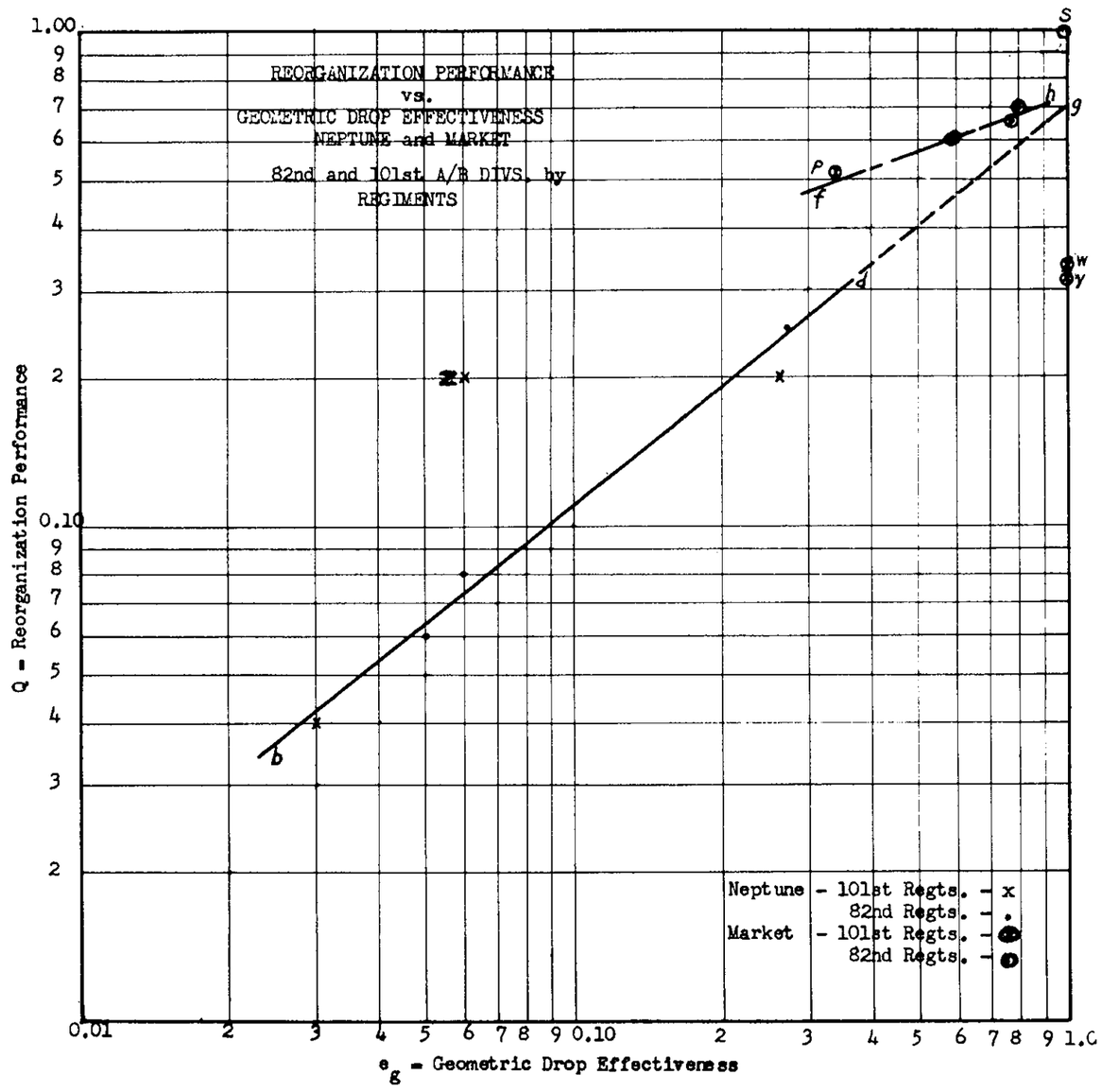


FIGURE 3
ENCLOSURE B

between the logarithm of accuracy and the logarithm of Q but there is insufficient data available to show whether this is the case. It is believed, however, that the general type of dependence upon a shown for Q is reliable. The relationship indicated by Figure 1 is as shown in Table II:

TABLE II

RANGE OF VARIATION IN Q FOR VARIOUS VALUES OF A

	a		Change in Q for unit change in a
	From	To	
NEPTUNE (Night)	0.7	1.0	1.0
	0.6	0.7	0.8
	0.5	0.6	0.75
	0.4	0.5	0.7
	-	0.4	0.6
MARKET (Day)	0.7	1.0	0.4
	0.6	0.7	0.45
	0.4	0.6	0.50
	-	0.4	0.3

16. Figure 2 shows that Q also depended upon concentration of the drop, both day and night. The comments regarding the drawing of curves bd, bg and fh in Figure 1 apply equally to the same curves in Figure 2 except that there is somewhat less scatter of points in Figure 2. The same anomalous points w, y and z also appear in Figure 2. The slope of curve bd indicates that a given change in drop concentration in the NEPTUNE operation produced a change in Q about 1.25 times as great. Curve fh indicates that in the MARKET drops a given change in drop concentration produced a change in Q about half as large. The difference between NEPTUNE and MARKET in dependence of Q upon drop concentration was therefore a factor greater than 2. Figures 1 and 2 and Tables II and III indicate that concentration in both NEPTUNE and MARKET had somewhat more influence upon Q, from 25 to 50 percent more, than did accuracy. This matter will be discussed further in later paragraphs.

17. The relationship between c and Q for various values of c is shown in Table III below. The values shown are taken from the curves of Figure 2. They coincide with the sort of variation in Q which would reasonably be expected.

TABLE III

RANGE OF VARIATION IN Q FOR VARIOUS VALUES OF c

	c		Change in Q for unit change in c
	From	To	
NEPTUNE (Night)	0.5	1.0	1.0 to 1.5
	0.4	0.5	1.0
	-	0.4	0.6
MARKET (Day)	0.8	1.0	0.4
	0.6	0.8	0.5
	0.35	0.6	0.6
	-	0.35	0.4

18. Figure 3 shows the dependence of reorganization performance upon the product of a and c which is geometric drop effectiveness, e_g. The anomalous points w, y and z again appear as in the previous figures and will be discussed further in later paragraphs. Curves bd for NEPTUNE and fh for MARKET can be drawn with considerable confidence in Figure 3. The scatter of the data is a great deal smaller than in either Figure 1 or Figure 2. The slope of curve bd indicates that in NEPTUNE a given change in e_g produced a change in Q about 0.87 as great in the range of e_g's experienced. Curve fh shows that in MARKET a given change in e_g produced a change in Q about 0.37 as great for the range of e_g's experience in that operation. The difference between NEPTUNE and MARKET in the effect on Q of changes in e_g is about 2.4. Q is clearly not linearly dependent upon e_g. Table IV shows the variation in relationship between Q and e_g for various values of e_g.

TABLE IV

RANGE OF VARIATION IN Q FOR VARIOUS VALUES OF e_g

	e_g		Change in Q for unit change in e_g
	From	To	
NEPTUNE (Night)	0.6	1.0	0.6
	0.3	0.6	0.65
	0.1	0.3	0.8
	-	0.1	0.8 - 1.0
MARKET (Day)	0.9	1.0	0.2
	0.4	0.9	0.4
	0.3	0.4	0.5
	0.2	0.3	0.7
	-	0.2	1.0

19. Comparison of Figure 3 with Figures 1 and 2 shows that " depended more directly upon e_g than upon either a and c alone in both NEPTUNE and MARKET and that the degree of dependence of Q upon e_g shown in Figure 3 is probably more reliable than that shown in Figures 1 and 2 for dependence upon a and c. An example of this is afforded by point p in all three figures. This point represents the mean experience of the three battalions of one regiment in MARKET. These units were dropped inaccurately but with excellent concentration. It is apparent that their reorganization performance was not as good as the drop concentration permitted but was considerably better than the drop accuracy curve would indicate. Their performance accords almost exactly, however, with that which would have been predicted by the e_g curve in Figure 3.

20. Although sufficiently detailed and accurate quantitative data on reorganization in VARSITY (Rhine Crossing) are not available to permit plotting against drop geometry, study of this operation indicates that the reorganization experience was in qualitative agreement with the conclusions in paragraph 19 above.

21. It is reasonable to suppose that many factors other than the geometry of the drop might affect reorganization performance. The fact that there is a certain amount of scatter of the data suggests that this was the case in NEPTUNE and MARKET. The fact that marked differences exist between the day and night dependence of Q upon drop geometry shows that there is at least one other important factor, i.e., visibility. Other possibilities are terrain, training, combat experience, planning, intelligence, enemy opposition, leadership, size of units, type of initial objective, techniques used and jump casualties among officers and men. Figure 3 shows that, with three exceptions, whatever other factors were involved, in the usual case in NEPTUNE and MARKET, their total effect was small compared to that of drop geometry. VARSITY experience again gives qualitative support to this conclusion.

22. Points w, y and z in Figures 1, 2 and 3 represent significant departures from the average reorganization performance. Points w and y

represent daylight performance only one-half as good as would be expected on the basis of accuracy, concentration or the over-all drop geometry. Examination of records shows clearly that this large difference must have been caused mainly by leadership in both cases. There is no indication that any other factor or factors were involved. In these two cases the records show that little emphasis was placed upon the quickest possible reorganization and take-off to objectives, that one hour was considered a satisfactory goal for reorganization time and that, in at least one case, movement toward the objective was definitely not planned to start until one hour after reorganization. It is not indicated here that this is bad, only that the attitude of these two regiments toward maximum speed of reorganization differed greatly from the usual one and that this produced the anomalies shown by points w and y.

23. Point z represents in a sense, the opposite extreme in variation from the usual. In this case, Q is more than twice as high as the curves in Figures 1, 2 and 3 would predict. It is not, unfortunately, possible to determine that any single factor was the cause of this unusual performance as it was in the case of the two regiments in MARKET discussed in the preceding paragraph. Detailed study of the operational data does, however, suggest certain possibilities. It becomes apparent that one group, about 300 men, composed of parts of two battalions, who dropped near the correct DZ and who were less scattered than the remainder of the troops scheduled for that DZ, are responsible for the relatively high reorganization performance figure. The accuracy and the concentration of this small part of the drop, about one-seventh of the troops intended for the DZ, are considerably higher than the mean for the drop as a whole. The difference is estimated to be about 50 percent in both accuracy and concentration. This might account for about half the variation between the actual reorganization performance and that predicted from Figures 1, 2 and 3. Another factor which may have assisted in reorganization is the fact that this group was dropped near and in correct relation to a village which was used as an orientation point in reorganizing. The remainder

of the three battalions which were supposed to drop in this area were scattered beyond visual range of the village. Since this was a night drop in hedgerow terrain it was necessary to be within, at most, a few hundred yards of any reference point to have a chance of seeing it at all. A third factor suggested by study of the records of the operation is that the leadership of the group involved was particularly aggressive and active in rounding up a sufficient force to take an objective which was considered to be the key to the entire 101st Division operation.

24. In summary, other factors, including luck, may have entered into the reorganization performance represented by point z, but it is considered that the three major ones are:

a. Better accuracy and higher concentration for that small part of the total drop which contributed most heavily to the Q value. It is estimated that this accounts for about half of the difference.

b. The group landed within sight of a briefed orientation point.

c. Leadership was active and aggressive.

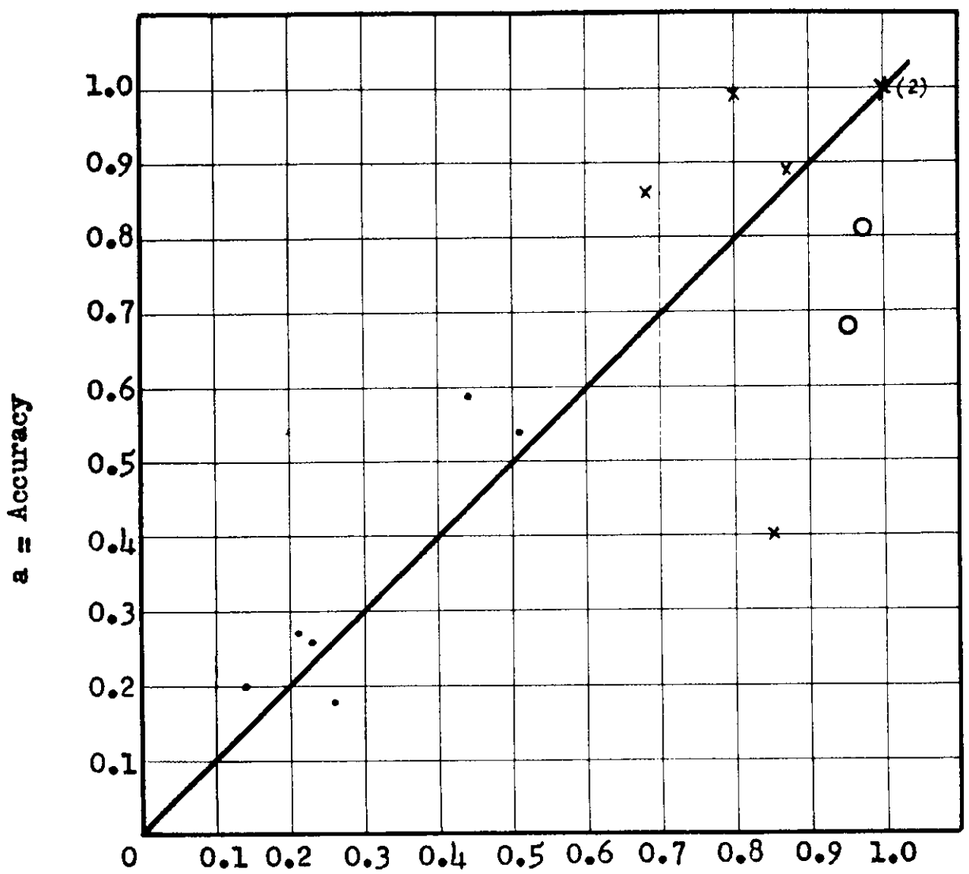
The relative contribution of the last two factors cannot be determined accurately but is estimated to be about equal.

25. In previous paragraphs it has been shown that relative concentration appears to have a greater effect upon Q than accuracy. To show this conclusively requires that Q be related to a and to c under circumstances such that any interrelationship between a and c is removed. Figures 1 and 2 show that in NEPTUNE and MARKET accuracy and concentration were, with one exception, both about equally low or high in each drop. The exception, point p, has been dealt with earlier. In VARSITY this was not the case; accuracy was generally considerably lower that concentration as shown on Figure 4 on which accuracy is plotted against concentration for NEPTUNE, MARKET and VARSITY. As indicated earlier, estimates of values for Q in the case of the two parachute regiments in VARSITY confirm that concentration has 25 to 50 percent more effect upon

FIGURE 4
ENCLOSURE B

ACCURACY vs. CONCENTRATION

14 PARACHUTE REGIMENTS
NEPTUNE, MARKET AND VARSITY



c = Concentration

ACCURACY vs. CONCENTRATION

14 PARACHUTE REGIMENTS
NEPTUNE, MARKET and VARSITY

NEPTUNE — .

MARKET — x

VARSITY — o

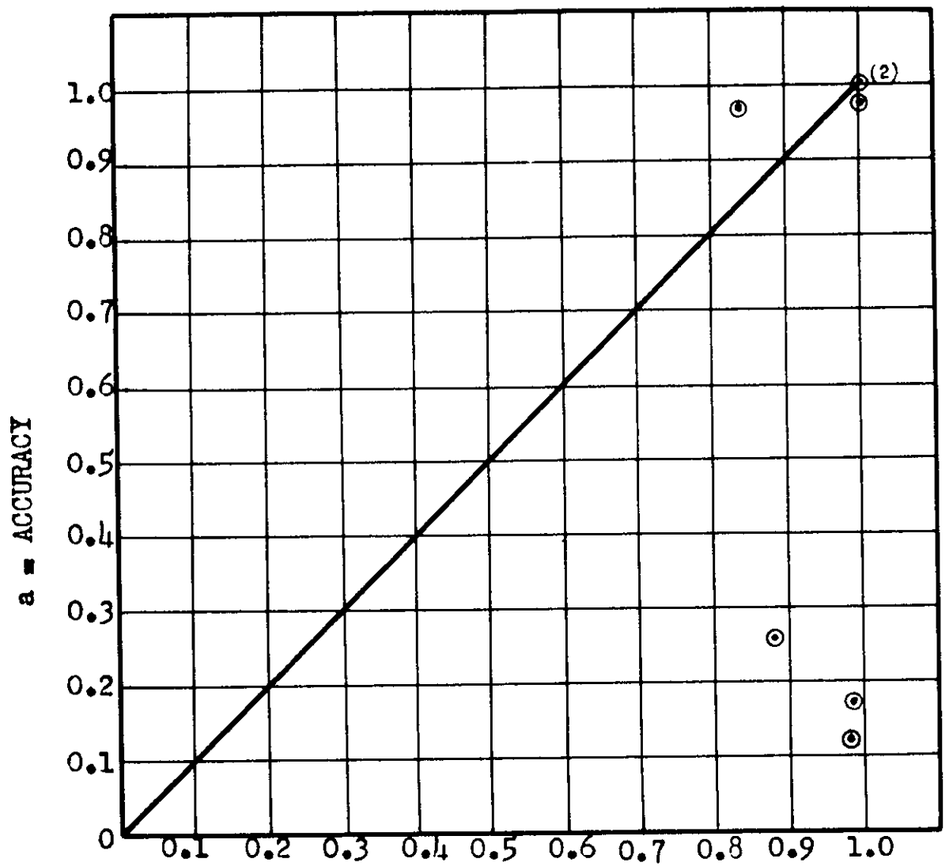
FIGURE 4
ENCLOSURE B

FIGURE 5
ENCLOSURE B

ACCURACY vs. CONCENTRATION

VARSITY

TWO PARACHUTE REGIMENTS
PLOTTED by BATTALIONS
(INCLUDING ONE FIELD ARTY. BN)



c = Concentration

ACCURACY vs. CONCENTRATION

VARSITY

TWO PARACHUTE REGIMENTS
PLOTTED by BATTALIONS
(INCLUDING ONE FIELD ARTY. BN.)

FIGURE 5
ENCLOSURE B

Q than does accuracy. The range of difference between a and c in VARSITY is more clearly shown by Figure 5 in which the accuracy and concentration of the drops are plotted by battalions. Accuracy varied from 0.13 to 1.0 while concentration ranged only from 0.88 to 1.0. Although only qualitative information is available on the value of Q for each battalion it is certain that the variation in Q's is not more than about 50 percent. It will be seen that curve fh on Figure 3 would, if extended, predict a Q of about 0.35 for an e_g of 0.15 and about 0.7 for an e_g of 1.0. This is within the range of values for Q estimated to apply to VARSITY except for those units whose low drop accuracy reduced e_g to very low values while concentration was high. In these three cases Q is estimated to have been not less than about 0.5. It is considered possible therefore that if more detailed data were available a somewhat more accurate expression for e_g might be deduced and might weight c by a factor of between 1.25 and 1.5 for drops with low accuracy and high concentration. Figure 4 shows however that in most cases accuracy was better than concentration and lack of such a refinement is not very serious.

26. The results of the analysis of the effect of drop geometry, the product of a and c, upon reorganization performance, Q, can be summarized as follows:

a. Geometric drop effectiveness, the product of accuracy and concentration, is the most important single factor controlling Q. Of 14 regimental reorganizations studied, 11 show practically complete dependence upon drop geometry even in widely different circumstances.

b. The relative importance of geometric drop effectiveness, concentration and accuracy, as here defined, is in the order of listing.

c. The dependence of Q upon any of these quantities is not linear. The data indicate a linear relationship between the log of Q and the log of each of the three geometric quantities. This is most clearly the case for log Q and log e_g.

d. Q falls off with decreasing accuracy, concentration and e_g about twice as fast for NEPTUNE drops as for drops in MARKET or VARSITY.

e. It appears from Figures 1, 2 and 3 that the reorganization criteria used, one hour and 80 percent strength for night drops and twenty minutes and 80 percent for daylight drops, were about equally difficult to attain and were about 30 to 40 percent above the best performance actually attained in combat. This might indicate that 80 or 90 minutes and 30 minutes, respectively, actually represented perfection for the operations studied. This accords with the general opinion of unit commanders. The ratio between absolute day and night rates appears to have been roughly 3 to 1.

III. EFFECT ON EQUIPMENT RECOVERY

27. Reorganization is not simply a matter of regaining control of personnel although this is the first essential and a major part of the job. The force so organized must have a sufficient amount of its arms and equipment to accomplish the assigned assault missions. Although personal arms and some items of equipment are dropped attached to the troops, a great deal of equipment was dropped, in World War II operations, in separate bundles released while the troops were getting out of the airplanes. It is therefore to be expected that the accuracy and concentration of the drops of these bundles would be the same as for the troop drops with which they are associated. In this case it would be expected that equipment recovery in an airborne parachute assault would be governed by drop geometry in the same manner and to the same degree as is the reorganization of troops.

28. Very little quantitative data is available on equipment recovery in NEPTUNE except that 60 percent of all bundles in the 101st Division assault were not recovered during the airborne phase of the battle. Estimates from study of the 82nd and 101st operation in NEPTUNE, supported by opinions of participants, agree in that less than 10 percent of crew-served weapons, communications and bundled ammunition appear to

have been available for the initial ground assaults and not more than 40 to 50 percent of bundled equipment dropped in the initial assaults was ever recovered. It is interesting to note that, of the forces delivered by air on D-day, about one-third of the 82nd and one-half of the 101st Airborne Division personnel were reorganized at the end of D-day and not more than about half of the total force dropped was brought under centralized control during the airborne phase of the battle. These troop reorganization figures compare very favorably with those for equipment recovery and show that poor drop geometry under NEPTUNE conditions made it about as difficult to recover equipment as to reorganize into units.

29. Data for MARKET are much more complete and show that, by the time reorganization was completed, from 80 to 100 percent of bundle dropped equipment had been recovered. This accords well with the personnel reorganization experience in MARKET.

30. It seems clear that the controlling factor in assault equipment recovery is drop geometry and that it is reasonable to assume about the same degree of dependence upon accuracy, concentration and geometric drop effectiveness as for reorganization performance.

31. It should be noted that this does not mean that if a bad drop makes reorganization performance low, say Q equal to 0.2, that this force will be properly armed because about the same percentage of equipment bundles will have been recovered. In general, such a force will be very inadequately equipped with crew-served weapons or ammunition, and communications. (It is likely that they will be adequately equipped with small arms and an accompanying basic load of ammunition, since the troopers drop with this equipment attached.) This arises from the fact that the 20 percent recovery is very unlikely to be properly distributed over all categories of equipment and from the fact that shortage of manpower will not permit the utilization of much equipment that is located. It is therefore likely that poor drop geometry will result in inadequately armed, as well as small assault forces. The NEPTUNE experience amply

demonstrates that this is particularly true at night or in terrain which limits ground visibility.

32. Recovery of parachuted resupply appears to follow the same general rules, set forth in paragraph 30 above, as far as dependence upon accuracy and concentration is concerned. Detailed and precise data are not available on this subject but it is clear from studies of both day and night operations that accuracy and concentration are at least as important in determining recovery rates and total ultimate recovery in resupply drops as in determining reorganization performance.

IV. EFFECT UPON RATE OF GROWTH OF ORGANIZED FORCE

33. The initial assaults upon first objectives in an airborne operation take place, in general, as quickly as reorganization is completed. In fact, it has been stated previously that the end point in time for reorganization is determined in most instances by the decision to start for the objective. In an ideal situation all troops and equipment would be under organized control at this time and the strength of the airborne force would remain constant from this time on except for attrition. In practice, however, it is often necessary to carry out the initial assaults with less than full strength and there may be a continuing growth of force for some time after initial reorganization. The range of effect of drop geometry upon the rate of growth and upon total strength of force ultimately organized is demonstrated by experience in NEPTUNE, MARKET and VARSITY.

34. In NEPTUNE roughly 20 percent strength was available for the initial ground assaults and the assaults were generally delayed from one to several hours by the difficulty of securing even this small number of troops in organized groups. By the end of D-day about 40 percent strength had been assembled and this force never grew beyond about 50 percent of strength. The experience of one regiment, the 505th, which had one of the best drops in this operation was recorded fairly clearly as follows:

Troops Dropped - 2041 E.M.
164 O.
Total 2205

Troops Reorganized for Assault Missions:

	Troops	Time
1st Group	450	H + 2.3 hrs.
2nd Group	180	H + 2.0
3rd Group	350	H + 4.5
Total	980	2.0 to 4.5 hrs.

Percent Strength - 44 percent, after 2 to 4.5 times the planned time elapse.

Troops under control on D-day at H + 1330 hrs:

1037 E.M.
86 O.
Total 1123 - 50 percent of strength

Equipment - Crew Served Weapons:

In Use on D-day at H + 1530 hrs	Dropped at H-hour 5/
31	30-L + HMG's
4	36 - 60 mm's
21	18 - 81 mm's
7	54 BAR's
2	8 - 57 mm A.T.'s
19	109 Bazookas

Troops under control from D + 1 to D + 6 days: averaged about 1400 including land tail.

On D + 21: 42 percent troops and 50 percent officers.

35. It is reiterated that the experience summarized in the preceding paragraph was considerably better than the average for NEPTUNE. The experience of most units was less than half as favorable.

36. In the MARKET operation from 80 to 100 percent strength was attained for practically all units within about one hour after the drops. Practically all troops were under control by nightfall of D-day and, consequently, only a negligible number rejoined their units from this time on. Recovery of bundled equipment for all units was virtually complete by the time reorganization had taken place.

37. The experience of the two parachute infantry regiments in VARSITY is similar to that outlined for the MARKET units although not

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5/ 57 mm Anti-tank Guns were landed by Glider

quite so favorable. Roughly two hours were required to secure complete control of all men and equipment dropped.

38. It would appear that drop geometry is a major factor in controlling not only the initial reorganization and equipment recovery performance, but also in affecting the rate of growth and final organized strength of parachuted forces. The rate of growth can be reduced by as much as a factor of 20 and the ultimate organized strength by a factor of 2 by differences in drop geometry experienced between MARKET (Day, open terrain) and NEPTUNE (Night, terrain restrictions on daylight visibility).

V. EFFECT UPON JUMP CASUALTIES

39. The only discernible effect of drop geometry upon jump casualties is that a complete miss of the DZ area may result in troopers landing in the sea, in rivers, on rocks, or in heavy woods. In general, the selection of DZ's in World War II operations was such that the terrain adjacent to DZ's was not usually much less favorable for parachute landings than the DZ's themselves with the exception of the above factors. In the NEPTUNE drop the only jump casualties which can be ascribed to landing off the DZ's are those resulting from landing either in a river or flooded area or in the sea. In MARKET there is no discernible case in which troops landing off the DZ experienced heavier jump casualties than those who were dropped correctly. River and canal hazards existed but no one dropped in them. In VARSITY there are a few instances of inaccurately dropped troops landing in heavy woods. The number is, however, very small in proportion to the total numbers dropped inaccurately.

VI. SUMMARY

40. It has been shown that, in operations NEPTUNE, MARKET and VARSITY, the geometry of the parachute drops was in general the dominant factor controlling reorganization performance, recovery of parachuted initial equipment and resupply and rate of growth and ultimate strength of organized forces after parachute delivery. These in turn are the factors which determine the size, composition and strength of the effective

fighting unit on the ground relative to that with which it is planned to accomplish the mission. The performance of the air forces involved in the delivery of parachute assault units had, therefore, a marked and measurable effect upon the ground operations in the airborne assaults studied.

41. In the operations studied the most reliable and direct dependence for all three items, reorganization, equipment recovery and growth of force, was that upon the product of accuracy and concentration which has been termed geometric drop effectiveness. Concentration appears to have had 25 to 50 percent more effect than accuracy upon reorganization performance and recovery of initial equipment.

42. The importance of drop geometry in the NEPTUNE operation (night) was about twice as great as in MARKET (day).

43. The differences in drop geometry observed in and between NEPTUNE and MARKET produced the following range of effects:

a. Variations in relative reorganization performance from 0.04 to 0.7 on a scale of 0 to 1.[6/]

b. Variations in initial equipment recovery and in parachuted resupply recovery of similar magnitude to that for reorganization performance.

c. Combining a and b above, variations in initial assault ground strength, in numbers of troops, from 20 percent to 100 percent of planned strength and from 10 percent to 100 percent in bundle dropped equipment and weapons. The accompanying variation in timing of the initial assault can be as high as a factor of 5.

d. Variations in rate of growth of organized forces as great as a factor of 20 and in ultimate organized strength as great as a factor of 2.

44. No systematic dependence of jump casualties upon drop geometry is indicated by study of NEPTUNE, MARKET or VARSITY. If inaccuracies in troop drops resulted in troopers landing in water or in heavy woods the

6/ The criteria used in the analysis are about 30 to 40 percent above any actual combat performance achieved in the operations studied and the absolute range of values for reorganization performance may therefore be 0.06 to 1.0.

troopers who did so sustained a high rate of casualties. In all other cases no effect is discernible. (This subject is treated more fully in Enclosures C and D.)

ENCLOSURE C OF WSEG STAFF STUDY NO. 3

FACTORS IN REORGANIZATION - EXCLUDING DROP GEOMETRY

I. INTRODUCTION

1. It was suggested in Enclosure A that, although drop geometry was ordinarily the dominant factor in establishing reorganization performance in the World War II operations studied, other factors might also exert a degree of influence. It was demonstrated that this was true to a marked degree in certain cases of reorganization performance which appeared to be anomalous with regard to the drop geometry experienced. It was further suggested that one or more of these factors might account for the systematic difference between NEPTUNE and MARKET in the relationship between Q and drop geometry. In this section of the analysis a summary is presented of such findings as the data permit relative to the effect upon Q of factors other than drop geometry.

II. ANALYSIS

2. Possible factors having a bearing upon Q are intelligence, planning, training, leadership, techniques used, combat experience, jump casualties, size of units, type of initial missions, terrain, visibility and enemy opposition. These possibilities are examined in the following paragraphs.

3. INTELLIGENCE: Intelligence of enemy strengths and dispositions and its effect upon the general course of airborne ground actions is treated in Enclosure H. Intelligence might enter the problem of reorganization in at least two ways. In the first place, knowledge of weather, enemy anti-aircraft and anti-airborne defenses is the basis for all planning and action taken to circumvent or neutralize their effects with the object of delivering the airborne force intact and to the correct objective areas. Drop geometry experienced is itself therefore governed in part by intelligence. This phase of airborne operations is covered in Enclosures I and J. The second way in which intelligence might have a bearing upon Q is in the degree to which, by aerial photographs, maps and other techniques, intelligence organizations are capable of familiarizing airborne forces in advance with the terrain upon which they will land. This might be termed terrain intelligence.

4. In reorganizing parachuted units terrain features are normally used as points of reference for orientation. It is clear therefore that the intelligence material supplied during planning must be complete and accurate with regard to such items in the DZ areas. Since troops may land at some distance from their intended DZ's it is also essential that they be furnished with intelligence material on the general operational area sufficient to permit orientation on the ground in such a contingency. Finally, since there will normally have been no previous opportunity for ground reconnaissance of the terrain they must traverse in order to reach their reorganization areas, the troopers must be furnished such information by intelligence sources in advance of their drop.

5. In most instances in the operations studied it is not possible to detect any difficulty in reorganization which can be ascribed directly to inadequate terrain intelligence. There is, however, one classical case in NEPTUNE with regard to the 508th Regiment and the Merderet River. The Merderet River valley was photographed repeatedly and it was determined that it would offer no great obstacle to ground movement. In actual fact much of the valley was flooded to a depth of several feet and caused not only about 36 drownings among troops dropped in it but great difficulty in the ultimate reorganization of the fighting units dropped in and around the area. The drop geometry experienced by this unit was, however, so poor as to mask much of the effect of lack of knowledge of the terrain.

6. It can only be said in summary that although terrain intelligence is important to reorganization it is not possible to determine from World War II any quantitative scale upon which its effects might be shown. In general, terrain intelligence appears to have been adequate for the purpose.

7. PLANNING, TRAINING, LEADERSHIP, REORGANIZATION TECHNIQUES: Available data does not permit detailed, quantitative analysis of the effects upon reorganization performance produced by these items. Such evidence as there is in the records of operations studied indicates only that, generally speaking, in World War II operations all units had about the same training, used reorganization techniques very comparable in effectiveness - capable

of coping with all but very poor drop geometry, enjoyed leadership comparable in respect to the qualities required in reorganization and operated under very similar plans for reorganizing into effective combat units.

8. There are, however, despite this general lack of quantitative evidence, one or two indications of the degree to which the type of factor under discussion may alter Q. As indicated in paragraphs 22, 23 and 24 of Enclosure A, dealing with drop geometry, leadership can produce an effect as large as a factor of two, that is, of the same order of magnitude as appears to exist between day and night reorganizations.

9. It can only be concluded that these factors are of importance and one of them, leadership, can influence reorganization performance by a factor of two. The apparent reason that little evidence is available upon the range of quantitative effects produced is that as far as reorganization performance is concerned, the necessary qualifications in these respects were present in practically uniform degree in the units and operations studied.

10. COMBAT EXPERIENCE: Referring to Figures 1 and 2 in Enclosure B, it will be noted that there is a greater spread of performance data for the units of the 101st Airborne Division in NEPTUNE than for units of the 82nd. Detailed study of the records upon which these data are based suggests that this variation in performance was due more to lack of combat experience of the 101st versus the 82nd than to anything else. This same factor, it may be speculated, may also have been an underlying reason for the difference in attitude toward the importance of speed in reorganizing which is evident in MARKET for two regiments of the 101st Airborne Division as compared to the other regiments participating in the assault. General study of the U.S. 17th Airborne Division performance in VARSITY, its first combat drop, indicates that lack of combat experience affected reorganization performance adversely to some degree in that greater reliance seems to have been placed upon reorganization of troops and equipment at the exact briefed location than was required in view of the circumstances. Many units were dropped with excellent concentration but poor accuracy. Instead of reorganizing where they were and proceeding directly to assigned or to the nearest major initial objectives,

such units in many instances elected to travel to their briefed reorganization areas before considering themselves organized for the initial assaults. It is difficult if not impossible to quantify this experience with any accuracy but a constrasting one can be described to illustrate the point. In MARKET, the Second Battalion, 505th Regiment, was landed in error, well concentrated, but on the wrong DZ two to three thousand yards away from the correct one. This unit had had a great deal of combat experience. Instead of the troopers' attempting to reach the briefed area before reorganizing, the unit reorganized where it was under enemy fire and proceeded to the attack without confusion. Part of the reason for this type of performance is undoubtedly excellent leadership, but the major factor is believed to be combat experience.

11. Combat experience appears, in general, to be of considerable benefit in assisting reorganization under difficult conditions. There is no evidence that it is particularly important in good drops. Data are not available in sufficient detail to permit quantitative assessment of its importance.

12. JUMP CASUALTIES: It has been demonstrated that leadership is important during reorganization. It follows that should sufficient jump casualties occur as to impair or remove leadership, reorganization performance would suffer. No case in which this occurred has come to light in the operations studied with regard to jump casualties, including Corregidor. In that operation jump casualties were more than twice as high as in any other studied, 11.2 per cent, because of the hard and rough terrain of the DZ's but this appears to have had no significant effect upon any subsequent part of the operation of the airborne unit involved. When it is considered that all officers in a parachute unit were trained to operate independently or to take over in the absence of superiors it is clear that even severe jump casualties would be unlikely to jeopardize reorganization performance very seriously. There is no evidence from any World War II operations that jump casualties were ever responsible for poor reorganization performance.

13. SIZE OF UNITS: Records from NEPTUNE, MARKET and VARSITY indicate, generally, that the smaller the unit the more rapid is the reorganization.

This is what would be expected. In a good drop, in daylight, in open terrain, combat experience indicated that a company could reorganize in roughly 20 minutes, a battalion in about 30 minutes and a regiment in about 45 minutes. The delays in going from companies to battalions to regiments are largely due to the necessity for more elaborate communications to be set up and more messages to be sent and received. In practice night drops and in the night drop behind friendly lines at Salerno, the evidence is that the battalion times should be doubled for night operations in open terrain and with perfect drops behind friendly lines, and trebled if the drops are behind enemy lines.

14. General examination of the three operations mentioned demonstrates that some delay may be caused by overlapping of units on the same DZ. Battalions dropped separately were usually able to reorganize somewhat more quickly than those dropped on a regimental DZ with other units. No precise quantitative data is available on this but it is reasonable to suppose that it is a reliable generality since there would be much less confusion on the DZ in the case of units dropped singly.

15. TYPE OF INITIAL MISSION: There is qualitative evidence that, in some cases, units whose initial mission was to act in a reserve capacity tended to reorganize at a slightly slower rate than those which had a definite objective to take immediately. The tendency appeared to influence reorganization only when there was no enemy opposition on the actual DZ's. This would seem to be a natural tendency and is probably real although in no case studied was the effect significantly large.

16. TERRAIN AND VISIBILITY: These two items are considered together since their effects upon reorganization are difficult to treat separately. With regard to visibility alone, it has been demonstrated in the preceding section of this analysis that the difference in reorganization time between daylight and night for the same percentage of strenth reorganized is a factor of about three, that is, it takes about three times as long at night. This applies to a perfect drop in open terrain in both cases. It has also been demonstrated that Q falls off roughly twice as rapidly with decreasing a, c or e_g for NEPTUNE as for MARKET. While it is true that NEPTUNE was a

night operation and MARKET was carried out in daylight, it is also true that the terrain in NEPTUNE was very different from that in MARKET. It would consequently be possible for part of the difference in the dependence of Q upon drop geometry between NEPTUNE and MARKET to be due to terrain effects.

17. Unfortunately the drops in NEPTUNE were so poor and those in MARKET so good that direct comparisons of Q values in one operation with those in the other for the same drop geometry are restricted to the upper end of the NEPTUNE curve and the lower end of the MARKET one. If this is done on the curves bd and fh on Figure 3 of Enclosure B it will be seen that at $e_g = 0.3$, Q is 0.47 on the MARKET curve and about 0.26 on the NEPTUNE curve, a difference of about a factor of two. When it is remembered that the reorganization performance criteria upon which these curves are based allow one hour at night and 20 minutes in daylight for 80 per cent reorganized strength it is apparent that reorganization proceeded in MARKET at roughly 6 times the absolute rate in NEPTUNE for an e_g of about 0.3. For perfect drops, $e_g = 1$, on the bases used for these curves, the ratio between absolute day and night rates would have been 3. It will be seen that the straight line extension of the NEPTUNE curve, dg on Figures 1, 2 and 3, does in fact meet the MARKET curve at almost exactly the same point in each case, $e_g = 1$ at $Q = 0.7$, approximately. This would indicate that the actual ratio of NEPTUNE and MARKET Q's at $e_g = 1$ was 3. The plotted NEPTUNE curve bd appears, therefore, to follow "open terrain" laws. It would appear from this that the hedgerow terrain in NEPTUNE did not contribute to a significant degree to the delaying effect introduced by its being a night reorganization and that the 2 to 1 rate of decrease of Q with e_g was a function of illumination only. It should be noted that this argument is based upon an extrapolation of curves. Such evidence as is available indicates that the straight-line extrapolation used is probably valid. There are, however, insufficient data to demonstrate conclusively that this is so.

18. It may be profitable at this point to examine the matter of terrain and visibility somewhat theoretically to discover whether any reasonable relationships can be deduced which might shed light on the problem. The effects of terrain in any type of military operation can be considered to be three in number. Terrain may limit visibility simply by imposing obstacles to the line of sight or by reducing contrast between an object and its background. It may also afford protection in the form of obstacles to missiles. It may provide friction in the form of obstacles to movement. Visibility in the open is governed by the amount of illumination present but it is apparent that this may be restricted by terrain regardless of the amount of illumination. It is equally clear that if the illumination is poor enough, visibility will be limited by it and not by any aspect of terrain.

19. Reorganization of troops depended a great deal in World War II upon their being able to see and recognize orientation points or signals and each other. It also depends ratewise to some extent on speed of movement. While speed of foot travel is linked to the friction aspects of terrain it is also governed a great deal, whatever the terrain, by illumination, one aspects of visibility. FM-101-10 shows a reduction in cross country route march speed in going from day to night illumination of 33 per cent. It should also be noted that although reorganization requires foot travel, particularly in bad drops, much of the time involved in reorganization is spent in searching for, collecting, removing from bundles and sorting out equipment and in sorting out personnel. Hence speed of travel alone does not control reorganization performance directly in any case. It can be seen that degree of illumination might therefore, even on theoretical grounds, affect reorganization to a proportionately much greater degree than the friction aspects of the terrain.

20. Examination of NEPTUNE indicates that the illumination on the ground during the first two and one-half to three and one-half hours after the drop was poor enough to restrict recognition visibility for troops to less than the distance between hedgerows. Terrain was accordingly not the primary limit on recognition visibility. It did in some cases restrict

the distance at which visual orientation signals, such as lights, could be seen although this was not true for flare signals.

21. Although the difficulty of movement in hedgerow country has been greatly emphasized,two factors of travel in this type of terrain were that it also afforded considerable protection and was difficult to traverse to a far greater degree for vehicles than for foot troops. A reorganizing parachute unit is largely traveling on foot and in NEPTUNE, little organized opposition was met at this stage of the operation. It may be significant that those troops who landed in the swampy and flooded areas near the Merderet appear to have had considerably more trouble with regard to movement than did those who landed in relatively firm hedgerow areas.

22. The foregoing examination leads to the conclusion that terrain was not a major factor in restricting the rate of reorganization in the night reorganization in NEPTUNE insofar as restriction to movement was concerned. It appears that illumination determined visibility and that this was the prime factor in determining the type of dependency of Q upon drop geometry exhibited in this operation. It is probable that the terrain limitation on visibility of signals exhibits so little effect because so few visual aids could be found and used after the drop. It is important to note that both the analytical and the operational examination made here are based upon the operation as it actually occurred. It is possible that if the drop geometry had been better than it was the effect of terrain might have been evident.

23. It is worth noting that if NEPTUNE had been a daylight operation the terrain would in many instances have limited ground visibility for recognition purposes to the distance between between hedgerows. Although it would have been possible for many of the troops to have oriented themselves on prominent or high features, both before and after the drop, it is probable that lack of ground visibility would have reduced the reorganization rates to values below those which would be predicted from the MARKET curves in Figures 1, 2 and 3. Unfortunately it is not possible to determine quantitatively, from study of any World War II operation, the reduction to be

expected. The effect of terrain reduction in visibility may be shown qualitatively to some extent by the slow rate of growth of organized forces after daylight on D-day.

24. ENEMY OPPOSITION: A certain amount of quantitative information on the effect of enemy opposition on Q is available from records of the MARKET operation. Study of VARSITY also sheds some light on this point in a qualitative way. In NEPTUNE other factors enter to such an extent as to mask any effects which enemy opposition on the DZ's might have had and all that study of this operation can reveal is that fact, that enemy opposition on the actual drop areas had negligible effect on reorganization rate compared to other factors.

25. In MARKET the 101st Airborne Division recorded little or no enemy opposition on its DZ's but fairly detailed data exist on the reorganization performance of 27 companies of the three regiments in the 82d Airborne Division, some of which did have opposition. Of these companies 18 reported no opposition on the DZ's during reorganization and 9 reported "light opposition." This term covers enemy security and anti-aircraft detachments armed with rifles, machine guns and 20mm anti-aircraft guns installed in towers. In one or two cases, light mortar fire was also reported. In Table I below, the experience of these 27 units is set forth.

TABLE I

EFFECT UPON Q OF ENEMY OPPOSITION
ON DZ'S - 27 COMPANIES IN MARKET

Regiment	Regimental e_g	No Opposition		Light Opposition	
		No. of Co.'s	Q 6/	No. of Co.'s	Q 6/
505th	0.80	6	0.65	3	0.94
508th	0.77	4	0.60	5	0.61
504th	0.58	8	0.49	1	0.53
		18		9	

6/ The mean of the Q's given here does not agree exactly with those given for larger units, such as battalions or regiments, because of extra time allowed larger units to organize headquarters and attached supporting units and set up internal communications.

26. From Table I it is clear that in every case those companies which experienced light enemy opposition on the DZ's reorganized at a higher rate than those which did not. The limited range of circumstances met in MARKET must be kept in mind. It is supposed, for example, that if drop geometry were sufficiently poor, particularly with respect to concentration, enemy opposition on the landing area would have a severe deleterious effect upon Q. MARKET did not include drops sufficiently scattered to illustrate or to quantify reliably the point at which this might occur. The slight evidence that does exist, as shown in Table II would indicate that, in MARKET, in good visibility, light opposition on the DZ might begin to produce a deleterious effect on Q for a drop with an e_g of about 0.5 with concentration below about 0.6. In Table II the 505th and 508th regiments are lumped together since their drop geometry was practically the same.

TABLE II

VARIATION WITH DROP GEOMETRY OF EFFECT ON Q OF OPPOSITION ON DZ'S

Regiment	Regimental e_g	No Opposition		Light Opposition		Per Cent change in Av.Q
		No. of Co's	Av.Q	No. of Co's	Av.Q	
505th + 508th	0.80	10	0.62	8	0.77	+ 24
504th	0.58	8	0.49	1	0.53	+ 8

27. In VARSITY there was considerable opposition on many of the DZ's. It was in general of a heavier weight than that described above in MARKET and consisted mainly of artillery and anti-aircraft units in the immediate rear of the German 84th Division defending a segment of the Rhine. General study of this operation indicates that the amount of immediate enemy opposition experienced in this operation had no serious delaying effects on reorganization. The chief result seems to have been a slight delay in departing for primary initial objectives, by which time much of the opposition to the entire operation had been successfully eradicated. It should be noted that drop concentration was generally very high in VARSITY, even when accuracy was low.

28. In summary, there is no evidence that enemy opposition on DZ's prevented or delayed reorganization to a significant degree in the World War II operations studied. There is some evidence that light opposition may even have improved Q when drop geometry was reasonably good.

III. SUMMARY

29. Factors other than drop geometry which might influence reorganization performance have been examined insofar as this has been possible by study of available data recorded on NEPTUNE, MARKET and VARSITY. It has been concluded that:

a. Terrain intelligence, planning, training, leadership and reorganization techniques used were important in influencing Q but available World War II data does not permit reliable quantification of their effects. Such evidence as there is indicates that differences in leadership may introduce a factor of 2 in reorganization performance. In general, in the World War II operations studied the necessary qualifications, as far as affecting Q is concerned, in respect to these five items appear to have been present in all units in practically uniform degree.

b. Combat experience appears to be of considerable benefit in assisting reorganization under difficult conditions. There is no evidence that it is particularly important in good drops. Data are not available in sufficient detail to permit quantitative assessment of its importance.

c. Jump casualties appear to have had no effect upon reorganization performance in the operations studied. These operations include Corregidor in which jump casualties were more than twice as high as in any other operation studied, 11.2 per cent.

d. Size of unit does affect Q in an inverse manner, as would be expected. Perfect reorganization in daylight in open terrain and with an ideal drop would be characterized for World War II combat operations by 80 per cent organized strength under headquarters control in about 20 minutes for a company, 30 minutes for a battalion and about 45 minutes

for a regiment. There is some qualitative evidence that a unit can reorganize faster when dropped alone than when dropped on a DZ with other units.

e. Type of initial mission may have a slight effect on Q. A unit which is to go into reserve may reorganize slightly slower, in the absence of enemy opposition, than one whose initial mission is the immediate seizure of a physical objective.

f. Terrain and visibility are considered together. The primary way in which terrain alone may affect Q is by restricting visibility rather than by restricting movement. When visibility was limited primarily by illumination, rather than by terrain, there was no observable influence of terrain on Q. Change in illumination from daylight to night appears to have decreased absolute reorganization rate by a factor of about 3 for good drops and relative Q falls off roughly twice as fast with decreasing geometric drop effectiveness at night as in daylight.

g. Enemy opposition on the DZ experienced in NEPTUNE, MARKET and VARSITY does not appear to have had an adverse effect upon Q. In fact, such quantitative evidence as there is from MARKET would indicate that, at least for good drops in daylight, light opposition on the DZ may actually improve reorganization performance.

ENCLOSURE D OF WSEG STAFF STUDY NO. 3

LOCATION OF DROP ZONES AND LANDING ZONES

I. INTRODUCTION

1. It is the purpose of this section of the analysis to determine from an examination of World War II records what effect the locations of DZ's and LZ's with respect to initial objectives had in the operations studied and, if possible, to discover the generally most favorable locations with respect to objectives.

2. In any type of assault the immediate purpose is to move in the shortest possible time from some starting point to some objective and seize it. Anything which occurs between the starting point and seizure of the objective to cause delay must be regarded as an obstacle. In general, in the whole progress of the art of offensive war, the purpose of every innovation has been to increase the over-all rate of movement of armed forces by reducing the effects of all obstacles, including enemy opposition, to values as near zero as possible.

3. Applying these criteria to an airborne operation, it would seem that the ideal to be aimed at in the troop delivery phase is the movement by air of organized, controlled, effective fighting units, properly deployed for action, directly to the objectives to be seized. The rate of movement of the force to the objectives would then be governed only by the speed limitations of the troop carrying aircraft. No time would be lost in reorganizing, moving to the objective, or in deploying to take it. The only remaining obstacles would be the enemy at the objectives and the physical nature of the objectives themselves. It was only in exceptional cases, usually involving small forces, that it was possible to deliver troops organized, controlled and deployed in this manner in World War II. It is also obvious that it would not usually be physically practicable to deliver forces of the proper size and type directly on each and every objective in an airborne operation, regardless of considerations of organization and deployment. Furthermore, from the point of view of

the air side of an airborne operation, the degree of feasibility of its task and the cheapness with which it can be performed vary, in an inverse manner, with the following considerations.

a. Number of flak areas to be avoided in laying out troop carrier routes,

b. Number of air routes along which flak must be neutralized or destroyed,

c. Number of troop carrier streams to be flown and protected from enemy air action,

d. Size of immediate battle area in which enemy is to be isolated and attacked, and

e. Numbers of drop and landing zones to be located and accurately hit with troops and equipment.

4. The necessary compromises between the ideal sought and the possible and practicable means results in the necessity for the use of DZ's and LZ's which may not coincide with the objectives.

5. The purpose of the foregoing paragraphs is to show clearly that DZ's and LZ's are not necessarily ends in themselves but may actually be intermediate steps introduced into an airborne operation by limitations imposed by the means available. They do, in fact, become the ultimate target for the air delivery phase, but their locations with respect to objectives may impose time delays on the troops delivered on the ground in comparison to the theoretical ideal delivery to the objectives. The question to be answered is where should they be located for optimum results under practical conditions.

II. FACTORS INVOLVED OTHER THAN PROXIMITY TO OBJECTIVES

6. In World War II operations several considerations other than proximity to objectives were involved in the selection of DZ's and LZ's. These factors and the results of the selections made are treated in the following paragraphs to the extent that available data permit.

7. JUMP CASUALTIES: This factor was often given careful consideration in DZ selection in World War II. Examination of available data

indicates that it was generally not necessary to select DZ's on this basis. Table I below shows jump casualty experience in NEPTUNE, MARKET and Corregidor.

TABLE I

JUMP CASUALTIES [1]

Operation	Unit	Percent D-day Jump Casualties [2]
NEPTUNE	82nd A/B Div.	4.24
	101st " "	2.40
MARKET	82nd A/B Div.	1.70
	101st " "	1.56
Corregidor	503rd PIR	11.2 [3]

8. In considering these values it is well to remember that in the first place, despite the care with which the drop zones are selected, unless the troop carrier delivery is of a high order of accuracy, the casualty rate on landing may be unaffected. In NEPTUNE, for example, it may safely be said that the paratroopers experienced a complete sampling of the Normandy terrain.

9. Table II shows the degree of variation in jump casualties with accuracy for NEPTUNE, MARKET and Corregidor.

TABLE II

VARIATION IN JUMP CASUALTIES WITH ACCURACY

Operation	Unit	a	Percent D-day Jump Casualties
NEPTUNE	82nd A/B. Division	0.32	4.24
	101st " "	0.33	2.40
MARKET	504th PIR, 82nd A/B Div.	0.86	2.70
	505th " " " "	0.99	1.39
	508th " " " "	0.89	1.15
	501st " 101st " "	0.40	1.53
	502nd " " " "	1.00	1.96
	506th " " " "	1.00	1.33
Corregidor	503rd Independent Parachute Regiment (- 1 Bn)	1.00	11.20

1/ No data are available for the 17th A/B Div. in VARSITY but jump casualties are believed to have been small, of the order of those in MARKET, because total D-day casualties were only 7.3 percent.

2/ There were 36 known drownings, 13.3 percent of the total, in the Merderet flooded area in this drop.

3/ There were 9 men who had missed the rock completely and were evacuated by boat later.

It is apparent that those troopers who landed accurately on the DZ's suffered about as many casualties as those who did not and no general trend with accuracy existed. Troopers who landed in water, in dense woods or in rocks suffered high jump casualties but otherwise none of the terrain in the operational area appears to have produced higher casualties than the DZ's selected.

10. It is apparent from Tables I and II that jump casualties were, in any event, too low to be of any serious consequence, except possibly for Corregidor. Even in that case, although jump casualties were nearly three times as high as in any other airborne operation on which data were recorded, they were considered acceptable for this operation. Jump casualties were expected to be 20 percent but it was considered that the gains to be expected from vertical envelopment were worth that.

11. Examination of jump casualty data from the World War II operations studied indicates that DZ location had no measurable effect on drop casualties. It is also indicated that in no case studied were drop casualties experienced a significant factor in subsequent performance. The significant point here is that in most cases the terrain surrounding a DZ did not differ much from the DZ itself. It is true that if the DZ is a very small island or a restricted valley in rugged mountains, missing it would cause high drop casualties. Such operations were rare in World War II and may, it is considered, be treated as special cases.

12. LANDING CASUALTIES: It requires little analysis to discover that gliders are much more sensitive to the terrain on which they land than are parachutists. Table III below shows the extent to which this is true.

TABLE III

GLIDER LANDING CASUALTIES vs. JUMP CASUALTIES

Operation	Unit	Percent Glider Landing Casualties	Percent Jump Casualties
NEPTUNE	82nd A/B Div.	10.60	4.24
	101st " "	10.10	2.40
MARKET	82nd " "	1.26	1.70
	101st " "	1.36	1.56

13. In NEPTUNE there were very few fields in the Cotentin Peninsula large enough to permit large numbers of gliders to land safely. In MARKET they could land safely almost anywhere. Although it is possible that the gains to be realized may at times justify the risk of high landing casualties, in general, it is evident that landing casualties may be a factor to be considered seriously in selecting LZ's. In other words, it does make a difference in restricted terrain if gliders miss an LZ large enough to accommodate them. It should be noted in connection with Table III that glider landing accuracy and concentration was very similar to parachute drop accuracy and concentration in each operation.

14. ENEMY OPPOSITION: It has been shown in a previous section of this analysis that the degree of enemy opposition on DZ's experienced in the World War II operations studied does not appear to have had a serious effect upon the subsequent operations of parachuted units. While it has not been possible to find clear quantitative data on this point in the case of glider landed troops, it is qualitatively evident from the operations studied that glider landings are considerably more vulnerable to enemy action immediately upon landing than are parachutists. Gliders present better targets. The cargo often presents a fire hazard when engaged by enemy weapons. Not only are their contents liable to destruction by enemy action but the troops landed may be kept by enemy fire from unloading their equipment from gliders except at the risk of losses in personnel. VARSITY offers several striking examples of glider force vulnerability to immediate enemy opposition.

15. To summarize, the evidence from the operations studied indicates that in DZ selection neither jump casualties nor any reasonable degree of immediate enemy opposition appears to have been a valid major consideration. In LZ selection, either or both landing casualties and enemy opposition were at times of sufficient actual importance to have had a valid influence upon choice of locations apart from all other considerations. Timing of glider landings can, it should be noted, also avoid their being subjected to immediate enemy action. It is also

important to note that in operations such as the Avellino drop (deep, restricted, mountain valley) and Corregidor (small, rough island covered largely with trees and military installations) gliders could not be used at all.

III. EFFECT OF DZ AND LZ DISTANCE FROM OBJECTIVES

16. The factors treated in the preceding paragraphs are of the type which, in general, tend to cause the DZ's and LZ's selected to be remote from the objectives to be seized. There are other considerations such as ease of navigation, identification of IP's and delivery areas, preferred air routes and numbers of tracks to be flown, which tend to have a similar effect. These items will not be covered in detail here. The following paragraphs deal with the effects of delivery area location upon the conduct of assault operations.

17. ASSAULT TIMING: In the absence of enemy opposition two items determine the time at which an objective is reached, performance in reorganization of the drop, or landing, of sufficient strength to start the assault and the distance to be traversed from the reorganization area to the objective. The penalty imposed by the distance to be traversed in reaching the objective can be measured in terms of time. It is clear that in the absence of enemy opposition en route or at the objective, the penalty is in direct ratio to the distance travelled. For this condition the troop delivery areas should obviously be located as near the objectives as other considerations will permit.

18. It has been demonstrated in another section of this analysis that, in the operations studied, immediate enemy opposition of the weight actually experienced did not adversely affect parachute troop reorganization and resulted in the opposition being destroyed. It is therefore clear that in cases in which the enemy opposition on the objectives were no stronger than was experienced on World War II DZ's, if the DZ's had coincided with the objectives, seizure of the objectives would have been complete by about the time the units were reorganized. This would avoid the time penalty which would otherwise be imposed by travelling from DZ's to objectives.

19. For glider landed forces, immediate enemy opposition appears to have been considerably more serious and it is therefore probable that in such cases the LZ locations selected or the timing chosen for the landings should be determined with this factor taken into serious consideration.

20. The third case to consider is that in which the enemy is known to be in the general operational area but not deployed on the actual objectives. In this case parachute troops should, it would appear, still be dropped on the objectives. They will not have immediate opposition and will have seized the objectives in the shortest possible time. The same applies to glider landed forces if the terrain will permit.

21. SIZE OF ASSAULT FORCE: In any case in which DZ's or LZ's must be guarded and secured from enemy action a part of the forces delivered to it cannot participate in assaults on objectives at a distance from the area. From this point of view it can be seen that the maximum assault strength is realized when the DZ's and LZ's are on the objectives.

22. It can also be seen that the size of the DZ or LZ area to be cleared of the enemy and secured has a direct bearing on the size of the force required for the job and, consequently, reduces the forces available for assault on objectives distant from the area in inverse proportion.

23. Finally, if the DZ or LZ being held for reinforcements or resupply is located at an appreciable distance from an objective it may be necessary to secure the route from the area to the objective to prevent the assaulting units from being cut off from the DZ or LZ. This requires still further strength and thereby reduces assault strength at the objective.

24. All of the assault strength and timing considerations listed in the preceding paragraphs lead to the conclusion that the troop delivery areas should be as close to the objectives as possible. It minimizes the amount and severity of fighting to be done by reducing the amount of organized enemy strength met, by allowing less time for enemy defensive deployment and by increasing the assault strength of the airborne units.

25. The generality underlying the factors discussed with respect

to assault timing and strength of assault forces is that what is taking place in the early stages of an airborne operation is a race between the friendly and enemy forces in reorganization and deployment. The goal of the assault forces is to get themselves deployed in defensive positions on the secured objectives as quickly as possible. The enemy job is to discover the assault, diagnose its location, objectives and strength, organize forces and deploy them so as to prevent the seizure of areas vital to him, and destroy the assault forces. It is evident that time and initial strength are of the utmost importance on both sides. It is also apparent that if security has been kept successfully the initiative is with the assault forces. The actual degree of importance of a quick assault in maximum strength in a given operation is governed in large measure by the intensity and speed of enemy reaction.

26. General consideration of all the factors in DZ selection appears to indicate that parachute troops should be dropped on or as near to their objectives as is physically possible with the means available. Selection of glider LZ's must take into account estimated enemy opposition and terrain but within these limitations the same general rule appears to hold.

27. In Enclosure E which deals with rate of movement in World War II airborne operations it is clearly demonstrated that data from the operations studied support the above conclusions. The findings are summarized in Figure 1 of Enclosure E.

28. An example of the effect of departing from the general principles developed in this analysis is afforded by the drop and landing of two brigades of the British 1st Airborne Division on D-day at Arnhem in Operation MARKET. Many factors had a bearing upon the outcome of the battle for Arnhem but the effect of the location of the troop delivery area is clear and unmistakable. The course of events was as follows:

a. The DZ's and LZ'S selected for the D-day assault were located seven to eight miles from the main objective, the road bridge at Arnhem. An area containing DZ's and LZ's of sufficient size to accommodate the entire division had to be secured for

the duration of the operation for reception of reinforcements and resupply. Between the DZ's and LZ's and the primary objective, the approach route lay through several heavily built up areas including the bulk of the city of Arnhem itself.

b. Each of the two brigades which jumped and landed on D-day was approximately the size and strength of a World War II U. S. airborne regiment.

c. The size of the landing and drop area to be secured by this force was such that it was decided that one brigade, less one battalion not brought in on D-day, should remain in the area to secure it while the other carried out the assault. The force available for the initial assault was, consequently, roughly one-half the force delivered.

d. Because of the distance to be covered by the initial assault units it was decided that attention should be given to route security, route discipline, and a maneuver plan such that the unit would be effective in frontal assault on any resistance met and also be secure to its rear. This, in turn, made it necessary to undertake as complete and thorough a reorganization and deployment for the advance as is normally required in a standard ground situation of this type. Although the geometry of the drop was excellent and reorganization rate the highest ever experienced by these units, this necessity imposed a time delay of two hours from the troop delivery to take-off of the first assault unit.

e. Of the 1st Para. Brigade, the initial assault force, the 2nd Battalion, was to proceed to the road bridge by the most direct route and take both ends of it. Because of the distance to be covered and the two hours already allowed the enemy in which to begin to react, the 2nd Battalion required four hours to reach the area of the north end of the bridge. The 1st Battalion, starting later, and the 3rd, travelling by a longer route, never got through

the alerted opposition. Because of the necessity to divert units to take care of enemy opposition enroute only Company A succeeded in reaching this point. The force for the initial assault on the main objective was, accordingly, about one-fifteenth of the force delivered. It arrived six hours after the drop.

f. Company A took the north end of the bridge, one-half of the 1st Airborne Division's primary objective, one hour later at 2030 hours, seven hours after the drop and five hours from the start of the assault.

g. C Company had been detached to take the secondary division objective, the railroad bridge, but the bridge was blown before they could take it.

h. Other elements totalling perhaps two companies in strength joined A Company later but no other unit of the division was ever able to get through the German opposition and the force at the bridge was eventually wiped out.

29. Here was, in summary, a clear case in which the distance from the objective of the DZ's and LZ's to be cleared and secured reduced the assault force to about one-half and then to one-fifteenth of the force delivered and gave the enemy an extra four to six hours in which to start to react to protect himself.

IV. SUMMARY

30. General consideration of the factors involved supported by analysis of available data from World War II operations studied confirms that:

a. DZ's chosen on or near objectives gave parachute units the best chance of assault success under all conditions covered by the operations studied.

(1) Jump casualties and enemy opposition in the drop area, as experienced in the World War II operations studied, did not significantly affect the success of the operations.

b. Glider LZ's could not be selected without regard to landing

casualties or the effect of immediate enemy opposition. Within the limitations imposed by terrain and estimated opposition on landing, the LE's nearest the objectives gave the assault troops the best chance of success.

ENCLOSURE E OF WSEG STAFF STUDY NO. 3

RATE OF MOVEMENT - TIMES TO OBTAIN OBJECTIVES

1. Since much of the value of an airborne operation comes from the element of surprise, it is important that the value of this element of initial surprise be not lost because of a situation in which an excessive amount of time is required for the airborne troops to travel from the drop zone (DZ) or landing zone (LZ) to the objective. The rate of movement of troops from the DZ or LZ to the objective depends essentially on the following basic factors -

terrain and natural obstacles

Visibility (daylight or darkness)

Enemy resistance

2. Whenever these factors, either individually or collectively, result in an excessively slow rate of movement toward the objective, the enemy is given additional time in which to react before the paratroopers can reach their objectives. In the extreme case this could enable the enemy to make it difficult for the paratroopers to take their objectives or even prevent it entirely. This rate of movement is significant mainly in relation to the speed of the enemy reaction in the first place, and to the strength and disposition of the enemy forces in the second place - since this determines how quickly and in what strength their forces can be thrown into the immediate battle area.

THE AIRBORNE OPERATION IN HOLLAND (OPERATION MARKET)

3. Three airborne divisions were employed in Operation MARKET - the 82d and 101st U. S. Airborne Divisions and the British 1st Airborne Division. The plan of MARKET was to use airborne forces to secure a corridor (and sieze vital bridges) through Eindhoven, St. Odenrode, Veghel, Udon, Gravo, Nijmegen and Arnhem through which the 30 Corps could move northward from a point south of Eindhoven. The principal missions of the units were as follows:

101st U. S. Division - Seize bridges near Veghel, near Zon, and at Eindhoven.

82d U. S. Division - Seize bridges at Grave and Nijmegen and over the Canals between these two points.

1st British Division - Capture the bridges at Arnhem.

In each division the principal mission was broken down into more specific missions for various smaller units in the division. In most cases specific missions were assigned to units of battalion size, but in some instances specific assignments were given to units as small as company size. This was especially true for the 82d Division.

4. The distances and rates of movement to the objectives are shown in Table I. The objectives used in the Table refer only to D-day. These objectives may or may not be the same as those of the original plan since the tactical situation may require temporary expediencies. In such cases, however, the objectives will always be directly related to the overall plan. Mean values are given for each battalion, and also for the two U. S. Divisions - the 82d and the 101st. In general, the units of the two U. S. Divisions experienced little opposition enroute to their objectives. The average time delay due to enemy opposition enroute is 11 minutes, based on those numbers which are available. The average distance traveled from the DZ to objectives on D-day was 2.26 miles. The weather was clear and sunny with good visibility. The terrain was flat, slightly wooded with embanked roads and some canals. Except for the canals, there was nothing about the terrain which would particularly

TABLE I

TIME, DISTANCE, AND RATE OF MOVEMENT - OPERATION MARKET (HOLLAND) D-Day 17 Sept 1944

Size of Unit		Time delay enroute to objective due to enemy hrs	Time to reach objective hrs	Distance mi	Average Rate of movement mph	Time delay due to enemy at objective hrs
101 U.S. Div. Landed: 1330						
501 Rgt.	Bn. - 1 Plt. eng.	0	2.75	5.3	1.93 (1.93)	0
	Bn. - 1 Plt. eng.	0	1.83	2.6	1.42 (1.42)	0
	Bn.	0	1.08	1.0	0.93 (0.93)	0
	mean	0	1.89	2.97	1.43	0
502 Rgt.	Bn.	slight	2.92	2.1	0.72	0.50
	Bn.	—	5.00	2.5	0.50	0
	Bn. - 1 Co.	0	1.67	2.5	1.50 (1.50)	0
	Co.	some	2.25	2.3	1.02	large
	mean	—	2.96	2.35	0.94	—
506 Rgt.	Bn.	0.67	1.75 (1.08)*	2.5	1.43 (2.31)	0
	Bn.	slight (0.17?)	1.08 (0.91)	2.5	2.31 (2.74)	0
	Bn.	slight (0.17?)	1.08 (0.91)	2.5	2.31 (2.74)	0
	mean	0.30?	1.30 (1.00)	2.50	2.01	0
82 U.S. Div. Landed: 1330						
508 Rgt.	Bn.	0	2.00(2.00)	0.57	0.28 (0.28)	0
	Co.	0	0.50 (0.50)	0.57	1.13 (1.13)	0
	Co.	0	5.17 (5.17)	—	—	slight
	Co. - 1 Plt.	some	8.00	6.91	0.87	some
	Bn.	0.25	3.00 (2.75)	3.64	1.21 (1.32)	0
	Plt.	0	2.00 (2.00)	2.00	1.00 (1.00)	0
	mean	—	3.10	2.74	0.90	—

TABLE I (Continued)

Size of Unit	Time delay enroute to objective due to enemy hrs	Time to reach objective hrs	Distance mi	Average rate of movement mph	Time delay due to enemy at objective hrs
82 U.S. Div. (continued)					
505 Rgt. Co.	0	0:67 (0.67)	1.50	2.25 (2.25)	0
2 Plts.	0.17	5.00 (4.83)	3.67	0.73 (0.76)	0
1 Plt.	0.08	5.00 (4.92)	3.51	0.70 (0.71)	0
Co.	0.25	1.00 (0.75)	0.75	0.75 (1.00)	0.25
mean	0.12	2.92 (2.80)	2.36	0.81	0.06
Bn.	0.75	2.00 (1.25)	1.00	0.50 (0.80)	0
Bn. - 1 Co.	0	2.00 (2.00)	1.00	0.50 (0.50)	0
Co.	0.25	0.75 (0.50)	1.00	1.33 (2.00)	0
mean	0.33	1.58 (1.25)	1.00	0.64	0
504 Rgt. Co.	0.42	1.00 (0.58)	1.75	1.75 (3.02)	3.00
Co.	0	0.75 (0.75)	2.00	2.67 (2.67)	3.25
Co.	0	1.25 (1.25)	2.00	1.60 (1.60)	0
mean	0.14	1.00 (0.86)	1.92	2.01	2.08
Bn. - 1 Co.	0.50	1.50 (1.00)	2.00	1.33 (2.00)	1.67
Co.	0.17	1.75 (1.58)	1.93	1.10 (1.22)	0
Co.	some	0.25	—	—	1.67
Co.	0.25	—	—	—	2.00?
mean	—	—	—	—	—
Co.	0	1.00 (1.00)	3.00	3.00 (3.00)	0
Co.	0	0.67 (0.67)	1.72	2.57 (2.57)	0
Plt.	1.00	3.00 (2.00)	2.27	0.76 (1.14)	0
Plt.	0	1.00 (1.00)	1.50	1.50 (1.50)	0
mean	0.33	1.56 (1.23)	1.83	1.61	0
Average 101 and 82	0.18 = 11m	2.14 = 2h 08m (1.67 = 1h 40m)	2.26	1.34 (1.63)	0.40 = 24m

* Values in parentheses refer to case where time delay due to enemy resistance has been removed.

hinder movement. The average time to reach objectives on D-day (including any time lost because of enemy opposition enroute) was 2.14 hours. The average rate of movement (including any time lost because of enemy opposition enroute) was 1.34 miles per hour. The values in parenthesis in Table I are those which refer to the rate of movement when the time delay due to enemy resistance enroute is removed. This gives an average rate of movement of 1.63 mph. When it is considered that paratroopers are heavily loaded, this figure compares favorably with the marching rate of movement given in the Field Manual [1/] - see Table II. These values are 2½ mph on roads and 1½ mph cross country for daylight and good weather. Comparing these values with the average value 1.63 mph it is concluded that there were no terrain features to cause any particular decrease in the rate of movement. It will be noted from Table I that there was considerable variation in the rate of movement of different units. Much of this variation can be attributed to the variation of aggressiveness and conservatism among unit commanders. An aggressive commander is inclined to march continuously to his objective despite indications of the presence of enemy troops there. A more conservative commander is inclined to send out an advance patrol and await its return before advancing upon an objective. Two to three hours can easily be lost in this manner.

TABLE II

RATES OF MARCH, MILES PER HOUR. (TAKEN FROM DEPARTMENT OF THE ARMY FIELD MANUAL, FM 101-10, Page 106

FOOT TROOPS

On Roads		Cross Country	
Day	Night	Day	Night
2½	2	1½	1

1/ Staff Officers Field Manual - Organizational, Technical, and Logistical Data, Department of the Army, Field Manual FM 101-10, Department of the Army, Aug. 1949.

5. At the objectives actually reached on D-day the enemy resistance was greater than enroute (causing an average delay of 0.40 hours), but likewise for the most part was small or lacking entirely. The average time delay due to enemy resistance at objectives for the two U. S. Divisions was 26 minutes, although in a few cases units of company size required up to 3 hours to seize their objectives. The general lack of organized enemy resistance on D-day was due in part to the element of surprise in the operation, and in part to the fact that there were no large enemy troop concentrations within the actual corridor which the U. S. troops were attempting to secure. There were, of course, troop concentrations of various sizes surrounding the operational area and at various distances from 4 to 100 miles from it, but it was not possible in the early hours of the operation on D-day for these forces to have any effect.

6. The 101st Division was to have taken Eindhoven on D-day within 6 - 8 hours after landing. Units reached Zon, on the way to Eindhoven, swiftly enough (2.3 mph) only to have the bridge over the canal there blown by the Germans when the airborne troops were within 100 yards. Whether a higher rate of movement or quicker departure from the DZ (getting troops to the bridge sooner) would have prevented this is not known, but if so, increasing the rate of movement and speed of departure from the DZ would have been important. Although a makeshift bridge over the canal was completed by 1730, the troops for no apparent good reason did not attempt to advance any further on D-day, and it was not until the following afternoon that this force captured Eindhoven. By the night of D-day the German records indicate that they were well aware of the airborne assault situation, and that orders were already being given for countermeasures. The German tactical situation maps show that before the end of D-day German forces had already started to move toward the Zon - Eindhoven region and the German map for D + 1 shows German road blocks south of Zon and just to the north of Eindhoven. This explains the appreciable resistance encountered at the north end of Eindhoven when the airborne forces resumed the march toward Eindhoven on D + 1. Had the

forces of the 101st continued their march on Eindhoven during the night of D-day, it is likely that this resistance would have been absent. Also this would have prevented these forces from falling behind their planned schedule. The plan was for the forces of the 101st from the north and the Guards Armor from the south to be in contact within Eindhoven by nightfall of D-day. The rate of movement of the armor to Eindhoven was slow and the whole operation immediately fell about 24 hours behind schedule because of the slowness of these two forces in the Eindhoven part of the operation. As it turned out this initial delay was serious since the extra 24 hours allowed the enemy increased time for reaction, and the whole timetable of the operation was altered. The slow rate of movement of the armor in reaching Eindhoven is shown by the following figures derived from statements in Reference 2. It is seen that the rate of advance toward Nijmegen on D + 1 was very small - 0.84 mph, somewhat less than the value in Table I for the ground troops. On D-day the British ground forces did not move out until 1435, and advanced only seven or eight miles on this day.

GUARDS ARMOR

Departed Valkenswaard	0600	D + 1
Arrived Eindhoven	1900	D + 1
Arrived Wilhelmina Canal	2100	D + 1
Total distance 12.6 miles, time 15 hours		
Rate of movement 0.84 mph.		
Departed Wilhelmina Canal	0815	D + 2
Arrived Grave	0820	D + 2
Arrived Nijmegen about	1200	
Total distance 34 miles in 5.75 hours		
Rate of movement 5.92 mph.		

7. In the 82d Division area at Nijmegen the rather swift enemy reactions also caused trouble. The planned schedule called for seizure of

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2/ First Allied Airborne Army - Operations in Holland, Sept - Nov 1944.

the Nijmegen bridge as soon as possible after landing, and in any case not later than noon of D + 1. Actually, elements of a battalion did get into Nijmegen during the night of D-day, and although it succeeded in destroying a building which was supposed to contain the controls for the demolitions on the bridge (which in itself points out the importance of fast movement to objectives) it was not able to get to the bridge itself, because of static enemy opposition. In the 82d area the decision to place emphasis on the high ground at Grosbeek rather than on the Nijmegen bridge was sound and justified in the light of available intelligence, which was inadequate. Had this battalion not been given the mission of first taking and organizing the high ground at Grosbeek, it could have entered Nijmegen much sooner on D-day, in strength. The German tactical situation maps show the movement of forces toward the Nijmegen areas beginning as early as D-day. The force in Nijmegen resumed action at first light but was unable to cope with the enemy and had to retire because of increasing pressure. The possibility of exploiting the initial surprise and taking the bridge with a small force had already disappeared on the night of D-day. By D + 2 the German garrison at Nijmegen had been reinforced with two battalions, about the same time that the British armor reached the Nijmegen area. The bridge was finally taken by 2000 on D + 3 but only after a large build-up of Allied forces, (including armor and artillery) and an assault crossing of the river. Starting on D + 4 the Guards Armored Division attempted to push up the main road from Nijmegen to Arnhem but the antitank screens of the enemy produced a very low rate of movement. Actually the Allied ground forces did not succeed in taking Arnhem, and it was not until D + 7 that sizable ground forces reached the southern bank of the river near Arnhem, a distance of about 9.5 miles from Nijmegen. In general the low rate of movement of the British ground forces was responsible for much of the lack of complete success of the operation. It also appears that if elements of the airborne troops had moved to the Nijmegen bridge more quickly and in more strength on D-day the situation there would not have reached such serious proportions.

ARNHEM[3/] [4/]

8. In the Arnhem sector the plan was to bring in the forces in three separate lifts on three consecutive days. The first lift on D-day brought in the 1st Parachute Brigade and the 1st Air Landing Brigade. The drop and landing zones were about seven miles from the main bridge at Arnhem which was the principal objective. Only the 1st Paratroop Brigade moved out towar Arnhem, and the 1st Air Landing Brigade remaining behind to secure and defen LZ's and DZ's. Two of the three battalions, the 2d and 3d of the 1st Paratroop Brigade, were assigned to capture the Arnhem bridge but to proceed by different routes. Having landed at 1330 it was 1530 when the Battalions moved out, an elapsed time of two hours. One company, A Company, of the 2d Battalion, reached the end of the bridge by 1930, six hours after landing. An additional hour was required to seize the end of the bridge. The rate of movement of this Company was 7/4.0 = 1.75 mph. Enroute to the bridge, C Company of the 2d Battalion, was assigned to split off and try to take the railway bridge. This bridge was blown just as they reached it, and C Company was surrounded by the enemy. Company B was left behind to attack an enemy position encountered enroute. During the night and early morning of the following day (D + 1) remnants of B and C Companies also reached the main bridge. The 1st and 3d Battalions traveling separate routes were severely harassed and split up by the now alerted enemy and never reached the bridge. Shortly after A Company reached the bridge a platoon attempted to cross it to seize the other end but was stopped by the fire from an anti-tank gun and an armored car firing straight up the bridge. At this time the small British force evidently had none of their artillery at hand with which to fire back. Had a larger force reached the bridge at this time, and preferably earlier, with some of the division artillery, the chances of defeating the small enemy force at the other end of the bridge and thereby capturing the bridge seem good. The entire course

3/ By Air to Battle - The Official Account of the British Airborne Divisions. London: His Majesties Stationery Office, 1945.

4/ 1st Airborne Division - Report on Operation MARKET. Arnhem, 17-26 Sept. 1944, Parts 1 - 3. Reproduced by H2. FMA.

of events at Arnhem point conclusively to the great importance of not splitting forces in the drive to the objective, and also of getting sizable strength to the objective in the shortest possible time. Had all three Battalions arrived at the bridge at the same time as A Company the bridge could easily have been taken. Valuable time was lost by having the DZ so far from the objective, by not moving out from the DZ fast enough, and by stopping to engage the enemy in minor fighting enroute. Splitting the brigade into three separate units in the drive to the objective turned out to be a poor plan.

OPERATION NEPTUNE - 6 JUNE 1944

9. The 101st and 82d Divisions participated also in Operation NEPTUNE in which the airborne troops were to assist the amphibious assault on the Normandy beaches. The first mission of the amphibious landings was to cut off the Cotentin Peninsula (which contains Cherbourg) so that Cherbourg could be used as a port of entry. The mission of the airborne forces was as follows:

a. Arrive 4 or 5 hours before the amphibious landings.

b. Seize and secure the causeway exits from the beach.

c. Seize important road intersections and bridges farther inland to block the movement of German reinforcements toward the beaches and into the general battle area.

10. The timing of the airborne landings was according to plan but in contrast to the Holland drop; owing to an unexpected fog bank over part of the peninsula, and to flak, the plane formation was almost completely disorganized. The result of this was that very few troops actually landed on the planned DZ's and the large majority of the troops were scattered far and wide. Although this made the reorganization problem much more difficult, on the other hand it had some beneficial effect, inasmuch as the scattering of troops over such a large area confused the enemy, making it difficult for him to estimate the magnitude of the invasion. consequence of this was to make the enemy reaction relatively slow and uncertain.

TABLE III

TIME, DISTANCE AND RATE OF MOVEMENT - OPERATION NEPTUNE (NORMANDY) D-day 6 June 1944

Size of Unit			Time delay enroute to objective due to enemy hrs	Time to reach objective hrs	Distance mi	Average rate of movement mph	Time delay due to enemy at objective hrs	Size of unit starting for objective	Size of unit reaching objective	Remarks
101st U.S. Div. Landed 0100										
501 Regt.	1 Bn.		some	4.5	2	0.44	0	15 men	50 men	
	2 Bn.		large	—	—	—	—	150-250 men	—	
	3 Bn.	(	0	—	—	—	—	150 men	—	Div. Reserve
		(	3	6 (3)	—	—	0	80 men	80 men	
502 Regt.	1 Bn.		3	3.83 (0.83)	1	.26(1.21)	12	5 men	61 men	
	2 Bn.		—	—	—	—	—	—	13 men	
	3 Bn.		1	4.83 (3.83)	7.7	1.6 (2.01)	1.5	18 men	120 men	
506 Regt	1 Bn.	(	some	—	3.5	—	0	50 men	—	
		(	some	—	—	—	—	150 men	—	
	2 Bn.		2	9 (7)	6.5	0.72 (0.93)	1.5	190 men	300 men	
	3 Bn.		0	3	3.7	1.23 (1.23)	2	33 men	53 men	
82nd Div.										
505 Regt.		Co.	some	4	2.1	0.52	1.5	128 men	128 men	
Landed: 0200	1 Bn.-1	Co.	some	—	—	—	—	—	226 men	
	2 Bn.		—	4.78	2.1	0.44	0	—	—	
	Plt.		0	—	—	—	—	42 men	42 men	
	3 Bn.		0	0.5	1.3	2.6 (2.6)	1.5	180 men	360 men	
507 Regt.	1 Bn.		0	1.5	2.7	1.8 (1.8)	5.75	75 men	75 men	
Landed: 0230	2 Bn.	(	some	—	—	—	—	3 men	80 men	Forced to withdraw without taking objective
		(	0	3.25	1.4	0.43 (0.43)	7	45 men	45 men	
		(	some	11	3.3	0.30	—	10 men	80 men	Objective not taken
	3 Bn.		—	—	—	—	some	75 men	76 men	

TABLE III (Continued)

Size of Unit		Time delay enroute to objective due to enemy hrs	Time to reach objective hrs	Distance mi	Average rate of movement mph	Time delay due to enemy at objective hrs	Size of Unit starting for objective	Size of Unit reaching objective	Remarks
82nd Div. (Cond)									
508 Regt.	1st Bn.	large	7.5	3.5	0.47	9	200 men	200 men	
Landed: 0200		large (4 days)	—	—	—	—	36 men	—	Never reached objective
		large (4 days)	—	—	—	—	7 men	—	Never reached objective
	2nd Bn.	7	9.5(2.5)	2.7	0.28(1.08)	large	130 men	60 men	Objective not taken
	3rd Bn.	large	12.5	2.6	0.21	large	1 platoon	180 men	Unit isolated for several days
Average - 101st and 82nd			7.15	3.07	0.81(1.41)	4.64 = 4h38m			

11. The German knowledge of the parachute drop was immediate. Because of the great scatter in the drop, however, the Germans received reports of paratroop forces over a very large area and the German High Command could not tell for several hours just what this indicated. It was not until 0400 (three hours after the first drops) that the High Command concluded that the general plan was to tie off the Cotentin Peninsula. An hour later the Germans became aware that they were about to be invaded from the sea.

12. Table III has been prepared from available records to show distances traveled and rates of movement on D-day. The scatter of the drop was so great that in general only small groups were able to assemble during the early hours of the operation. In some cases when a battalion commander found himself with a handful of troops he would start out immediately for his objective, in many cases picking up additional troops enroute. In other cases troops did not move for three or four hours (about the time of dawn) until larger numbers of men had been collected before they started moving out toward objectives. The numbers of men starting for objectives and reaching objectives (growth enroute) are shown in the Table. In the case of the 2d Battalion of the 502d Regiment for example, the drop was so scattered that most of the day was consumed in assembly, and this unit took no part in D-day fighting.

13. The airborne assault in Normandy was not as much of a surprise to the enemy as that in Holland, and the enemy troops had been well briefed on this possiblity. This is reflected perhaps in the entries shown in Table III for the time delay enroute to objectives due to enemy resistance. While actual numbers are mostly lacking for Normandy (Table III), the average would be at least several hours or more in contrast to the average figure of 11 minutes for Holland (Table I). The average distance traveled to objectives (including delays due to enemy resistance enroute) based on the time the units started out from their drop areas was 7.15 hours. The average of the rates of movement was 0.81 mph. Using those data which allow the effect of enemy resistance to be removed, the average rate of

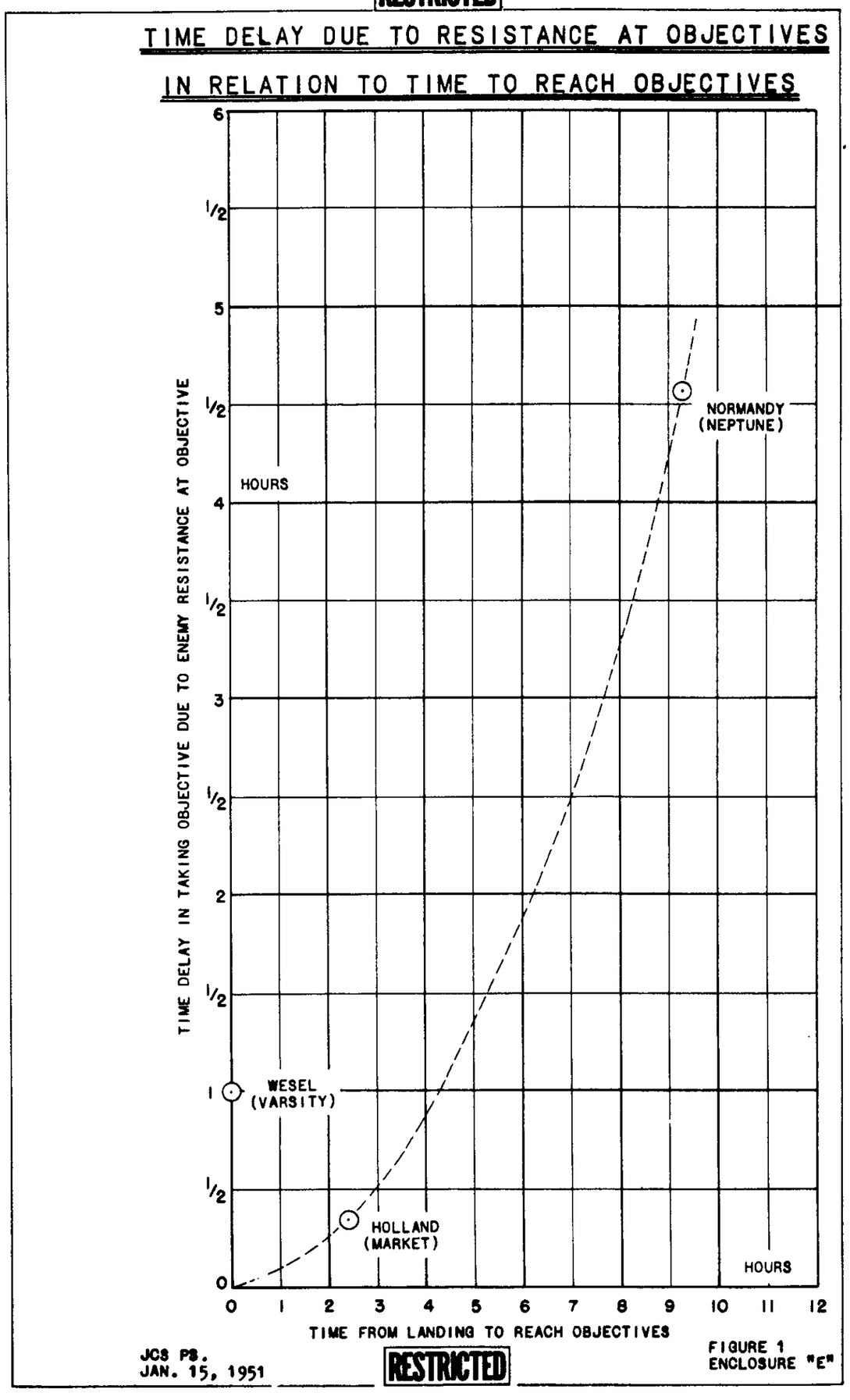
movement is found to be 1.41 mph. The weather was fair but the night was quite dark with a low overcast and limited visibility not exceeding five to six yards. The terrain was flat with hedgerows, some orchards, open fields, and roads with drainage ditches. In the region of the Merderet River where some of the 82d dropped there was some marshland and inundated ground. The value of 1.41 mph for the rate of movement when the effect of enemy resistance is removed is practically the same as the value 1.5 mph, which is the average (from Table II) of the travel rate at night on roads and cross country. This implies that on the whole the terrain had no significant effect on rate of movement. The difference between the value 1.41 mph for Normandy and the corresponding value of 1.63 mph for Holland can be ascribed to the difference between night and day - i.e., the effect of visibility.

14. In Normandy the average time delay on the drop zones was 2.15 hours, and if this be added to the average time 7.15 hours to reach objectives, the figure 9.30 hours is obtained for the average time after the drop to reach objectives. The objectives under consideration here refer only to those involved in operations on D-day, and they may or may not be exactly the same as planned. They will in any case, however, be in direct support of the original plan. Correlated with this is the average time of 4.64 hours to take objectives. In Holland the average time spent on the drop zones was 0.78 hours, and the average time from landing to reach objectives is 0.78 + 1.67 = 2.45 hours. The average time delay at objectives due to enemy resistance in this case was 0.40 hour. This suggests that the greater the elapsed time to reach objective the greater will be the enemy resistance to be expected at the objective since the greater elapsed time gives the enemy additional time to alert, move, and strengthen forces. This is indicated in Figure 1 which is based on only the two operations studied, MARKET and NEPTUNE. A point is also indicated for Operation VARSITY, where the drop zone and the objective were essentially the same. In this case the drop was upon prepared enemy positions, and the total time to take the objective was about one hour--the time required to overcome the enemy.

FIGURE 1

TIME FROM LANDING TO REACH OBJECTIVES

RESTRICTED



JCS PS.
JAN. 15, 1951

RESTRICTED

FIGURE 1
ENCLOSURE "E"

15. SUMMARY - Judging from the situations studied in World War II there seems little doubt that it is highly advantageous to get to the objectives as soon as possible (i.e., high rate of movement) even if this has to be done without having full strength available at the moment. This exploits to the fullest the benefits of the initial surprise and enables action to be taken at the objective before the enemy is sufficiently alerted for strong defense, or before the enemy strength can be built up. It is easier in the long run to push hard to the objective continuously until it is reached than to permit a delay and then run the risk of having much stronger resistance to overcome. In an airborne assault all of the actions studied clearly show that a high probability of success in seizing an objective may be expected if even a moderate force reaches the objective in a sufficiently short time. Aggressiveness and the acceptance of additional risk in order to reach the objective in the shortest possible time can pay great dividends in an airborne assault.

ENCLOSURE F OF WSEG STAFF STUDY NO. 3

RATE OF BUILDUP

1. In planning and carrying out an airborne operation it must be determined (or estimated) how large a force is required for the operation and also the time scale with which the men and supplies will be delivered. The question of how much of the available airborne strength to use in operations NEPTUNE and MARKET was hardly a problem, since these operations dictated the use of all forces available. As far as the rate of delivery is concerned considerable latitude is available to the planners in choosing the time scale for committing men, equipment, and supplies to the operational area. The upper limit of this rate is, of course, limited by the amount of airlift available at any one time; and this is essentially what determined the D-day lift for the two largest airborne operations of World War II -- Operations MARKET and NEPTUNE. In general the rate of buildup will depend upon the following principal factors:

available airborne troops

available airlift

distance from base airfields

weather

enemy interference (enemy flak and fighters)

OPERATION MARKET (HOLLAND)

2. In the initial phase of Operation MARKET parachute and glider landings were made at three distinct areas simultaneously on D-day, the 101st and 82nd U. S. Divisions to the south between Eindhoven and Nijmegen, and the 1st British Division to the north near Arnhem. In the U. S. areas most of the strength was brought in on D-day; whereas at Arnhem the plan was to build up the strength by means of three airlifts on three consecutive days. As far as one can tell the <u>total</u> lift on D-day was limited by the availability of aircraft. The troop carrier aircraft availability for MARKET was 1250 C-47 transports (usable either for paratroops or glider tow) and 354 British bombers (for glider tow). There was no lack of gliders. This airlift could accommodate all the parachutists and roughly 50 glider loads from each of the U. S. divisions and about one

parachute brigade and half the glider troops of the British division. The allocation for D-day was as follows:[1/]

	C-47 (Paratroops)	Gliders
1st British	145	358
101st U. S.	424	70
82nd U. S.	480	50

More than two-thirds of the total lift on D-day was by parachute aircraft.

I. THE U. S. 101ST AIRBORNE DIVISION

3. The forces into the 101st division area on D-day are shown in Table I.

TABLE I

FORCES BROUGHT INTO THE 101ST AREA ON D-DAY

Unit	Parachute Transport	Gliders	Personnel Landed
Div Hqrs & Hqrs Co	7	8	106
Division Artillery Hqrs	3	3	33
Division Signal Co	2	14	70
Division Recon Plat		15	34
326 Abn Medical Co		6	54
326 Abn Engineer Bn	16		252
377 Prcht F A Bn (elements of)	12		78
501 Prcht Inf Regt	129	8	1967
502 Prcht Inf Regt	135	8	2101
506 Prcht Inf Regt	132	8	2190
TOTALS	436	70	6885

4. The command echelon of division headquarters was set up at Zon which was close to the glider LZ "W". Two battalions of the 502nd Regiment were in division reserve securing the division airhead around LZ "W" and endeavoring to seize the bridge at Best which was not far from LZ "W". D + 1 was a day of building up of forces on both sides. The second lift came in as planned, but the Germans too were increasing in strength throughout the MARKET area, as shown by the situation at Aalst (the approximate location of the British armour south of Eindhoven), in the 101st area at Best, in the 82nd area at the edge of the Reichswald and at Nijmegen, and in the area of the British 1st Division at Arnhem. Only a small part of the 101st artillery came in on D-day.

5. On D + 1 the two battalions which had been engaged in securing LZ "W" were unable to take the bridge nearby at Best because of the

1/ Operation Market - Air Invasion of Holland, Headquarters IX Troop Carrier Command.

general area of the enemy's heavy artillery, mortar and small arms fire. At 1530 on D + 1, 428 gliders landed the 3rd battalion of the 327th glider infantry regiment, an engineer battalion, more of the 377th Prcht FA Bn, and a few medical, signal and artillery troops, plus supply and some vehicles; in all, about 2580 men. The 3rd Bn of the 327th was assigned the mission of providing local protection for the LZ and the Division service area. There was a resupply drop to the Division by 121 B-24 bombers of which only 40 percent of the drop was recovered.

6. Poor weather on D + 2 cut down the airlift effort and postponed the lift arrival until 1500. Of the 385 gliders dispatched only 209 arrived intact on the LZ, principally because of bad weather. These brought the 1st and 2nd Battalions of the 327th, the remainder of the 377th FA, elements of another FA battalion and of an anti-tank battalion, and some division artillery. In all, about 1350 troops were brought in. Because of bad weather resupply missions were cancelled on this day. At 1415 two battalions of the 502nd reinforced by one squadron of the 15/19. Hussars (British Armour), launched an attack against the bridge at Best and succeeded in taking the bridge at 1800. There is no indication that the guns brought in on this day by glider (75 mm how., 57 mm AT) were used in this action, but rather that it was only with the help of the Hussars that the action succeeded. At 1700 enemy tanks approached Zon bridge from the east side of the corrider and shelled that and other targets in the area. These tanks withdrew after two were knocked out by the anti-tank guns which had just arrived. This was very marginal timing indeed, and had the anti-tank guns not become available in the nick of time the presence of the enemy tanks could have become a serious problem. Had more of the artillery been available at the beginning of the action rather than delivered in later lifts, the battle at Best would probably have succeeded much sooner, and without outside assistance such as that furnished by the Hussars. About two battalions always had to be committed to the defense and security of the landing zone.

II. U. S. 82nd AIRBORNE DIVISION

7. The airlift for the 82nd on D-day was very similar to that for the 101st, and is shown in Table II.

TABLE II

FORCES BROUGHT INTO 82ND AREA ON D-DAY

Unit	Parachute Transport	Gliders	Personnel Landed
Div Hqrs and Hqrs Co	7	12	155
Div Artillery Hqrs	3	2	72
Div Signal Co	2	8	51
Div Recon Plat 1/		6	29
80 Anti-tank Bn (Battery A)		22	79
307 Abn Engineer Bn	27		388
376 Prcht FA Bn 2/	48		564
504 Prcht Inf Regt	137		2016
505 Prcht Inf Regt	126		2151
508 Prcht Inf Regt	130		1922
325 Glider Inf Regt	2		40
TOTALS	482	50	7477

1/ Includes 8-57 mm guns
2/ Includes 10-50 cal. MG, 17-75 mm pack howitzers

It will be noted that considerable artillery was brought in with this division on D-day, by parachute as well as glider. The battalion was assembled and firing in a little more than an hour after landing.

8. As far as rate of build-up is concerned, the activities of the 508th Regiment are of particular importance. This regiment had particularly full commitments. These included holding the high ground from Syler to Nijmegen, to establish several strong road blocks, assist in the capture of two bridges, at Hater and Honinghutie, to advance on Nijmegen and attempt to seize the bridges, and finally to clear and hold glider landing zone "T" for the glider build-up to come the next day, D + 1. The first strong counterattack came on the morning of D + 1 from the Reichswald and the enemy captured much of the landing zone near the forest. This was a serious situation since a large glider lift was soon expected on this day. Nearly all of the 508th was ordered to clear the landing zone near Syler, which necessitated recalling troops which were engaged in the important attack on Nijmegen. Although this succeeded in clearing enemy troops from the landing zone in time for the gliders' landing, those landing on the eastern side of the LZ were subjected to

mortar, artillery, and small arms fire. Had the LZ not been cleared in time, the enemy could have effectively ruined more of the glider build-up which came on this day. As it was, some of the gliders and glider troops were lost to enemy action. A landing zone, LZ "O", also had to be cleared by elements of the 505th. 450 gliders came in with three artillery battalions, the remainder of the anti-tank battalion, medical and signal personnel, and vehicles -- about 1300 personnel in all. The resupply by parachute from 135 B-24 bombers on this day was about 60 percent effective.

9. On D + 2 the planned schedule of build-up was for the 325th Glider Infantry Regiment of some 2700 troops to land in the 82nd Division area. On this day elements of the 505th reinforced by the Armored Guards were fighting a hard battle to gain the Nijmegen bridge, but the forces available for the attack were insufficient. The 325th Gl. Inf. Regt. was unable to take off from England because of bad weather, and in fact was unable to get in until D + 6. Had this regiment come in on schedule it would most likely have been possible to take the Nijmegen bridge on D + 2. The Nijmegen bridge was south of Arnhem and taking it in the planned time (not later than D + 1) was most important for the success of the operation. If the 325th could have been committed earlier, say on D + 2, the bridge could probably have been taken the same day. This would have represented a valuable saving of time which could well have significantly affected the outcome of the whole operation. There was a resupply drop on this day by 30 C-47's on LZ "O" but the recovery was negligible. There was a resupply drop on D + 4 by 400 C-47's; the supply recovery was estimated at 60 percent.

10. It required seven days to bring in all the airborne elements of the U. S. Divisions. During this time the Divisions were obliged to protect the LZ's with considerable forces while carrying out their assigned ground missions. This requirement for LZ protection reduces the strength which would otherwise be available for the essential tasks of the troops. Rate of build-up, and its strong dependency on weather conditions, can certainly be a critical factor in an airborne operation. The failure of

the 325th Glider Infantry Regiment to land until D + 6 not only slowed down the operation, but also could have led to defeat if the German counter-attacking forces had been stronger. The late or non-arrival of the air re-supply lifts became a serious matter by D + 3. These effects are brought out even more forcibly by the course of events at Arnhem.

11. An attempt has been made to secure some figures which indicate the enemy rate of build-up. This has been done by estimating from various action reports the number of enemy troops reported in contact with the U. S. troops for each day, in both the 101st division area and the 82nd division area. This is shown in Table III below, together with the U. S. rate of build-up.

TABLE III

RATE OF BUILD-UP - U. S. AND GERMAN TROOPS (MARKET)

	101st Area		82nd Area		Total		Cumulative Total	
Day	U.S. Troops	German Trps in contact	U.S. Troops	German Trps in contact	U.S. Troops	German Trps in contact	U.S.	German
D	6885	580	7477	1244	14362	1724	14362	1724
D+1	2580	1570	1300	675	3880	2870	18242	4594
D+2	1350	3000	0	1708	1350	4708	19592	9302
D+3	0	620	0	2616	0	3236	19592	12538
D+4	0	100	0	-	0	-	19592	-
D+5	0	2240	0	-	0	-	19592	-
D+6	-	-	2700	-		-	-	
TOTAL	10815*	8110*	8777**	6243**				

* Up to and including D + 5
** Up to and including D + 3

No great accuracy can be claimed for the figures showing the number of German troops in contact. They indicate a large superiority in numbers of U. S. troops for the first two days, but with German strength growing thereafter to proportions not greatly less than those of the airborne forces. It must be remembered that the forces of the 82nd Division and the 101st Division were reinforced by some of the British ground forces after linkup. These additional forces are not included in Table III. The first coordinated German counter-attack on a divisional scale was made in the 82nd area on D + 2. Heavy German counter-attacks were made near Veghel on D + 5, D + 7, and D + 8. Beginning on D-day two German divisions (estimated 50 percent strength) departed from the West coast of Holland for

a 98 mile march to the airborne battle area. They covered this distance in 5 days, arriving in the battle area by D + 5. Table III shows the importance of employing a very high rate of build-up in an airborne assault, in order to have large numerical superiority over the enemy before his build-up can become effective.

III. THE BRITISH 1ST AIRBORNE DIVISION AT ARNHEM

12. Owing to the limitations on airlift, the rate of build-up plan for the 1st British Division at Arnhem was to use three separate airlifts on three consecutive days. The 1st Air Landing Brigade was to land by glider and the 1st Parachute Brigade by parachute on D-day. The D-day lift comprised 155 parachute transports and 358 gliders. It brought in the following units:

Tac Div Hq
1st Airlanding Recce Sqdn
1st Airlanding Light Artillery Regt
1st Anti-tank Battery
1st Parachute Engineer Sqdn
9th Field Company of Engineers
1st Parachute Brigade
1st Airlanding Brigade (not all)
16th Parachute Field Ambulance
181st Airlanding Field Ambulance

A British Brigade is of about the same size as a U. S. Parachute Regimental Combat Team. Although exact numbers have not been found, it is estimated that this lift brought in 5500 - 6000 men. The Airlanding Brigade forces brought in on D-day were used to protect the LZ and DZ for the second lift to follow on the next day. The plan called for the second lift, containing the balance of the Division, to arrive not later than 1000 on D + 1, and the Polish Parachute Troops on D + 2. Some fighting was necessary to hold the dropping and landing zones.

13. On D + 1 the second airlift arrived 5 hours later than planned. It brought in the 4th Parachute Brigade, the balance of the 1st Airlanding Brigade, plus artillery, anti-tank, and medical attachments. There was also a small amount of resupply by 35 aircraft on this day with fair recovery. Forces were still committed to secure the resupply drop and landing zones. On D + 2 31 gliders carrying elements of the Polish Brigade landed in the area. The greater part of this brigade, consisting of the

parachute elements, could not be brought in on D + 2 because of weather. This force was also not brought in on D + 3 because of poor weather. There was a resupply drop on D + 3 but the pre-arranged DZ was in enemy hands, and the failure of communications precluded changing the drop area. All supplies fell into enemy hands. The drop of the parachute element of the Polish Brigade which was scheduled for D + 2 did not take place until D + 4 when only about half of the planned parachute force was dropped. This drop was south of the lower Rhine near Arnhem. A resupply drop was also made on D + 4, but was not very successful owing to enemy fighter activity. Ammunition, food and water were running very low in the British Division. Bad weather on D + 5 made airlift activities impossible. There was also a resupply drop on this day but only a small quantity was recovered owing to wide dispersion and enemy snipers; most of the ammunition and supplies fell into enemy hands. The weather was bad on the D+ 7 and D +8 and there is no record of the 1st Division having received any further resupply after D + 6. The total British forces of the 1st Division numbered about 10,000 men, which includes 1100 glider pilots. Of this number 2500 survived the battle to be evacuated. The size of the Polish Brigade is unknown, but probably did not exceed 2600 men.

14. The rate of build-up, as well as resupply, was a most critical factor in the Arnhem end of Operation MARKET, and can be pointed out as one of the decisive factors which contributed to the failure of the 1st Division to secure the Arnhem Bridge. Had it been possible to bring in all of the forces on D-day, including the Polish Brigade, it seems there is nothing to indicate that the bridge could not have been readily secured. Or, even if the second lift had arrived on the forenoon of D + 1 as planned, instead of being delayed 5 hours by weather, according to a British statement 2/ the difficulty of the situation might have been alleviated to a significant degree. As in the case of the U. S. areas, the troops required to protect the drop and landing zones were urgently needed at a very vital time in the battle (the first 24 hours).

2/ By Air to Battle - The Official Account of The British Airborne Divisions, 1945, P. 98. London: His Majesty's Stationery Office.

OPERATION NEPTUNE (NORMANDY)

15. Three airborne divisions were used to assist the amphibious invasion in Normandy -- the 101st and 82nd U. S. Divisions and the British 6th Division. There were available approximately 1384 troop-carrier transports and 3300 gliders. In the planning it was estimated that it would be possible to lift the parachute troops of all three divisions plus small glider forces in a single lift. Other airborne troops consisting of glider infantry with supporting weapons and medical and signal units were to arrive later on D-day and D + 1. Seaborne echelons of the 101st and 82nd Divisions were to come in with the amphibious landings on the beaches and join their divisions on D + 1.

16. All of the airlift of the 101st was brought in before the end of D-day. The main force consisting of parachute troops came in at about 0200. This was followed by a glider serial near dawn (0400) and another at dusk (2100-2300). The D-day lift of the 101st Division was composed of the following units:

TABLE IV

D-DAY LIFT OF THE 101ST DIVISION

Unit	Parachute Transport	Glider	Personnel
0100-0200 June 6, 1944			
501 Prcht Inf Regt(1)	134		2211
502 Prcht Inf Regt(1)	117		1930
506 Prcht Inf Regt(1)	120		1980
377 FA Bn(2)	54		547
	425		6668
0400 June 6, 1944			
81 AA and Anti-tank Bn(3) (2 batteries) plus misc units		52	220
TOTAL	425	52	6888
2100 June 6, 1944			
Miscellaneous (medical and communication personnel and materiel)		32	165

(1) According to the TO/E this would include 8-81 mm mortars and 27-60 mm mortars

(2) According to the TO/E this would include 10-50 cal. machine guns and 17-75 mm pack howitzers

(3) This includes 16-57 mm anti-tank guns

17. In considering questions of rate of build-up in the airborne part of Operation Neptune it is essential also to consider the character of the parachute drops and glider landings. Because of fog and flak encountered over the land the parachute transport formations became broken up and became so widely dispersed that for the most part, anything closely approaching the planned drop in accuracy and concentration was out of the question. Disregarding a few stray sticks, the drop of the 101st was scattered over a rectangle twenty-five by fifteen miles. About 70 percent of the initial lift unloaded in an area about eight miles square. The 1500 paratroopers (22 percent of the personnel) who landed outside this area were either killed or captured without contributing directly to the accomplishment of the D-day mission.[3/] This number of troops must be discounted from the fighting strength since they were essentially removed from the battle field. Of the remaining troops the scatter was so great that only relatively small units were able to be formed for D-day missions. This naturally imposed a handicap on the airborne troops in the accomplishment of their missions. In many ways it had about the same effect that would have obtained if the drop had been accurate as planned but with a fraction of the forces. By dawn of D-day about 1100 of the 6600 paratroopers were on or near the Division's objectives. Of these 1100, many were at or committed to objectives not their own, having picked up with the nearest available group. During the day there was a slow build-up of strength as isolated small groups found and became attached to larger groups, and at the end of D-day the organized parachute strength of the 101st Division was about 2500 men (see ref. 3, p. 131 and p. 42 of ref. 4).[4/] Thus only about 27 percent of the original parachute force of the division was working together at the end of D-day.

18. Owing to the great scatter of the drop much of the weapons and equipment was lost. Communications equipment was very scarce. By evening of D-day only 85 artillerymen of the 377th Parachute Field Artillery Battalion had assembled into a group. They had with them only one 75 mm

3/ "Rendezvous with Destiny" - a History of the 101st Airborne Division, Rapuart and Northwood, Washington, Infantry Journal Press, 1948, p. 95.

4/ "Utah Beach to Cherbourg" - American Forces in Action Series, Historical Division, Department of the Army, 1947.

howitzer. Five other howitzers (out of the original 17) had been recovered but at such a distance that they could not be used and had to be abandoned. Thus, only one 75 mm pack howitzer was salvaged from the D-day drop, and there is every indication that this gun was never fired on D-day. Due to bad scattering most of the artillerymen had fought during the day as infantrymen with various pick-up groups. About 60 percent of the bundle equipment dropped was not recovered. Especially felt by the parachutists was the loss of many radios and mortars. Ammunition also became scarce in some units. At dawn on D-day gliders came in with 2 batteries of the 81st Anti-aircraft Anti-tank Battalion, about 220 men. No record is found of the 57 mm anti-tank guns of this battalion being used on D-day. Just before dark on the evening of D-day, a second glider lift came in consisting of 32 Horsa gliders carrying 165 communication and medical personnel and equipment. The large size of the gliders and the smallness of the fields resulted in considerable loss due to crashes. About a third of the personnel was lost but presumably much of the equipment was recovered in usable condition.

19. The only remaining build-up scheduled for the 101st was the link-up with its seaborne elements which would end the purely airborne phase of the operation. Included in these seaborne elements were the 327th Glider Infantry Regiment, the 321st Glider Field Artillery Battalion and the 907th Glider Field Artillery Battalion. The 3rd battalion of the 327th came ashore shortly after noon on D-day but bivouacked near the beach that night. This battalion was scheduled to lead off an advance of the 506th at 0430 on D + 1. However, because of enemy action, it could not join forces in time and the 506th had to proceed without it. The link-up was finally made at midnight, at which time this reinforcement was urgently needed. By the end of D + 1 the build-up of artillery was becoming effective. On D-day (not later than noon) definite contact had been made between elements of the 4th Division, which had come over the beach, and the 3rd Battalion of the 501st at Pouppeville, a town very close to the beach. On D + 1 sizable forces of the 4th Division were committed in the

original airborne battle area, but the airborne forces were still fighting alone at the most forward lines. The 321st Glider Field Artillery Battalion landed most of its personnel on Utah Beach on D-day, but were unable to get their guns and vehicles until D + 3, and therefore did not join the 101st until D + 4. The 907th artillery was unable to join the division until D + 3. However by D + 2 the 101st had been reinforced by the 327th Glider Infantry Regiment and with two battalions of artillery borrowed from the amphibious force (see ref. 3, pp 150-151). Thus the purely airborne phase of the operations of the 101st may be said to have ended on D + 2 at the latest.

20. The D-day lift of the 82nd Division consisted of the units shown in Table V.

TABLE V

FIRST D-DAY LIFT OF 82ND DIVISION (0200 JUNE 6, 1944)

Unit	Parachute Transports	Gliders	Personnel Landed
505 Prcht Inf Regt(4)	117		2095
507 Prcht Inf Regt(5)	117		2004
508 Prcht Inf Regt(5)	117		1994
Div Hqs and Engineers		27	303
80 AA Bn(6) (2 batteries and misc Div. units) came in at 0400		52	220
Totals	351	79	6616

SECOND D-DAY LIFT OF 82ND DIVISION (2200 JUNE 6, 1944)

80th AA Bn(7) (1 battery and misc. Div. units)		26	135
Miscellaneous		49	301
319 FA Bn(8)		50	418
320 Glider Inf FA Bn(8)		50	319
Totals		175	1173
SUM TOTALS	351	254	7789

(4) Includes 27-60 mm mortars, 12-81 mm mortars, and 2-75 mm howitzers
(5) Same as (4) less the 75 mm howitzers
(6) Includes 16-57 mm anti-tank guns
(7) Includes 8-57 mm anti-tank guns
(8) Includes 12-75 mm howitzers

21. As in the case of the 101st Division the drop of the 82nd Division was widely dispersed, and only relatively small units were organized into fighting groups on D-day. Likewise, much of the communications equipment and weapons was lost. One of the two 75 mm pack howitzers of the 505th was recovered. There is no record of the recovery of any of the other pack howitzers which were dropped (6 in all). Six of the sixteen 57 mm anti-tank guns were recovered from the first glider landings on D-day but were not in position until 1730 hours. Parachute and glider elements of the 82nd Airborne Signal Company which came in with the first lift were badly scattered and assembled with much difficulty. Much equipment was lost. Only one of the three SCR 193 radios landed during D-day was operative, and it was not until the night of June 6-7 that radio contact was established with the 4th Infantry Division (which landed on the beach on D-day and was to link up with the airborne forces) and with the Division base in England. A glider lift came in the evening of D-day carrying mostly artillery, engineers and special troops. It is reported that this operation was marked by high losses[5] due to crash landings and to enemy artillery and small arms fire. At the end of D-day it is estimated in ref. 6[6] that 30 percent of the division forces were under control. The G-3 report at the end of D-day states the following:[7]

> "Combat Efficiency. Excellent, short 60 percent inf., 90 percent Artillery."

22. The 82nd Division received a troop build-up lift by 197 gliders which came in between 0700 and 0900 on D + 1. This lift brought in the 325th Glider Infantry Regiment consisting of 2360 troops. Weapons brought in with this unit include the following:

18 light machine guns
12 heavy machine guns
36-60 mm mortars
18-81 mm mortars
109 rocket launchers
54 Browning automatic rifles
9-57 mm anti-tank guns

5/ Tactical Employment in the U. S. Army of Transport Aircraft and Gliders in World War II. The Archives of the AAF Historical Office, p.14, Chap.IV

6/ 82nd Airborne Division - Action in Normandy, France, June-July, 1944, p.5.

7/ 82nd Airborne Division G-3 Periodic Reports (including Sitreps) No. 2-34, Normandy, 7 June - 11 July 1944, Operations Reports, AGO

There were many crash landings of these gliders and casualties totalled approximately 7.5 percent. The only remaining build-up scheduled for the 82nd was that coming from the linkup with its seaborne echelon. A poor resupply drop occurred about 0630 on D + 1. Of the 208 transports starting out, owing to poor weather and visibility conditions and to intense enemy ground fire only 148 transports dropped their cargoes. The drop pattern was poor and bundles were scattered. Only about 50 percent of the drop was recovered initially. Continued search later increased this to 70 percent recovered. This resupply mission on the morning of D + 1 was scheduled automatically. Thereafter other resupply missions were to be on call if needed. The automatic mission was the only parachute mission ultimately flown but a small amount of supply was taken in later by glider. The records show that 2 gliders landed on D + 3 with some badly needed communications equipment. Some idea of the strength of forces at the end of D + 1 may be formed from the following statements taken from ref. 6.

> "The 325th's regimental strength at the close of the day was approximately 85 percent."
>
> "At 1900 the 507th at approximately 25 percent strength."
>
> "Regimental strength of the 508th at the close of the day was approximately 25 percent."

The G-3 report[8/] for the end of D + 1 contains the following statement:

> "Combat Efficiency. Excellent--50 percent organic Arty missing. 505 Inf. has less than half strength, 507 Inf has 25 percent present. 508 Inf less than 25 percent present. 325 Inf 85 percent present."

The G-3 report also shows that the 82nd had no information on the 101st until late on D + 2.

23. A small leading element of the sea echelon -- Company C, 746th Tank Battalion -- made contact with elements of the 82nd by 0900 on D + 1, and the two elements together participated in actions on this day. Also during the day of D + 1 contact was established between the 82nd and 4th Infantry Division. The G-3 report on D + 2 states no material change in combat strength. On D + 3 all of the seaborne artillery attached to the 82nd (the 456th Parachute Field Artillery Battalion and the remainder of the Division Artillery) joined units of the 82nd and went into position with

8/ G-3 Report

them. The 90th Division Artillery and one battalion of the 4th Division Artillery were in general support of the 82nd. Thus the purely airborne phase of the action of the 82nd ended on D + 3. At the end of D + 3 the G-3 report reads as follows:

> "Combat Efficiency: Excellent. 507th and 508 Prcht Inf each now at approximately 35 percent full strength. 325th Gl Inf now at approximately 75 percent strength. No material change in other units."

24. It is believed that the following excerpt from ref. 3 (pp. 41-42) gives a fairly accurate description of the situation of the two U. S. Airborne Divisions at the end of D-day.

"A hard fight had been fought on D Day by the 82d and 101st Airborne Divisions - a fight that had not gone entirely according to plan and had cost heavy casualties. Not one battle but fifteen or twenty separate engagements had been fought.

"Both divisions had had scattered drops, with varying losses in men and materiel. Initial dispersion was further aggravated by the Normandy terrain; the hedgerows made it difficult to assemble and still more difficult to coordinate the maneuver of units. Some units were completely unaware of others, fighting only a few hundred yards away. The groups were usually mixed, and men strangers to their leaders fought for objectives to which they had not been assigned. Still, the airborne operation was in general a success. Small groups of parachutists took advantage of a surprised and temporarily disorganized enemy to seize many of the vital objectives quickly.

"When D Day ended, the 101st Airborne Division had accomplished the most important of its initial missions. General Taylor had estimated at noontime that, despite the errors of the drop, the tactical situation of his division was sound. The way had been cleared for the movement of the seaborne forces inland. The northern sector in the vicinity of Foucarville was securely held by the 502nd Parachute Infantry. On the other hand, the forces holding the southern flank of the Corps front along the Douve north of Carentan were not as strong as intended. The le Port bridges had been taken, but the bridgehead had to be abandoned. The la Barquette lock was occupied, but precariously. Virtually isolated, with a total strength nearer three companies than three battalions, short of ammunition, and facing unexpectedly tenacious opposition, the prospects of the southern units did not appear bright. In the St. Come-du-Mont area the enemy effectively held the 501st Parachute Infantry against the swamps in the vicinity of les Droueries and Bse. Addeville. There were no men to be spared to proceed against the railroad and highway bridges across the Douve, and the enemy was thus left strong and mobile to the southwest.

"Yet here, as elsewhere on D Day, the weakness of the American forces was more than offset by the almost total lack of aggressiveness on the part of the enemy. Positions which tactically should have required battalions for defense could be and were held by small improvised forces which had to worry more about cover from artillery and mortar fire than about counterattack. Probably the weakest feature of the whole situation at the close of D Day was the lack of communication. This had plagued the activities of most of the battalions during the day. At night, though it was only the southern forces that remained out of contact, the southern flank was precisely the most seriously threatened portion of the division sector (Map No. 9).

"The situation of the 82d Division was more serious than that to the east. The plan by which the 82d was to have been placed in possession of both banks of the Merderet was voided by the faulty drop. Large numbers of the division were isolated west of the Merderet, unable to reach the division's planned objectives in that area. The La Fiere bridgehead had been won only to be promptly lost. This was costly, for it created a tactical problem that engaged the major forces of the entire division for the next three or four days. Moreover, the expected reinforcements by sea and glider had not arrived by the end of D Day and many of the latter had been irretrievably lost in landing. General Ridgway, viewing the operation at the Merderet and lacking information about the other divisions was naturally alarmed and took measures to consolidate his defensive base at Ste. Mere-Eglise.

"There was probably little optimism in the minds of the most of the commanders of the 101st and 82d Divisions as D Day came to a close. Of the 6,600 men of the 101st Division dropped on the morning of D Day, only 2500 men were working together at the end of the day. Reinforcements were needed for all of the airborne units. Such reinforcements had to come across the beach. Fortunately the seaborne landing had been relatively unopposed. The arrival of the 4th Division had freed the 101st Airborne Division of responsibility in the north and east and released a large part of this division for employment elsewhere. The rapid progress of the 4th Division on D Day promised to improve greatly the situation of the two airborne divisions."

25. It has been pointed out that as a result of the great dispersion in the parachute drop, not only did the troops become mixed up and separated from their units but on the first day at least most of the fighting strength consisted of relatively small impromptu groups which had collected and were directed by more or less improvised leadership. In view of this peculiarity of the airborne phase of Operation NEPTUNE, of equal importance as far as rate of build-up in the ordinary sense is concerned is the rate at which the small and the isolated groups were able to form into larger groups or units and eventually come under the control and direction of a regimental headquarters. In general, small groups more or less isolated and not in communication with their controlling headquarters do not have the same effective fighting strength as when the same number of troops are formed into a smaller number of larger size units with normal leadership and under headquarters control. The exact relation between the fighting strengths for these two situations would undoubtedly be very difficult to determine and certainly cannot be attempted here. As far as organized fighting strength is concerned, and for lack of anything better, the values given for regimental strength can be used as a rough guide when available. The build-up as estimated in this manner and including any additional

reinforcements is shown in Table VI. The number of German troops in contact has been derived from various battle records, and is also shown in the table.

TABLE VI

ESTIMATED RATE OF BUILD-UP IN TERMS OF FIGHTING STRENGTH (NEPTUNE)

	101st Area		82nd Area			
Day, end of	Total Organized Strength U. S. Troops	German Troops in Contact	Total Organized Strength U. S. Troops	German Troops in Contact	Total U.S. Organized Strength Troops	Total German Troops in Contact
D	2500	2140	2500	2570	5000	4710
D + 1	3500	2325	2700	1550	8200	3875
D + 2	5600	720	4700	2880	10,300	3600
D + 3			5300	700		

26. It is of interest to note that in the MARKET Operations, Table V, the number of enemy troops in contact increases with time, indicating a build-up of forces thrown into the action. In NEPTUNE, however, Table VI shows a decrease in the number of enemy forces, indicating the effects of attrition as well as a slow withdrawal. Actually - and in contrast to Operation MARKET - the battle area was so well isolated by tactical air support that it was impossible for the Germans to bring up reinforcements and thereby effect a build-up. Table VI indicates that on D-day there was little difference in the fighting strength of the U. S. and German forces. Had the German reaction been faster, and particularly if it had been more aggressive, it seems that it would have made the situation of the airborne divisions a very tenuous one - especially on D-day. Had isolation of the battle area by tactical air support been less complete such that the Germans could have effected some build-up - as they did in the Holland operation - the airborne assault could have been placed in great jeopardy. Considering the rather serious loss in fighting strength because of the poor drops, the airborne assault could still have been exploited to better advantage if greater forces could have been brought in on D-day. This might well have

enabled the airborne forces to take all their objectives without the time delay that actually occurred. As it was, the effective strength of the initial assault was reduced to about one third as a result of the poor drop, thereby losing a potential three to one superiority over the enemy. As shown by the table, at least, the U. S. fighting strength on D-day was only slightly greater than that of the enemy who were in a defensive position. This was hardly a sufficient margin of superiority in fighting strength, especially for an assault, to insure rapid defeat of the opposing forces. The 327th Glider Infantry Regiment and also evidently the 1st British Airborne Division were available to be brought in by air on D-day. Either the lift was not available to do this, or else it was thought that these additional troops would not be needed for the initial assault -- or possibly both. The plan called for the link-up of the seaborne echelons of the airborne divisions on D + 1. The 327th was about a day late in joining the 101st division, and the artillery units were two to three days late. The seaborne elements of the 82nd linked up on D + 3 -- two days late.

27. Summary

Operation MARKET points out the serious role which weather can play in interfering with a planned rate of build-up of troops and supplies. The five hour delay in landing reinforcements at Arnhem and especially the four day delay in landing reinforcements at Nijmegen -- both due to weather -- had marked effects on the outcome of the operation. Everything points to the great advantages which can be derived from employing the fastest possible rate of build-up, and ideally this would lead to committing all of the planned strength in the initial assault. Thus, if all of the British forces had been brought into Arnhem on D-day, this could have had a decisive influence on the battle there. It is brought out by NEPTUNE and particularly by MARKET, that the more the success of an operation is made to depend on later build-up the greater becomes the risk that the operation can fail. Also, employing a build-up by consecutive lifts requires the use of ground forces to secure the drop and landing zones, and thus diverts this much strength from the main missions of the operation. It is essential to have

artillery available without delay. Operation NEPTUNE clearly indicates how a badly scattered drop can result in a serious decrease in effective fighting strength. This can be offset to some extent if a fast enough rate of build-up with reinforcements is possible. In case the effective fighting strength of the airborne assault does not have much superiority over that of the enemy, it is imperative that the enemy be completely isolated by tactical air support so that he cannot receive reinforcements.

ENCLOSURE G OF WSEG STAFF STUDY NO. 3

COMMUNICATIONS

I. INTRODUCTION

1. An airborne operation is comparable in complexity and diversity of forces involved with an amphibious assault. It is at least equally dependent upon precision and coordination in execution. Its range from point of ground contact with the enemy to its rear bases is at least as great and often greater. It is as dependent upon its rear for timely and adequate resupply and reenforcements. In airborne operations the forces delivered by air are normally irrevocably committed once they are delivered and must rely for survival mainly upon their own success. There is seldom an opportunity to retire gracefully from an awkward situation to return on some other more favorable day. Such an operation as is described here is greatly dependent for success upon its communications. This section of the analysis deals with the degree of this dependency experienced in the World War II airborne operations studied.

II. EXPERIENCE IN CERTAIN WORLD WAR II AIRBORNE OPERATIONS

2. The effects of inadequate communications, whenever this difficulty occurred in the airborne operations studied, are apparent from the highest to the lowest echelons, inter- and intra-service. The causes range from poor planning, lack of or inadequately trained personnel, inadequate range capability, poor equipment performance, to breakage and complete loss of equipment in delivery. The effects produced by such inadequacies resulted in a wide range of situations extending from delay, loss of equipment, loss of troops, to even being a major factor contributing to the loss of a battle. The available data do not permit systematic, quantitative treatment of the subject. The following paragraphs illustrate the problems met and the results experienced.

3. PLANNING: In NEPTUNE the forward headquarters of one airborne unit understood that they were to receive an on-call resupply mission on D + 1 consisting of 119 C-47 loads, 442,000 pounds of equipment and supplies.

The troop carrier headquarters understood that the resupply mission was to be dispatched automatically unless cancelled by the airborne unit. The misunderstanding apparently arose because of a failure in liaison between the air and ground commands for the NEPTUNE airborne operations. In any event, communications from the airborne force in Normandy back to the U. K. were nonexistent at the required time. No facilities had been planned for direct communication from the airborne unit on the ground to troop carrier aircraft in the air. The mission was flown. The result was the loss to the enemy of most of the supplies because the drop zone was not in the hands of the airborne forces. This caused difficulty and delay in the ground actions of the unit because of shortages in equipment. The airborne unit had lost almost 60 per cent of its initial equipment in the D-day night drops and glider landings and consequently was badly in need of this resupply.

4. Another instance of the effect of failure to plan adequate communications is afforded by an experience in MARKET. A badly needed glider resupply mission was expected to arrive on a preplanned LZ. The east side of the LZ was under heavy enemy fire, the west side was clear of fire. There were also flak positions to the east of the LZ. The airborne troopers watched the glider mission come over and gliders release and land on the east side of the LZ. Some, apparently confused, flew through the flak into Germany. No radio communications from ground to troop carrier forces in the air had been planned and there was accordingly nothing that could be done on the ground except to watch. Casualties in the glider force were heavy and a large quantity of supplies was lost.

5. No facilities for communicating from ground to tactical air forces in the air were planned for the NEPTUNE airborne forces. Close ground support by fighter bombers was not at that time beyond the earliest stages of development in that theater and consequently the need for such ground control facilities was not understood by planning echelons. (This incidentally was not the case for Naval gunfire support for which communications facilities were well planned.) It was demonstrated in at least two

instances in NEPTUNE that the troopers in the battle felt the need for ground communications to fighter bombers in the air. There is one recorded case of a paratrooper persuading a fighter operating overhead to come and lend immediate specific and controlled assistance. The records are not clear as to how this was accomplished except that the Naval gunfire support communications equipment may have been pressed into service for this purpose. The other example is at the opposite end of the scale. Airborne engineers had succeeded after many hours of labor under fire to reconstruct a bridge. Just as it was finished, friendly fighter bombers came over and knocked it out. There was no way to communicate with them to prevent or break off the attack.

6. In operation VARSITY close air support of troopers of the U. S. 17th Airborne Division was to be provided by British 2d TAF. The ground controllers and their equipment were British glider borne units. The operation was so planned that all ground controllers came in with the British 6th Airborne Division. Those allotted to the U. S. units then had to make their way on the ground to the units with whom they were to operate. No close air support missions requiring ground control could be run for U. S. units until several hours after they were on the ground. Fortunately, this delay did not have serious consequences because of lack of tenacious enemy resistance. Close air support would nevertheless have been useful in easing the troopers' task if they had had it earlier.

7. OPERATION: In the early stages of an airborne operation, units of battalion size or smaller are apt to be out of physical contact with each other and with higher unit headquarters. Regimental and higher headquarters in the operational area are almost certain to be out of physical contact with each other, except for visiting officers and couriers, and this separation often continues throughout the operation. The senior forward headquarters is, of course, physically cut off from its rear by distances up to several hundred miles. Under these circumstances the reliable operation of control facilities, wire and radio, over ranges from a few hundred yards to a few hundred miles, assumes inordinate importance,

even in the smallest units.

8. In both NEPTUNE and MARKET, sufficient instances are cited to indicate that radio communication often did not work well in woods or in high hedgerow terrain even when units were only a few hundred yards apart. In the open the ranges achieved by such equipment were generally adequate. In MARKET, instances of this difficulty are cited for divisional radio communications with regiments and with Corps Headquarters and in NEPTUNE the effect was felt at all levels. In one recorded instance of this effect in NEPTUNE, a company attack was delayed one hour and 55 minutes while awaiting the return of a runner who had been dispatched with orders for a platoon which could not otherwise be brought under control for the attack. The runner was under heavy enemy fire throughout this assignment. Wire was not available. The radios were operating but contact could not be established. The second platoon of D Company of the 508th was overrun by the enemy because the company commander could not bring the fire of the first platoon to its aid.

9. In MARKET, contact between the forward headquarters and the rear in the U. K. was weak and unreliable even though ground relay via the British 2d Army was employed.

10. The 2d TAF was to provide all close air support to the 82d Airborne Division in MARKET and arrangements were made for a common frequency between tactical aircraft in the air and the U. S. ground controllers. Although they tried throughout the MARKET operation, no U. S. ground controller was ever able to establish contact with a 2d TAF aircraft in the air. There was consequently no ground controlled close air support for this unit until a single Canadian ground controller with Canadian radio equipment was borrowed from Corps Headquarters.

11. At Arnhem in MARKET one reason for communications failing between this area and the rest of the operation was lack of adequately trained operators and maintenance men. For two days the Corps Commander was not aware of the serious plight of the unit at Arnhem and there was therefore no realization that emergency relief action was required.

12. DAMAGE AND LOSS: It has been shown that deficiencies both in communications planning and in equipment operation were apparent in NEPTUNE, MARKET and VARSITY, and that these deficiencies resulted in delays and casualties and general equipment and supply shortages. In NEPTUNE a more serious difficulty in communications arose from loss and damage to wire and radio equipment in the drops and landings. Records of the 82d Airborne Division actions in NEPTUNE include estimates that as much as 95 per cent of that unit's communication equipment was not available for use on D + 1 through being either missing or damaged in drop or landing. Whether the percentage figure given is precisely correct or is only of the right general order is academic. The shortage of operable equipment was certainly great and the results serious. The 101st communications equipment fared similarly but to a somewhat lesser degree. This factor accounts in large measure for the continued lack of cohesion and central control in the airborne force for the first few days, marching and countermarching of small groups of men, often at cross purposes and without mutual support or even knowledge of each other's existence. The difficulties introduced by the generally dispersed and inaccurate drops and landings were aggravated by the indicated severe shortage of communications equipment.

13. Specific examples illustrating the effects of lack of communications through loss and damage of wire and radio gear follow.

a. Elements of one battalion of the 501st in NEPTUNE were assigned to take the bridges near La Barquette to protect the flank of the 101st. A small force from the 1st Battalion did reach the area but on D + 1, although the bridges were still intact, they were not firmly secured. No one outside the 1st Battalion was aware of this fact; both regimental and division commanders operated on the basis that this part of the mission had been accomplished and no further effort need be made. In actual fact the small force at this location was in great difficulties and needed help badly in the form of supplies, ammunition, reinforcements and medical aid.

b. At the La Fiere bridge across the Merderet River, three groups of troopers were actually operating in the area during D-day, for much of the time completely unaware of each other. One force captured both ends of the bridge about noon of D-day before the enemy was deployed in strength in the area but, not knowing the whereabouts of any other force and thinking the group might be more useful elsewhere, the leader of the force took most of his men and departed. Several days of hard fighting and heavy casualties were experienced in regaining this vital crossing.

c. Even on D + 3 when most of the area was under reasonably cohesive control, the 82d did not have communication with its forces west of the Merderet River and was considerably concerned as to their fate. It was not possible to coordinate their activities with those of the remainder of the division.

14. In MARKET, loss and damage to communications equipment did not occur to a serious extent except at Arnhem where it contributed to the isolation of the 1st British Airborne Division. There was a general shortage of wire in U. S. units because of the great extent of perimeter held and the rapid movement of forces from one part of the area to another. The effects of this, while making the job more difficult, did not, apparently, seriously influence the outcome. It is possible that the availability and use of the Dutch public telephone system alleviated this shortage to some extent.

15. One aspect of experience with communications in the operations studied requires illumination at this point. Although it is true that the records show that a certain amount of damage occurred on landing, particularly with regard to radio gear, by far the largest factor in reducing the amount of operable equipment, in cases where severe shortages occurred, was difficulty in finding the bundles dropped. This is a penalty associated with poor drop geometry at night or in terrain which limits ground visibility in daylight. Another generality commonly reported in all World War II airborne operations is that the equipment was too heavy and bulky, both wire

and radio. In view of the normal lack of vehicular transport in such operations it is believed that this was a valid and well-grounded complaint.

III. SUMMARY

16. The character of an airborne operation dictates the requirements of the communication system by which its execution is controlled. Study of the records of World War II operations shows that:

a. Communications planning often left serious gaps in the overall system and in some instances the consequences to the operation as a whole were severe.

b. Equipment, operators and maintenance personnel, considered as an entity, produced a system deficient in reliability, mobility and range. This inevitably resulted in the necessity for a disproportionate reliance upon the initiative, aggressiveness and judgement of small unit commanders who, while extremely capable, were often in no position to make major battlefield decisions without information or some degree of guidance and control.

c. Loss and damage of communications equipment in landing accounted for a major share of the inadequacies experienced in drops and landings having poor geometry.

d. Available data on the World War II operations studied do not permit quantification of the communication problem. It can only be said that inadequacies sufficiently serious to jeopardize whole operations did occur.

INTELLIGENCE - ENEMY GROUND STRENGTH AND DISPOSITION

I. INTRODUCTION

1. Intelligence of the enemy is, of course, basic to the execution of any military operation. Serious inadequacy in pre-operational intelligence is capable, by itself, of defeating any kind of assault. One aspect of an airborne assault which makes it particularly sensitive in this regard is that defeat is almost certain to mean complete loss of the entire force committed. While it has not been possible to quantify the importance of intelligence in airborne operations, this section of the analysis deals qualitatively with this subject as it affected the outcome of the World War II operations studied. (Terrain intelligence has been treated separately in Enclosure C of the analysis.)

II. EXPERIENCE IN CERTAIN WORLD WAR II AIRBORNE OPERATIONS

2. MARKET: In Operation MARKET the airborne penetration was on a very narrow axis perpendicular to a stabilized land front. Three airborne divisions, the 101st, 82nd and British 1st, dropped and landed along this axis 19, 50 and 60 miles, respectively, from this front. In general, the intelligence estimate indicated that enemy reaction could be expected to be quickest and strongest against the assault nearest the land front and progressively weaker and slower toward the deeper penetrations. It was thought that the axis of this assault was also the enemy's main axis of supply. Finally, intelligence estimated that the enemy would not be able to move large forces from other parts of the front to cope with the MARKET-GARDEN assault.

3. In actual fact the axis of the assault was a sector boundary within the opposing enemy army and was not a main enemy line of communications. Coordinated but light enemy reaction took place against the 101st assault about 7½ hours after the landing and in general this division, nearest the land front, did not experience heavy enemy reaction until the enemy had had time to move forces in from the flanks. On D-day only about 7 per cent of the enemy forces ultimately engaged were within the perimeter outlined by the outermost initial assault objectives. From D + 2 onward opposition in this area was heavier than expected because of the enemy's ability to move troops in from a distance.

4. The bridge and the town of Best were considered secondary objectives by the 101st on the basis of the intelligence made available to the unit and only a small force was detailed initially to seize the area and set up road blocks. In fact this bridge and town were on the enemy's main line of communications and of vital importance to him. His reaction here was strong. The Best area became a major battle ground and the bridge was not secured during the airborne phase of the operation.

5. Because the axis of MARKET was a sector boundary within the enemy army and because of the German command setup, enemy reaction along this axis from Zon south to Eindhoven was slow and weak and there was apparently nothing to prevent the capture of Eindhoven from the north on the evening or night of D-day instead of the afternoon of D+1 as actually happened.

6. Further along the axis in the 82nd area, there were within the perimeter established by the outermost objectives about 20 per cent of the enemy forces ultimately engaged, or nearly three times the percentage which existed 30 miles nearer the front. Enemy reaction on a coordinated basis in the 82nd area was later than in the 101st area, about 23½ hours after the landing, but it was somewhat stronger than the pre-operational intelligence estimate predicted. From this attack onwards, fewer tanks were encountered than had been predicted but the over-all coordinated strength was greater.

7. In the Arnhem area, the deepest penetration of all, where the 1st British Airborne Division entered the assault, intelligence predicted heavy flak but little and late ground reaction. In fact, the flak did not materialize to any serious extent on D-day but enemy ground reaction did. German Army Group B Headquarters, controlling the whole defense of Holland was located just outside Arnhem and a panzer division was resting and refitting in the area. This was not known to the First Allied Airborne Army. Although not many enemy troops or tanks got into action in the first few hours, there were enough to delay and block most of the British force attempting to reach the Arnhem road bridge. After the initial blocking and delaying actions enemy strength increased rapidly and the situation was well in their hands from the evening of D-day onwards.

8. In the course of the first eight days of this assault the enemy was able to withdraw some 85,000 troops from in front of the Canadian Army on the northern flank of the penetration. These troops came from as far west as Walcheren and, although seriously decimated before reaching the battle area, the remaining troops were sufficient to affect materially the course of the battle all the way from Eindhoven to Arnhem. Two of these transferred divisions were able to move at the rate of almost 20 miles per day.

9. It should be noted that the enemy commanding general had the benefit of knowing the Allied intentions and plan of action within a very few hours after the initial landings. This came about through the German capture of Allied documents containing this information left by glider troops in a crashed glider. Although this was of the greatest significance in allowing the enemy to deploy his forces to the best possible advantage, the fact is not altered that Allied intelligence of enemy strengths and dispositions was not completely accurate nor adequate.

10. NEPTUNE: In this operation intelligence of the enemy strength and disposition appears to have been excellent. It has been pointed out in a previous section that terrain intelligence was not wholly accurate but, in general, pre-operational intelligence appears to have been adequate in every other respect.

11. VARSITY: Pre-operational intelligence for this assault appears to have been excellent as to enemy strength and disposition, and in a general study of the operation no examples of significant inadequacies in this respect show in the records.

12. It is interesting to note that the airborne assault in NEPTUNE took place when there was no established land front in Normandy and the whole amphibious and air operation depended literally upon knowledge of the enemy gained without this most important advantage.

13. VARSITY was likewise undertaken as a part of PLUNDER, the massive amphibious crossing of the Rhine. Here again the whole operation depended upon intelligence gained without the assistance of having a land fron with the enemy.

14. While it is not possible to do more than speculate as to the reasons for the inadequacies in intelligence for the MARKET operation as compared with NEPTUNE and VARSITY, one possibility presents itself which may merit consideration. At no time in World War II did the airborne forces, either ground or air, control or execute the process of securing the raw intelligence material upon which their plans were based. In all cases they were dependent for their material upon the established Army and Army Air Force intelligence organizations whose primary intelligence missions were to serve the interests of Army ground forces and Air Force strategic bombing, isolation and interdiction activities. With this in mind, it is interesting to note that in NEPTUNE and VARSITY the interests of the two intelligence groups coincided and also were identical with those of the airborne forces. It was essential to the planning of the over-all landings in Normandy and of the crossing of the Rhine that accurate and detailed knowledge of enemy strength and of his disposition be available, not only for the surface crust of resistance but to a considerable depth. The airborne assault in both cases took place within the depth from the enemy's front in which all armed forces had a vital and primary interest.

15. In contrast to this, in MARKET the primary interest of the ground forces in detailed information on the enemy's strength and particularly his disposition, was limited in considerable degree to the first few miles of depth. On the other hand, the airborne assault forces needed information in great detail on enemy disposition as far as 60 miles or more behind this front. The major primary Air Force enemy intelligence interest at this time appears to have been in strategic bombing targets. Nothing here is intended to suggest that considerable efforts were not made to gather and disseminate the information required, only that it was not generally a primary mission for the agencies involved.

16. In accordance with the foregoing, it is suggested that more effective efforts were made to collect and disseminate knowledge of the enemy's strength and disposition in the depth required for planning an airborne assault whenever such information was also of vital and primary interest to the collecting agencies.

III. SUMMARY

17. In general, intelligence of the enemy appears to have been adequate in NEPTUNE and VARSITY and less than adequate in MARKET. In MARKET, inaccuracies in such intelligence were responsible to a high degree for the defeat at Arnhem. The suggestion is made that it is possible that detailed information of enemy strengths and dispositions was available to airborne forces in direct proportion to the importance of such information to ground and air force agencies responsible for its collection.

ENCLOSURE I OF WSEG STAFF STUDY NO. 3

TROOP CARRIER PERFORMANCE IN AIRBORNE ASSAULTS

I. INTRODUCTION (General)

1. The tactical use of troop carrier aircraft, as distinguished from other military uses for air transport, was the air segment of vertical envelopment which proved to be one of the most important new military tactics evolved, during World War II. The airborne capability of both the Germans and the Allies introduced new factors into the principle of isolation of the battlefield. Additional tactical situations requiring airlift arose when combat forces became isolated by weather, lack of surface communications, or enemy action. Air evacuation in support of the military medical services, though not directly tactical, relieved the combat elements of the encumbrance of casualties and reduced ground traffic in the maneuver areas.

2. Allied losses in troop carrier aircraft were much less than the losses sustained by the Germans in their airborne operations. Glider losses in comparison have little significance in that the Germans operated only about 100 glider sorties, 1/ while the Allied number of glider sorties totalled approximately 5,000 in all theaters.

3. Troop carrier units participated in all theaters of combat operations during World War II. Although the major airborne operations were conducted in Europe, those in the other theaters, such as operation THURSDAY (Wingate Expedition) and Corregidor, were also significant. Gliders were used most extensively in the European theater. Four U. S. airborne divisions were delivered in whole or in part into battle by troop carrier forces; the 82nd, 101st, and the 17th in Europe, and the U. S. 11th Airborne Division in the Pacific. The U. S. 13th Airborne Division was retained in Europe as strategic reserve, but was never delivered to battle by air. In addition an Airborne Task Force composed of the 2nd Independent Parachute

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1/ Tactical Employment in the U. S. Army of Transport Aircraft and Gliders - Office of the Chief of Military History, Department of the Army.

Brigade (British), 509th Parachute Battalion (U.S.) 517th Parachute RCT (U.S.) 1st Battalion, 551 Parachute Regiment (U.S.) and the 550th Glider Infantry Battalion (U.S.), performed the airborne invasion of Southern France. The 503rd RCT operating independently performed airborne operations at Corregidor and in the Southwest Pacific area. U. S. Troop Carrier Forces, in addition to delivering the above U. S. units into battle airlifted the British 1st Airborne Division twice into combat operations. In summary, troop carrier units participated in 21 assault airborne operations in all theaters. Four of these were considered major operations, 12 less significant, and five minor in scale.

4. A need for special design in troop carrier equipment arose and indicated that the responsibility for its development should stem largely from the units charged with the task, and that its development should be based on the primary mission of airlifting airborne troops and equipment into combat, with a secondary mission of augmenting general theater air logistics requirements.

5. The Germans' successful capture of the Island of Crete was their most significant airborne operation of the war. After this the Germans carried out only two small airborne operations - one against Leros in 1943 and the other in the Ardennes in 1944. The former met with success; the latter was definitely a failure. When they really needed the capability in order to counter-attack the Allied invasion of France, the German Luftwaffe had been beaten down to such an inferior status that, had sufficient troop carrier aircraft and airborne needs been available to them, it was then impossible for them to regain required control of the air.

6. Soviet Russia was the first country in the world to experiment with vertical envelopment on a large scale as a new military tactic. Although such was done by this country in peacetime, very little was accomplished in wartime other than small missions behind the German lines for supporting partisan activities. A German appraisal of airborne operations[2/] charges

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2/ Office of the Chief of Military History, Department of the Army - Airborne Operations - A German Appraisal

this failure on the part of the Russians to the fact that the Soviet Air Force had proved far inferior to the German Luftwaffe and that the awareness to this inferiority persisted until the final stages of the war. It points out further that the Russians were primarily at home on the ground and were not in their best element when on the water or in the air. A final conclusion to this German appraisal points out that although the Russians did not carry out any significant airborne operations during World War II, "it should not lead to the false conclusion that the Soviet Union is not concerned with this problem or would fail to make use of this weapon during future military operations".[2/] Intelligence information appears to confirm the merit of this conclusion.

II. COMMAND RELATIONSHIP

7. The U. S. basic forces for airborne operations in World War II included the airborne and air-landed units under control of the Army, and Troop Carrier units under the control of the Air Force. This differed from the German organization in that the German parachute rifleman was a member of the German Air Force and wore the ordinary German Air Force uniform. Similarly, Japanese airborne troops were under control of the Japanese Army Air, the officers having been originally drawn from the Air Corps. If reported views of German commanders as to the effect of this difference in control are correct it can be concluded that such an arrangement worked well when employing parachute troops on a small scale for demolition operations or subversive activity; however, from a point of view of large scale operations including the air-landing troops and subsequent divisions of normal infantry, control by the GAF became unwieldy, especially in the aspects of logistics and training. During the Russian campaign, German parachutists were employed at various points as infantry units and engineers while under the control of GAF. Coordination with the Army units logistically was complicated, lack of proper training was evident, and casualties are said to have been high.

2/ Office of the Chief of Military History, Department of the Army - Airborne Operations - A German Appraisal

8. The command structure and relationship for U. S. airborne operations influenced every phase of planning and execution. The problems were numerous, but generally overcome, especially when the participating units were permitted adequate joint training and preparation prior to a mission. Before the activation of the First Allied Airborne Army in World War II, airborne operations into North Africa, Sicily, Italy, Normandy and Southern France were conducted on a "cooperative" rather than on a "unified command" basis. Due largely to the personalities and abilities of the commanders concerned, this met usually with a high degree of success. Areas of difference were resolved at highest Troop Carrier - Airborne Unit level; rarely was a split view on a joint problem referred by either commander to the respective higher echelons. Granted that this system was workable at the time, especially in minor operations, there were occasions in which difficulties in reaching agreement in planning may have made the execution of the missions of either or both air or ground units more difficult. For example, the arrangement and location of the drop zones most desirous to the ground commander were not always acceptable to the air commander. Sometimes, in order to reach the DZ's as desired by the ground commander to expedite the achievement of his objective, it would have required the troop carrier axis of approach to pass over or parallel closely enemy flak installations; or sometimes terrain features, in the DZ area, interfered with the ability of the troop carrier forces to maneuver their formations and drop in the pattern desired by the ground commander, thus threatening the accuracy of the drop. On the other hand, to change the location and arrangement of the DZ's may have interfered with the ground problem by making it more difficult to achieve the objective. When both problems were considered critical, mutual compromise may have resulted in a weaker plan than one arrived at by a unified command decision based upon thorough considerations of both problems. After the activation of the First Allied Airborne Army, the "unified" type of command structure provided flexibility and ease in the planning and execution of major airborne operations in Holland and Germany. Because of the "Army" level or status of this airborne force, all other

appropriate forces, including individual naval vessels and isolated anti-aircraft units, were better acquainted with the detailed aspects of the airborne plans, including routes, altitudes, time schedules and means of identification both while in the air and on the ground. Similarly, the airborne forces were better acquainted with the detailed plans of the forces with whom they came in contact. Pertinent information was available to the airborne operation planners at the outset of its planning, and was not delayed in reaching the airborne force as an "after-thought". Changes of major proportion from original airborne plans were held to a minimum unless urgent modifications were required. No substantial changes were accepted at the last minute unless intelligence revealed that the enemy had imposed critical situations, such as placing reserves in the vicinity of the drop zones, posting or mining drop zones and landing zones, or placing new AA batteries within range of the force.

9. Reported views thus indicate that where minor operations were conducted, a "cooperative" basis for command was adequate. However, for larger operations such as "MARKET" in Holland, and "VARSITY" in Germany, the "unified" airborne force structure which controlled all the participating forces was highly desirable through all phases of an airborne operation. The airborne operations into Sicily evidenced difficulties which might have been alleviated by close joint staff coordination and planning, better joint briefing, and better general dissemination of information, particularly recognition information, to all forces involved. Considerable loss to troop carrier and airborne forces was caused by the accidential firing by Allied Naval and Ground Forces on their own aircraft. The exact loss of troop carrier aircraft and personnel to this unfortunate situation is not known; however, it is known that 37 troop carrier aircraft and 14 gliders did not drop or land troops and did not return to home base. Forty-eight aircraft were badly damaged and non-operational for the remainder of the operations. It was estimated that 50 per cent of the troop carrier forces were fired upon by friendly naval forces. Reports indicated that the firing began approximately 5 to 15 miles north of Malta, forcing two

aircraft to return and land on an emergency field at Gozo, Malta. The crew of one of the aircraft shot down over the sea was picked up by a navy vessel, the commander of which stated that the parapack bundles under the aircraft fuselage looked like torpedoes. This most unfortunate situation more than likely would not occur again; however, had an over-all unified airborne force command structure been present to participate at the highest theater planning and briefing level with the other participating forces, it is highly probable that such an error would not have arisen. Airborne operations in Holland and Germany benefited from the "joint" and unified aspects of command structure during all three phases, preparation, assault, and consolidation and exploitation.

III. EQUIPMENT

10. AIRCRAFT (POWERED)- Troop carrier aircraft of World War II were not designed to perform the troop carrier primary mission. They were, on the other hand, somewhat more adapted to the secondary mission of providing air logistics as directed by the theater Air Force Commander. This emphasis in design was imposed by factors of time, availability and lack of appreciation in the early stages of the War, of the need for an aircraft primarily designed to perform the troop carrier combat function. The war ended before the introduction to service of an airplane designed primarily to meet airborne requirements. Furthermore, many aircraft were immediately available by converting commercial airliners (DC-3's) into troop carrier aircraft (C-47's) by reinforcing the floors and enlarging the doors. The C-47 and C-46 were not particularly well suited for airborne operations. The doors were too small for bulky equipment, the loading platforms were too high off the ground, and side loading and unloading made operations more difficult than they would have been with wide, rear-loading doors, direct loading and unloading, and a strong landing gear which could survive hastily prepared landing strips. These aircraft did not suffice for the tactical advantages of rapid loading and unloading, or the ability to drop heavy equipment in a fully assembled ready-to-fight condition. These aspects would have been of great advantage to the Army Airborne Forces who were deprived of heavy equipment until their land-tails had joined them, and were forced to use a limited amount of lighter airborne ordnance, artiller and vehicles in the initial assault made available to them by gliders (CG-4A's) with a maximum payload of only 3750 lbs.

11. Operation VARSITY was the only airborne operation in which C-46's participated in Europe. As this was the first time that these aircraft were used in combat the results were looked upon with keen interest. It was known that the C-46 had several advantages over the C-47 in that it carried a payload almost equivalent to two C-47's and,

therefore, only half as many personnel were needed. Furthermore, troops could be dropped in a more concentrated pattern because of two jump doors and almost twice as many troops per aircraft. However, the C-46 was more vulnerable to enemy fire due to the position and size of the fuel tanks and a maze of hydraulic lines. A puncture in the fuel tanks caused gasoline to run towards the exhaust stacks near the center section where chance of fire was great.

12. The statistics in Table I were compiled from Operation VARSITY comparing the results of the 313th Troop Carrier Group which flew the C-46's with the 315th Troop Carrier Group which flew C-47's, each group encountering approximately the same amount of enemy fire.

TABLE I

COMPARISON OF C-46 AND C-47 IN OPERATION VARSITY

	C-46	C-47
Group	313th	315th
Sorties	72	81
Losses: Aircraft	19	14
Aircraft damaged	38	42
Percentage of Aircraft Unharmed	21%	31%
Percentage of Aircraft Hit that were lost	33%	25%
Losses: Personnel		
KIA and MIA	33	26
WIA and IIA	22	8
Total Casualties	55	34
Percentage of Personnel Unharmed	82%	90%
Troops Dropped	2038	1235
Equipment Dropped in lbs.	126,834	79,030
No. of A/C needed to do same job	72	133
Ratio to Aircraft Actually Used	1.00	1.64
Projected Losses:		
Aircraft Lost	19	23
Aircraft Damaged	38	69
Personnel Losses: KIA and MIA	38	43
WIA and IIA	22	13
Total Casualties	55	56

It can be concluded from the above statistics that despite the additional percentage of losses to use of C-46 aircraft on this operation, the results obtained were more effective than would have been the case if an equivalent in C-47's had been used. The C-47's carried maximum payloads

of 5850 lbs., whereas C-46's carried 10,500 lbs. It thus appears that an aircraft larger than the C-47 might have been superior in World War II operations. This emphasizes the importance of determining the optimum size and design of medium troop carrier aircraft.

13. GLIDERS - Glider participation in U. S. combat airborne operations began with the invasion of Sicily. This, for the first time, provided the airborne units with jeeps, trailers, and completely assembled light artillery pieces incident with the initial assault. The glider used by the U. S. airborne units, the CG-4A (Waco), was capable of carrying only 3750 lb. payload. Two of these were required to carry an artillery piece and its prime mover. The British Horsa glider, available only in small numbers, could carry a payload of 6900 lbs. Two CG-4A's could be towed by a single tug aircraft, however, only one Horsa glider could be towed per unit aircraft. The main advantage of the Horsa over CG-4A glider was the ability of getting the gun plus the prime mover into one glider. The construction of the Horsa was chiefly laminated and not as strong as the CG-4A with its frame of welded steel tubing and sturdy canvas skin. The CG-4A has the advantage of direct nose loading and unloading features, whereas it was necessary to remove the entire tail assembly for loading and unloading the Horsa. The reinforced nose and tubular steel bracings of the CG-4A provided better crash protection in the CG-4A than was available to the Horsa. Flight characteristics of the CG-4A were better chiefly because of its smaller size and weight, and it could also land in smaller space than could the Horsa.

14. Airborne operations of World War II were limited by the ranges, speeds, and radii of action of troop carrier aircraft as indicated below:

a. C-47 radius of action for parachute drop, with 6 parachute equipment racks, gross weight 31,000 lbs. = 325 nautical miles.

b. C-47 radius of action, single tow glider, no extra tanks = 270 N. M.

c. C-47 radius of action, single tow, two cabin tanks of 100 gal. each = 380 N. M.

d. C-47 radius of action, single tow, two P-38 wing tanks in cabin of 170 gal. each = 475 N. M.

e. C-47 radius of action, dual tow, standard leak-proof gas tank installation = 220 N. M.

f. C-47 radius of action, dual tow, 2 cabin tanks = 315 N. M. (with P-38 tanks = 400 N. M.)

g. C-46 radius of action for parachute lift = 581 N. M.

h. C-46 radius of action dual tow = 390 N. M.

i. C-47 range at 5000 ft., 140 IAS, 29,000 lbs. (gross wt.)

(1) -650 gal. = 7 hours + 40 min. --- 1070 N. M.

(2) 850 gal. (2 cabin tanks) = 10 hours --- 1400 N. M.

(3) 1050 gal. (4 cabin tanks) = 11 hrs. + 20 min -- 1710 NM.

(4) 990 gal. (2 P-38 tanks) = 11 hrs. -- 1620 N. M.

j. C-46 range at 5000 ft., 160 IAS, 45,000 lbs (gross wt.) = 1960 N. M.

15. The above data was reported by the IX Troop Carrier Command as of 25 April 1945. Weight of fuel above the inherent capacity of the aircraft deprived airborne units of payload on a basis of 6 lbs. per gal. added plus the weight of the installation. It is evident that the use of gliders limited the range of airborne operations considerably. In addition, as is later pointed out, glider formations were not as flexible in marginal weather conditions. The expense connected with their use (approximately only 10% were retrieved from MARKET) was extremely high. Many gliders were destroyed or damaged in landing, and in some instances the equipment carried was also destroyed or damaged. In view of the experience with glider landings in World War II, the possibility of using powered aircraft in an assault role to land in unprepared landing areas in place of gliders deserves consideration. A glider, once released, is committed to a specific field in the battle area whether the conditions there are critical to its survival or not.

A powered aircraft has a better choice of local conditions, is more flexible in marginal weather, has greater range when not towing, and has less chance of being left behind to be destroyed on the field of battle. Powered aircraft can fly during instrument conditions when required, but similar conditions are prohibitive to gliders. Evasive action is difficult to execute when towing gliders. The question of comparative vulnerability on the ground has not been determined.

16. NAVIGATION AIDS - The value of dependable navigation aids became evident early in the development of the airborne weapons system. A critical lack of efficient aids was most apparent in the first U. S. combat airborne operation in history, incident with the Allied invasion of North Africa (TORCH). In conjunction with the Center Task Force at Oran, Algeria, on the morning of 8 November 1942, the second Battalion, 503d Parachute Infantry was directed to make a parachute attack between TAFARAOUI and LA SENIA airfields, for the purpose of seizing and holding the airfields for Allied combat aircraft. To assist the pilots and navigators in locating their objective, a British naval vessel was to transmit a homing signal from a warship 17 miles and 300° from the initial point (IP). In addition, Allied agents in the vicinity of the drop zone were to send a homing signal from a "Eureka" beacon (ground) to be picked up by the aircraft equipped with "Rebecca" receivers. Both aids at these initial points failed, and the pilots experienced much difficulty and delay in pinpointing their positions in the general area. The airborne force failed to achieve its planned mission, not having reached the original objective until D plus one at 1600 hours, and then with only 60 percent of their starting force.

17. Subsequent airborne operations in Europe and in the Pacific improved proportionally in accuracy and concentration with the development and availability and improved reliability of navigational aids, pathfinder teams, and experience in their application. The highest accuracy and concentration achieved in European airborne operations was in the airborne invasion of Holland by the First Allied Airborne Army (MARKET). Presence of navigational aids for this next to the last airborne

operation of the war in Europe is in sharp contrast to the first operation. Available by this time were the following navigation facilities:

a. Radio Air

(1) MF beacons

(2) VHF/DF homing facilities

(3) MF/DF (for air/sea reserve)

b. Radar and Visual Aids

(1) Eureka beacons (DZ's and LZ's)

(2) Compass beacons (route check points)

(3) Coded Light Beacons (on marker ships in the channel and on DZ's)

(4) Colored Panels (DZ's and LZ's)

(5) Colored Smoke (DZ's and LZ's)

(6) Occult lights (flashing) and searchlights (at check points in friendly territory)

(7) Photographs and maps for pilotage

(8) Trained Pathfinder Teams (air and ground)

The availability of adequate navigational facilities was far greater for MARKET than for TORCH. Such factors as weather, enemy action, human error, etc., at times subtracted from the ability of air crews to navigate even with adequate navigational aids. These factors are discussed in the following paragraphs. The fact is evident, however, that without a sound system of basic navigational aids, critical inaccuracies occurred even when these other influences were not present.

IV. TRAINING

18. As the employment of airborne forces progressed in World War II it became increasingly evident that troop carrier forces must be specially trained for dropping airborne units under combat conditions. A serious deficiency in the training for the airborne invasion of North Africa was the fact that the troop carrier squadrons were not relieved from air logistics missions in sufficient time to rehearse their part prior to the actual operation. Due to the limited areas in England, and the employment of troop carrier units on air cargo missions, the air crews did not have an opportunity to practice long range instrument flights over strange territory at night. Many of the navigators had little experience and were assigned to the squadrons just prior to the operation -- their abilities unknown to the pilots. The flight was approximately 1200 statute miles in length, a one-way mission for the troop carrier as well as airborne units, the air crews having been instructed to land, after execution of the parachute drop, on the dry lake bed of the Sebkra D'Oran, immediately west of the drop zone. Not long after a night take-off from England at 2130 hours D minus one, the entire force of C-47 aircraft encountered cloudiness and the formation began to break up. Upon arrival in the objective area at dawn the formation had scattered from Spanish Morocco to points shortly east of Oran. Three landed in Spanish Morocco where the crews and troops were interned. One landed at Gibraltar due to engine failure, two landed on La Senia Airfield, one east of Oran, and the remaining 27 aircraft eventually landed on the dry lake bed of Sebkra approximately 20 miles west of the DZ. Of these, only 48 percent (eighteen aircraft) of the force had been able to execute a formation parachute drop prior to landing.

19. As pointed out before, the absence of adequate navigational aids, plus the lack of training in navigation on the part of a large percentage of the troop carrier crews accounted largely for the inability of the airborne force to achieve its planned objective in operation TORCH. The dispersion of the drops, while creating a difficult situation for the airborne troops, also resulted in confusing the enemy as to the location

and strength of the assault.

20. In addition to the unilateral training of units, it was shown that much of the training must be accomplished jointly with the airborne units. The value of joint training of air and ground units showed repeatedly in airborne operations in every theater. One of the most significant examples of this need was evidenced during the airborne operation at Tagaytay Ridge in the Southeast Pacific Theater. Tagaytay Ridge, whereon the DZ was located, was approximately 35 miles east of Manila. The over-all objective of this operation was to flank the Philippine Capital from the south with the main ground force, and the airborne operation was to flank the enemy defense positions to the east in order to cut the Jap supply line and seal their escape route. The first wave of 48 C-47's carrying 913 paratroops approached the DZ on top of a broken to overcast cloud layer. The pilots were responsible for operation of the jump signal. The first two serials of 9 aircraft each dropped accurately on the DZ. However, troops from the remaining 30 aircraft paratroops began jumping 4 to 5 miles east of the DZ into the overcast. It was learned that an anxious jumpmaster saw a parapack parachute open from an accidental release, and jumps were made without waiting for the pilot to give the green light. When the following pilots saw the jumping action ahead, many gave the green light though they knew they had not reached the DZ. Paratroops in some cases left the aircraft at 1200 ft. instead of the prescribed altitude, and at airspeeds up to 135 MPH instead of from 100-110 MPH prescribed in order to avoid being stunned by opening shock. The percentage of those missing the DZ was 62.5 percent, approximately 600 troops. The afternoon mission experienced similar errors which resulted in 85 to 90 percent of the troops committed missing the DZ. Adequate joint training could have eliminated this element of human error.

21. In sharp contrast to the Tagaytay operation was the airborne operation successfully carried out in Southern France (DRAGOON). This operation took place after air and ground units had been given an adequate time for joint training prior to the operation, and subsequent to the ex-

perience gained in operation NEPTUNE in Normandy. Troop carrier units were based approximately 500 miles away on 10 airfields north of Rome. The main parachute lift consisted of 396 C-47 aircraft spaced in 9 serials of approximately 45 a/c each, precisely timed at intervals two minutes head to head. Of all these aircraft 85% dropped on the DZ's or immediate areas during hours of darkness (0330 hrs.) in spite of haze, no moon, and a heavy ground fog. The value of joint training paid dividends in this operation.

22. Basic training of troop carrier units was conducted in the Zone of the Interior prior to movement of the units overseas. As the war progressed in the theater, troop carrier units developed in proficiency. In the European theater, a troop carrier pathfinder group was activated on a provisional basis for the purpose of uninterrupted training with the airborne unit pathfinder teams. This was the only troop carrier unit which was permitted to train for its primary mission most of the time. Individual and unit training of other troop carrier units was constantly carried out even though approximately 90 percent of the missions were for air cargo. Low altitude navigation, formation flying, and night training missions were conducted when feasible in connection with the air movement of equipment, supplies, and units other than airborne. Although this was valuable it did not suffice for the total training requirement of uninterrupted joint training with the airborne units as an integral airborne force, or the development of the techniques required for good accuracy and concentration in large scale airborne operations. The troop carrier commander unless otherwise directed, as often was the case, tried to keep the units proficient by rotating them with the airborne units to assist the airborne units with their training requirements, and to refresh the troop carrier units in their primary mission after long periods of being committed solely to missions of air cargo. It was estimated prior to operation VARSITY that the troop carrier units, then at the peak of World War II proficiency, required a minimum period of two weeks stand-down from air logistics missions during which time powered aircraft and gliders were

placed in operational readiness, units moved to staging areas, and a "dress rehearsal" with token airborne units conducted. By this time practically all air crews participating had experienced at least two, and in most cases three or four, major airborne operations.

V. WEATHER

23. As in most other types of military operations, weather is a factor which can influence airborne operations extensively. It can preclude them, make it impossible to sustain them logistically and tactically once committed, and cause inaccuracies and dispersion of drop pattern. Although bad weather conditions, in the operations studied, were overcome in some cases by experienced crews, they seriously subtracted from total achievement in the airborne invasions of Sicily (HUSKY) Normandy (NEPTUNE), and Holland (MARKET). In each of the above, the local phenomena were not predicted. Weather coupled with hours of darkness was a most damaging influence in both Sicily and Normandy. Although the moon phase was bright, and the weather was clear with no precipitation forecasted, very high winds were encountered on the Sicily operation which drifted aircraft and gliders so far away from the check points on Malta and Sicily that they could not be identified at night. In Normandy, with similar moon phase and clear weather, a fog bank was encountered between the initial point and drop zones which, aggravated by enemy flak, caused a wide dispersion in accuracy and concentration. In Holland, beginning D plus one and lasting for approximately 6 days, weather moved in lowering ceilings and visibilities which precluded complete tactical air support and air logistical support after the forces were committed. Although the initial assault in Holland on D-day produced the highest accuracy and concentration for airborne operations during the war, the subsequent support operations were seriously affected by weather conditions.

24. Dispersion of troops on ground and jump casualties were influenced by the velocity of the surface wind. Operations with a surface wind greater than 15 miles per hour resulted in a higher rate of casualties and the dispersion delayed considerably the assembly of the airborne troops on the ground. This condition was most apparent during the initial drop in Sicily where drops were executed in gusts ranging from 20 to 35 miles per hour. Detailed results of the effects of jump casualties and dispersion are covered in separate sections of the airborne study.

25. Low ceilings and low visibilities made glider operations hazardous and in some instances, as in MA KET, precluded their use entirely after D plus 2 until D plus 6. One complete regimental combat team planned for use on D plus one was not available to the Airborne Army until D plus 6. Gliders could not be towed during instrument conditions, nor could they be employed in some conditions of low ceilings and low visibilities wherein the tug aircraft could operate singly.

26. In all airborne operations, therefore, weather conditions should be adequate, not only for the D-day operations, but for subsequent operations until the entire force has been placed in its planned positions and is no longer logistically dependent on air operations.

VI. PLANNING

27. The Combat Airborne operations required varying lengths of time for planning purposes. No standard time could be established as applicable for all situations, but it is apparent that planning time requirements were reduced by the development and application of standard basic planning procedures applicable to both ground and air units. It is further evident that adequate time has to be allowed for joint planning if an airborne operation is to be executed successfully. Adequate time was not always available. For example, the airborne operation into Germany which originated at theater level in the preliminary phases of the offensive achieved much better results than the airborne operation into North Africa which was added as an afterthought to a major ground operation which had already been planned, and sufficient time not given troop carrier or airborne units to become completely integrated into the overall operation.

28. Coordination of the troop carrier/airborne tactical plan with all participating forces became an important basic consideration as a result of the airborne operations in Sicily. Lack of complete coordination and dissemination of pertinent information to all appropriate forces, including surface vessels operating singly, produced the tragic circumstances of having Allied ships and troops fire on their own troop carrier aircraft and aggravated a situation already made critical by weather (high winds) and errors in navigation. The exact percentage of degradation to be attributed to this unfortunate circumstance has not been measured for lack of appropriate data; however, it is evident that some of the inaccuracy, lack of concentration, and loss in this operation can be attributed to lack of coordination. Briefing in recognition procedures was part of the system of coordination and was a joint responsibility which, not fully met, endangered the overall effectiveness of operations.

VII. SUMMARY OF TROOP CARRIER OPERATIONS

29. An analysis of operation NEPTUNE shows that although a few of the airborne units were dropped on or near their DZ's on the first night missions, in general, the drops were severely scattered. Troop carrier navigation was excellent until reaching the initial point prior to the run-in on the DZ's, at which point low cloudiness and enemy flak caused the formation to break up and many of the drops were scattered. Fortunately, no Allied gunfire was encountered, as was the case in Sicily, because of impressive lessons learned by that time. In subsequent phases of re-supply, intense flak and ground fire, coupled with a rapid movement in the ground situation and poor weather, caused a high loss of equipment dropped. The following Table II shows a summary of the IX Troop Carrier Command operations for NEPTUNE.[3/]

3/ The Effectiveness of Third Phase Tactical Air Operations in the European Theater - prepared by the Army Air Forces Evaluation Board in the European Theater of Operations - dated August 1945.

TABLE II

SUMMARY OF IX TROOP CARRIER COMMAND OPERATIONS

(NEPTUNE)

AIRCRAFT	
Dispatched	1662
Sorties	1608
Completing mission	1581
Abortive	76
Destroyed	41
Damaged	449
Troops dropped on objective	13215
Artillery weapons dropped	223
Pounds of combat equipment and supplies dropped	1641448
Flying time hours	7092

PERCENTAGES	
Aircraft abortive	4.6%
Aircraft destroyed and missing	2.5%
Aircraft damaged	27.0%
Gliders not released at LZ (lost)	1.6%

TROOPS DROPPED OR LANDED	
By aircraft	13215
By gliders	4047
Total	17262

GLIDERS	
Dispatched	512
Sorties	512
Released at LZ	503
Not released at LZ (lost)	9
Troops landed on objective	4047
Troops not landed on objective	43
Artillery weapons landed	110
Jeeps landed	281
Pounds of combat equipment and supplies landed	412477
Flying time hours	1118

POUNDS OF FREIGHT DROPPED OR LANDED	
By aircraft	1641448
By gliders	412477
Total	2053925

ANALYSIS OF COMBAT EQUIPMENT DROPPED OR LANDED

	Aircraft	Gliders	Total
Number of jeeps	0	281	281
Number of artillery weapons or mortars	223	--	333
Gallons of gasoline	1667		1947
Pounds of mines and explosives	16297	[illegible]	26652
Pounds of ammunition	596621		798683
Pounds of rations	81701	[illegible]	87373
Pounds of combat equipment	946829	194388	1141217

The 41 aircraft destroyed, and the 449 aircraft damaged were all a result of enemy flak and ground fire. There were no known losses of troop carrier aircraft to enemy air action.

30. During Operation MARKET the U.S. IX Troop Carrier Command, augmented by 38 and 46 Groups, RAF, delivered three airborne divisions, two U.S. and one British in Holland at Eindhoven, Nijmegen, and Arnhem - a total of 19,907 troops dropped during daylight hours. This troop carrier operation was one of the most successfully executed, producing, as indicated in Table 1, a high order of accuracy and concentration. From D-day on 17 September until D plus 9, there were 5,549 troop carrier aircraft dispatched of which 153 (2.3 per cent) were lost to enemy flak. Thirty-five aircraft were lost and 279 damaged by enemy flak on D-day in spite of 283 anti-flak missions by the Allied Expeditionary Air Forces on D minus one, the attack on 117 anti-flak positions on D-day by 821 B-17's of the U.S. 8th Air Force, and 1324 sorties of fighters and fighter bombers of the AEAF, 40 per cent of which were anti-flak patrols. Again there were no losses of troop carrier aircraft to enemy air action. Of 2557 gliders dispatched, 2262 reached their landing zones and 139 were lost. It is significant to note that although much effort was directed against known enemy flak positions, serious losses to troop carrier forces did occur on the southern approach route and in the Arnhem area where most of the anti-flak missions were directed. The following Tables IIIA and IIIB show a daily summary of airborne and air supply operations.[4/]

4/ The Effectiveness of Third Phase Tactical Air Operations in the European Theater--prepared by The Army Air Forces Evaluation Board in the European Theater of Operations - dated August 1945.

TABLE III (A)

SUMMARY OF AIRBORNE AND SUPPLY OPERATIONS (MARKET) AIRCRAFT

Date	Dispatched	Reached Objective	Lost	Troops dropped & landed	Vehicles landed	Artillery weapons dropped	Tons of equipment and supplies dropped
D-day	17 Sept.						
U.S.	1174	1150	35	16320		278	504.2
Brit.	370	331	0	180		0	0
Tot.	1544	1481	35	16500		278	504.2
D+1	18 Sept.						
U.S.	1283 b	1245	29	2011			653.8 b
Brit.	329	303	3	0			97.4
Tot.	1612	1548	32	2011			751.2
D+2	19 Sept.						
U.S.	445	243	20				71.2 d
Brit.	209	181	13				434.6
Tot.	654	424	33				505.8
D+3	20 Sept.						
U.S.	356	355	0	125			466.6 f
Brit.	164	152	9	0			432.3
Tot.	520	507	9	125			898.9
D+4	21 Sept.						
U.S.	177	128	5	998			99.0
Brit.	117	91	23	0			303.5
Tot.	294	219	28	998			402.5
D+6	23 Sept.						
U.S.	531	489	9	556			26.1
Brit.	123	115	6	0			325.0
Tot.	654	604	15	556			351.1
D+7	24 Sept.						
Brit.	21	21	0				41.9
D+8	25 Sept.						
U.S.	34	34					48.7
Brit.	7	6	1				15.5
Tot.	41	40	1				64.2
D+9	26 Sept.						
U.S.	209	209 g		882	238		378.7 g
Totals:	5549	5053	153	21072	238	278	3899.5

Footnote:-

b. Includes 252 Eighth Air Force bombers used for resupply.
d. Plus 340 gallons of gasoline dropped.
f. Plus 4486 gallons of gasoline dropped
g. Troops landed on air strip at Grave.

TABLE III (B)

SUMMARY OF AIRBORNE AND SUPPLY OPERATIONS (MARKET) GLIDERS

Date	Dispatched	Reached LZ	Lost	Troops landed	Vehicles landed	Artillery weapons dropped	Tons of equipment and supplies landed
D-day	17 Sept.						
U.S.	120	106	13	499	91	8	85.2 a
Brit.	358	319	1	2908	420	44	0
Tot.	478	425	14	3407	511	52	85.2
D+1	18 Sept.						
U.S.	904	868	19	4209	402	64	559.8 c
Brit.	296	275	1	1200	443	52	21.0
Tot.	1200	1143	20	5409	845	116	580.8
D+2	19 Sept.						
U.S.	385	213	73	1386	131	61	245.0 e
Brit.	44	33	0	107	63	9	0.
Tot.	429	246	73	1493	194	70	245.0
D+6	23 Sept.						
U.S.	490	448	32	3472	139	52	348.1
Brit.	0	0	0	0	0	0	0.
Tot.	490	448	32	3472	139	52	348.1
	2557	2262	139	13781	1689	290	1259.1

Footnote:-

a. Plus 640 gallons of gasoline landed.
c. Plus 520 gallons of gasoline landed.
e. Plus 25 gallons of gasoline dropped.

31. Operation VARSITY, across the Rhine River into Germany, also received a high degree of accuracy and concentration from the performance of the U. S. IX Troop Carrier Command and the 38 and 46 Groups, RAF. Here again there were no losses to the troop carrier forces from enemy air action. However, during the two days airborne operations 64 troop carrier aircraft were lost to enemy flak and 499 were damaged. Reports indicate that during operations on the first day much of the loss and damage was caused by light weapons from enemy troop concentrations. Here again, as will be shown later, the Allied anti-flak program was very intense, but did not achieve the desired neutralization. A study of this operation revealed that in numerous cases enemy flak installations were not knocked out until they had been overtaken and captured by the troops that were dropped. The following Table IV gives an analysis of the loads delivered by both U. S. and British troop carrier forces.

TABLE IV

ANALYSIS OF LOADS CARRIED IX TCC

Troops	17,262	Gasoline	1,947 gals.
M/T	281	Bombs	26,652 lbs.
Artillery weapons	333	Ammunition	798,683 lbs.
Other combat equipment	1,141,217	Rations	87,373 lbs.

ANALYSIS OF LOADS CARRIED - RAF (38 and 46 GROUPS)

Troops	7,162	Bicycles	35
Artillery weapons	29	Containers	622
M/T	296	Panniers	731
Tanks	18	Bundles	154
Bombs	2,000 lbs.	Signals Equipment	12

VIII. SUMMARY

32. Available data do not permit separate quantitative assessment of any of the above factors of influence in this analysis. It may be concluded, however, that each factor influenced final results in varying degree in different situations. A combination of all these factors may have been present in certain operations, while those less significant in some were most apparent in others. Table V shows the percentages of drop accuracies and concentration attained by troop carrier forces in Operations NEPTUNE, MARKET, and VARSITY, taking all influences into consideration. These figures have been developed from data obtained from official reports of the troop carrier and airborne units. They do not include the percentages of accuracy and concentration achieved by the glider landings in each operation; however, it may be concluded that in each operation the geometry achieved in the glider landings was affected by the same factors of influence and to at least the same extent.

TABLE V

TROOP CARRIER DELIVERY [5/]

Operation	Airborne Div.	a Accuracy	c Concentration	e_g Geometric Drop Effectiveness
NEPTUNE (Night)	82d A/B Div. (Mean)	0.32	0.33	0.11
" "	101st A/B Div. "	0.33	0.25	0.08
" "	82d Plus 101st "	0.32	0.29	0.10
MARKET (Day)	82d A/B Div. "	0.82	0.78	0.64
" "	101st A/B Div. "	0.80	0.95	0.78
" "	82d Plus 101st "	0.81	0.87	0.71
VARSITY (Day)	17th A/B Div. "	0.75	0.96	0.72

33. In computing the figures in the above table, accuracy has been taken to mean the distance relation of the dropped items to the drop

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5/ See Enclosure B.

zone, and concentration to mean the distance relation of the dropped items to one another. When all sticks fall within the DZ it follows that a = 1. Similarly, if all the sticks land within an area equal to the size of the DZ (not necessarily on the DZ), then it follows that c = 1. The geometric drop effectiveness as a product of accuracy and concentration reflects only the troop carrier delivery performance during the assault phase on D-day of each operation. It is no indication of the total effectiveness of the overall airborne operation.

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WPRS System Eval Study #3

ENCLOSURE J OF WSEG STAFF STUDY NO. 3

TACTICAL AIR SUPPORT OF AIRBORNE OPERATIONS

I. INTRODUCTION

1. The aspects of tactical air support to be considered here have been limited to escort, anti-flak and specific air support missions in support of airborne troops from the time they reach the ground until the end of an airborne operation. Pre-D-day tactical air preparation of the airborne areas has not been included in the study of the effects of air action on specific airborne operations. The exclusion of the "softening-up" effort, however, is not meant to detract in any way from the degree of importance it may have had. The value of the general air superiority achieved in World War II was recognized by participating ground and air commanders. Similarly, tactical air missions destroyed much of the enemy's lines of communications, railroads, motor transport and personnel. Enemy troop and transport movement was reduced by his being forced to move much of the time only at night. Although tactical air operations are recognized as having been beneficial to ground force operations in general, the assessment of the effectiveness of such operations is extremely difficult and cannot be stated quantitatively without making a complete analytical study beyond the scope of this enclosure.[1/] Thus it is not possible to state here in a definite way to what extent the tactical air effort affected the rate of advance of friendly troops, their ability to seize and hold objectives, the movement of enemy troops, destruction of specific pre-planned targets, or other similar parameters. The discussion of air support of the specific airborne operations studied must, therefore, be not only limited in scope but also qualitative and general in nature.

1/ A first attempt in this direction was made for a few World War II actions of 21 Army Group in British Military Operational Research Report No. 34, "The Effect of Close Air Support," December 1946.

II. TACTICAL AIR ACTIONS IN OPERATIONS NEPTUNE, MARKET AND VARSITY [2/]

A. OPERATION NEPTUNE

2. On D-day in Normandy the IX Troop Carrier Command was given escort and area cover by fighter-bombers during daylight hours. (No escort was flown for Troop Carrier operations during hours of darkness since none was considered necessary). These escort operations were uneventful, the only reporting of the presence of enemy fighters was by aircraft performing surface convoy cover. These reported sighting and chasing off 3 FW 190's within range of the troop carrier stream. No claims were made by fighter-bombers assigned to troop carrier escort.

3. Although records show that eleven D-day missions were flown by fighter-bombers in response to eight requests submitted by the Army to the Combined Control Center, it is not indicated that these requests were originated by airborne units. Three of these missions were armed reconnaissance along the road in the airborne area leading from Carentan to La Haye du Puits, where railway targets and a highway bridge were bombed. Of a total of 3945 D-day sorties (in support of the entire amphibious and airborne invasion) including 2065 fighter-bomber sorties of the Ninth Air Force and 1880 fighter and fighter-bomber sorties of the Eighth Air Force, the total loss to enemy action was 34 aircraft to flak. The Luftwaffe offered no opposition to the airborne landings and no troop carrier aircraft were lost to enemy air action during the airborne phase of the NEPTUNE assault. Although it is known that the air programs of isolation of the battlefield and direct support helped in denying the enemy effective use of countermeasures, and contributed to the ability of Allied ground units to secure a foothold on the continent, the exact degree of effectiveness of the D-day air efforts is not known. Low cloud conditions (10/10 overcast) contributed to the lack of visual and photographic records, and pilots' reports

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2/ All figures appearing in this section relative to U. S. and British tactical air operations have been taken from official U. S. Army Air Force, British Royal Air Force and First Allied Airborne Army records of the World War II actions examined.

on damage to the enemy varied greatly. A reliable system of tactical air control had not yet reached a high state of development. As a result targets were bombed which were not considered good air objectives, and there were cases where better results might have been attained had the effort been better controlled. In general, however, the lack of enemy air opposition made it possible for Allied tactical air forces to carry out attacks on pre-planned military targets in the battle area with relative ease. The resulting destruction to enemy troops and equipment significantly reduced the enemy's ability to counter-attack the combined assault. It is not possible to determine from the records what proportion of this tactical air activity was in specific support of the airborne operation itself.

B. OPERATION MARKET

4. Operation MARKET in Holland had associated with it one of the greatest anti-flak efforts of the War in Europe. Since the northern troop carrier route lay over enemy territory from the coast to the objectives, whereas the southern troop carrier route did so only after the initial point (IP), most of the anti-flak operations were along the northern route. The anti-flak coverage of the northern route flak positions apparently was very successful, since there was little loss to troop carrier flights along this route. Not only were land batteries knocked out, but several flak ships and barges off the Dutch Islands were destroyed. The southern route, on the other hand, was not as effectively covered by anti-flak efforts. Here, as well as in the Arnhem area, troop carrier losses and damage were greatest. A total of 117 flak positions along both routes were bombed by 821 B-17's on D-day. Three B-17's were lost to flak and 84 damaged. This force dropped 3139 tons of bombs, including 250 lb. and 120 lb. fragmentation bombs, and 500 lb. general purpose bombs. In addition 85 Lancasters and 15 Mosquitoes of the RAF Bomber Command dropped 535 bombs on coastal batteries in the Walcheren area which were a threat to troop carrier aircraft and gliders. No British troop carrier aircraft or gliders were lost on D-day (northern route) but 35 U. S. troop carrier aircraft and 13 gliders were

lost and 279 damaged on the southern route on D-day. It may be concluded that the anti-flak effort reduced the effectiveness of enemy flak installations, but did not, as was indicated by troop carrier losses, neutralize enemy flak completely.

5. In addition to the tactical bombing on D-day, missions of escort, area cover over drop zones and landing zones, and anti-flak patrols were performed by the U. S. Eighth and Ninth Air Forces, by the Air Defense Great Britain, and by the 2d Tactical Air Force, RAF. (Sorties flown into the battle area were in support of the combined MARKET-GARDEN assault in Holland and it is generally not possible to separate those in support of MARKET from those in support of the whole operation, except for escort of troop carrier forces.) These aerial forces prevented enemy aircraft from entering the airborne battle area in significant numbers, and from attacking troop carrier air columns. They also assisted in the flak suppression program. A total of 30 German aircraft consisting of 15 ME-109's and 15 FW-190's were sighted and engaged by 166 F-51's of the Eighth Air Force on escort missions. Seven enemy aircraft were destroyed to a loss of one F-51. The enemy made no further attempts on the troop carrier train on D-day, and no troop carriers were lost to enemy air action. D-day sortie rates for each of the above forces were as follows:

U. S. Eighth Air Force	550)	(F-47s (F-38s (F-51s
U. S. Ninth Air Force	166	F-51s
Air Defense G. B.	371)	(Tempests (Spitfires (Mosquitoes
2d TAF, RAF	84)	(Tempests (Spitfires (Mosquitoes

The D-day summary showed an Allied loss to the sorties listed above of 25 A/C to enemy flak, 1 to enemy air and 132 damaged by enemy flak, with a loss of 7 enemy aircraft to Allied air action. D-day air claims against enemy ground activities in the battle area are as follows:

	Destroyed	Damaged		Destroyed	Damaged
Locomotives	4	7	Tanks	4	1
R R box cars	93	38	Misc. Vehicles	2	0
Staff cars	3	0	Flak and guns	59	89
Motor Transport	20	9	Misc. Bldgs.	1	12

This tabulation illustrates the type of data which can be obtained from Air Force records. It is clearly indicated in the reference cited in Footnote 1 that the relationship between air claims and actual damage achieved is unknown but it is known that, for various reasons, such claims are usually optimistic. Moreover, it will be appreciated that it is difficult to associate such data with the outcome of the actions of the ground troops -- which is what would be required to evaluate the effectiveness of tactical air support to ground troops. Finally, practically no airborne unit records contain the data necessary to show in what way or to what degree ground actions were influenced by tactical air activity in the operations studied.

6. A diversionary program was carried out on D-day in which dummy parachute drops were executed by 20 aircraft of the RAF Bomber Command. These drops were made in three areas 15 to 20 miles northwest of the Nijmegen-Arnhem Corridor. These dummies were accompanied by firing devices with instantaneous and delayed fuzes so as to simulate carbine and machine gun firing. German intelligence overlays show that these were believed to be actual drops until D + 4. An immediate force was sent against them, but the capture of an Allied Field Order on D-day revealed that the main threat to the enemy lay in a different area. It is evident, however, that this effort, even though not strongly counter-attacked, diverted a certain (but unknown) amount of enemy attention for approximately four days.

7. The weather, which was excellent on D-day, began deteriorating on D + 1 at Allied air bases. The cloud cover was 5/10 to 8/10 and the ceiling varied from 2000 to 3000 feet. However, the ceiling and visibility in the target area were good. German forces in the Reichswald had launched a severe counter-attack placing pressure on the 82d Airborne Division. A call for direct air support to assist in dealing with this threat was sent out and a force of 97 Spitfires and Mustangs of the 2d TAF arrived within 1 hour and 30 minutes. This is the one clear cut case in which both air and ground

force records agree as to the request, dispatch and delivery of direct air support. In none of the records, however, is the exact effect of the attack on the Reichswald shown. (Several records of requests by troops for direct air support have been found but in only one or two cases can it be determined whether the support was given and in no case is it indicated what its effect may have been. This does not imply that much of the air support requested may not have been given. It indicates only that there is no evidence either way.) Also on D + 1, 246 B-24's of the Eighth Air Force dropped 782 tons of supplies in all division areas, with a loss to flak of 13 B-24's and 80 damaged. Tactical air support claims for D + 1 are as follows:

	Destroyed	Damaged		Destroyed	Damaged
Locomotives	7	0	Radar Positions	1	0
Box Cars	20	14	Flak Positions	39	19
Staff Cars	8	0	Misc. Bldgs.	4	4
Motor Transport	76	24	Ammo. Trucks	8	1

The same remarks and limitations apply to this listing of claims as were given in paragraph 5 concerning D-day claims. During the D + 1 activities, 90 ME-109's were engaged by fighters of the Eighth Air Force escorting troop carrier formations. Thirty-five enemy A/C were destroyed and one damaged. Eighth Air Force lost 17 A/C to enemy air action. Although enemy air reaction was much stronger than on D-day, this enemy effort had no significant effect on the Allied ground situation, and the escort of troop carrier operations was again completely effective, in that no troop carriers were lost to enemy air action.

8. On D + 2, weather had deteriorated to visibilities of one to two miles, ceilings of 1500 and 2000 ft., with cloud cover from 7/10 to 10/10 over-cast. This condition curtailed Allied air activity. Twenty-four enemy aircraft strafed troops in the Arnhem area at intervals all during daylight hours. Although weather was bad at the Allied air bases, it was not prohibitive on the enemy air bases within range of the battle area. This aspect produced an obviously different effect on the airborne operations, as it permitted the enemy temporary local air superiority during the

morning operations. Later in the day, 127 Spitfires of the ADGB and 182 F-51s of the Eighth Air Force managed to get into the area. The 182 F-51s engaged 125 enemy ME-109s with the result of 23 enemy destroyed to 9 F-51s lost in air action.

9. Bad weather persisted on D + 3. The flak in the Arnhem area was intense and accurate on this day. No enemy aircraft were encountered in the general battle area by Allied air forces, but three fighters out of 248 ADGB sorties, and five fighters out of 679 U. S. 8th AF sorties were lost to enemy flak.

10. On D + 4 weather was again unfavorable. Slight improvement in the afternoon permitted airlift of supplies and about 50 per cent of the Polish Parachute Brigade. Approximately 100 enemy fighters were lying in wait for the return of the troop carrier aircraft. These enemy fighters were engaged by 137 fighters of ADGB and 95 fighters of the 8th AF, which resulted in an enemy loss of 20 A/C and 4 damaged to an Allied loss of 3. No troop carriers were lost.

11. No Allied air operations took place on D + 5 on account of prohibitive weather. Despite the weather over Allied bases and enroute to the battle area, 10 enemy FW-190s were sighted over Oosterbeek, but no actual attacks on ground troops were reported. The Germans had cut the supply corridor near Veghel with 30 tanks and 2 battalions of infantry in an attack from the east. The 101st supported by elements of the British Thirtieth Corps forced the enemy to withdraw the following morning and the supply channel was reopened. This was accomplished with no tactical air support.

12. The Luftwaffe reaction on D + 6 was the strongest yet met. Weather had improved and permitted 489 transport and 448 glider sorties to all airborne division areas. The enemy attacked the escorting Allied fighters with 135 Luftwaffe aircraft. This effort was engaged by 586 fighters of the 8th USAF which resulted in a loss of 8 enemy A/C and 22 U. S. aircraft. There were no troop carrier losses to enemy air action, but 20 A/C and 1 glider were lost to flak.

13. On D + 7 only most critically needed missions were flown because of bad weather. Forty troop carrier aircraft were dispatched to the British 1st Airborne Division area and all were damaged by flak. During the day the Luftwaffe, in unknown strength, strafed troops in the Arnhem area. Although 36 Spitfires escorted the transports and 22 Typhoons provided area cover, there was no air-to-air contact with the enemy and no troop carriers were lost to enemy air action.

14. On D + 8, weather improved sufficiently to permit direct air support to the troops at Arnhem. Units of 2d TAF, RAF strafed enemy guns and troops, and bombed enemy guns and mortars. One hundred ME-109s, FW-190s, and JU-88s were engaged by 96 fighters of ADGB, resulting in 36 enemy losses to 5 ADGB losses. Fifty aircraft of the above enemy force were JU-88s which attempted to bomb the bridge at Nijmegen. One bomb hit the bridge but the bridge remained passable.

15. On D + 9, the MARKET-GARDEN operations officially came to a close. The weather, which prohibited morning operations, improved sufficiently in the afternoon to airland the 1st Light Anti-Aircraft Battery and an Airborne Forward Delivery Airfield Group (British Units) on the air strip at Grave. There were no losses to the transports and escort was uneventful. However, 250 armed reconnaissance and 100 anti-flak patrol sorties engaged approximately 112 enemy FW-190s and ME-109s. Forty enemy aircraft were destroyed to a loss of 2 aircraft to U. S. 8th AF and 1 to 2d TAF, RAF.

16. The following is a summary of statistics on tactical air support operations for MARKET-GARDEN:

A/C Dispatched		A/C Lost	Enemy A/C Claimed	
8th AF Fighters	2273	87	Destroyed	160
8th AF Bombers	1127	15	Probably lost	7
9th AF Fighters	209	1	Damaged	39
Air Def. G. B.	1627	13		
2d TAF, RAF	534	7	(An estimated 525 enemy sorties were encountered)	
RAF Bomber Com.	402	2		
Totals	[illegible]	125		

17. In summary, it is evident from the above that the Allies had a degree of air superiority sufficient for daylight troop carrier operations. The air escort program was completely successful since no troop carrier

aircraft or gliders were lost to enemy air. Although the Allied anti-flak program was intense, and evidently attained considerable success along the northern route, serious losses to flak occurred on the southern approach route and in the Arnhem area. This suggests that some of the effort given to escort might have been better directed to anti-flak missions along the southern approach and in the Arnhem area. Bad weather seriously curtailed tactical air operations in direct support of and in isolation of the battle area. In addition to a serious weather effect on tactical air operations it appears that heavy air traffic during escorted troop carrier operations produced a further adverse effect on air support of ground operations by 2d TAF, RAF. The following is quoted from "Report of Tactical Air Operations in Europe," prepared by the Army Air Forces Evaluation Board in August 1945, to illustrate the effect of this restriction:

> "While Eighth Air Force fighters were escorting the various lifts of airborne troops and their supplies in the battle area, it was not possible for technical reasons for aircraft of 2d TAF to operate there at the same time. Consequently available air effort was wasted and the troops on the ground could not receive the direct air support they required against normal ground targets. This was emphasized by weather, as there were only quite brief periods when any air force could operate. The 1st British Airborne Division received practically no cooperation at all and the American airborne divisions little more until all airborne operations were over. 83d Group of 2d TAF has provided great assistance to all previous Second Army operations, and this restriction was, therefore, a serious operational handicap. It is essential that some alternative system be devised, so that ground forces, including airborne troops, are not deprived of air support at vital periods."

In general it may be said that during the MARKET-GARDEN operations air superiority was maintained during troop carrier operations in the battle area, isolation of the battlefield was not completely accomplished, and direct air support played an apparently minor role in determining the outcome of the ground actions. The state of the weather was a greater handicap to the Allied Air Forces than to the enemy. While it may have been a factor in preventing the Luftwaffe from putting up a maximum effort, it kept the Allies from bringing to bear the full weight of their air power in terms of continuous air superiority over the battlefield, interdiction and direct support.

C. OPERATION VARSITY

18. Operation VARSITY took place at a time when Allied air power was approaching its peak and the strength of the Luftwaffe had been seriously depleted. Enemy air activity was sporadic and almost absent close to the front lines. The GAF was unusually cautious and did not seek combat. Records indicate only 2 Allied aircraft lost and 2 damaged to enemy air action in the VARSITY battle area. This single instance occurred on D-day, at which time 35 ME-109s and 30 FW-190s were engaged by 370 U. S. aircraft, or a part thereof, of the U. S. 66th Fighter Wing. Of the 65 enemy aircraft encountered, 44 were destroyed and 10 damaged. There were no troop carrier or glider losses to enemy air action. The flak suppression effort, on the other hand, did not meet with the desired amount of success. Records indicate 52 troop carrier aircraft, 3.28 per cent, lost and 348 damaged by enemy flak. Despite the attacks on known enemy flak positions by some 370 sorties of the U. S. 9th Air Force and 2d TAF, RAF, plus some additional fighter-bomber special anti-flak missions (numbers unknown) immediately prior to the arrival of the troop carrier forces, there still remained sufficient flak in action in the battle area to cause significant troop carrier losses. It is evident that the flak suppression program was not as successful as was anticipated, and probably should have been more intensive. (Part of the anti-flak program for VARSITY was carried out by artillery fire and was, in general, no more effective than that executed by tactical aircraft.) 3/

19. Direct air support of both the ground forces and of the airborne troops on the ground in the combined Rhine assault was provided on D-day. It is difficult to assess the value of direct support to the airborne forces alone because the missions were designed to soften up enemy resistance in the whole battle area. Medium bomber forces attacked eighteen towns known to have been prepared for defense by the Germans. In addition, fighter-

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3/ See British Operations' Research Report, "German Flak and Allied Counter Flak Measures in Operation Varsity (Airborne Landings in the Rhine Assault)", No. 2, O.R.S. and O.R.S. 2d Tactical Air Force Joint Report No. 4, 7 July 1945.

bombers made attacks against enemy gun and mortar sites, and enemy forward positions and strong points, and armed reconnaissance was maintained continuously in the area. During the course of operations on D-day there were only four requests by the Forward Visual Control Party with the British 6th Airborne Division, and none from the U. S. 17th Airborne Division. (However, it is pointed out in Enclosure G that the 17th had severe difficulties with ground-to-air communications on this day). In the tactical air support of the British 6th Division, enemy targets were hit on an average of 10 minutes from the time of request from combat elements in contact with the enemy. Out of 26 request missions controlled by the Forward Visual Control Party on D + 1, four were in the 17th Division sector, and 22 in the British sector. Again on D + 1, the average time delay in getting air support to the combat elements was 10 minutes after the request was made. This appears to be the best average achieved by the tactical air control system in support of airborne operations in Europe. A system of orbiting of preplanned and scheduled fighter-bomber aircraft in the battle area was used. These aircraft were called by the FVCP and assigned targets which they attacked after being visually vectored by the FVCP. The targets accepted were attacked with rockets, cannon and bombs, in many cases within 300 yards of friendly troops.

III. CONCLUSIONS

20. Examination of tactical air operations associated with operations NEPTUNE, MARKET and VARSITY leads to the following conclusions for these operations:

a. A sufficient degree of air superiority was maintained during troop carrier operations to prevent losses of troop carriers to enemy air action. It is indicated that a certain degree of air superiority must exist in the marshalling areas, in all troop carrier routes from these areas to the drop and landing zones and return, and in the drop and landing areas whenever any of these areas or routes is in use by troop carrier aircraft in order to keep troop carrier losses to enemy air action within acceptable limits. It is not possible to determine what the minimum requisite degree of air superiority must be from the operations studied here.

b. All Allied troop carrier losses to enemy action were caused by flak or other ground fire. It was, accordingly, important to reduce flak and attempts were made to do this by tactical air action. It may be concluded that the anti-flak effort reduced the effectiveness of enemy flak installations, but did not, as was indicated by troop carrier losses, neutralize enemy flak completely.

c. Although a considerable amount of air effort was applied to isolation of the battlefields and interdiction of enemy movement, no conclusions with adequate supporting data can be drawn as to the effect of this activity upon the progress of the ground battles in these operations. Enemy movement was curtailed to a considerable extent but not prohibited.

d. The records on direct air support in the three operations studied indicate the course of development of this employment of air power, but the amount of such direct support received by airborne troops appears to have played a relatively minor role in determining the outcome of the ground actions of airborne troops.