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STUDY PROJECT
AMSCD 61- 4

STAFFING CRITERIA FOR TOE MEDICAL UNITS PHASE I

FINAL REPORT
DECEMBER 1960

CONDUCTED BY
OPERATIONS RESEARCH INC
SILVER SPRING, MD

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STAFFING CRITERIA FOR TOE MEDICAL UNITS PHASE I

FINAL REPORT
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CONDUCTED BY
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HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE SURGEON GENERAL
WASHINGTON 25, D. C.

DEFENSE LOGISTICS STUDIES
INFORMATION EXCHANGE

IN REPLY REFER TO

MEDEV

1 February 1960

SUBJECT: Development of a Method for the Determination of Staffing Criteria for Selected TOE Medical Units

TO: Suggested Agency
Operations Research Incorporated
8605 Cameron Street
Silver Spring, Maryland

1. References:

a. R&D Directive Number 26, Hq DA, 9 October 1959, subject: Army Operations Research.

b. Draft, AR 310-32 (undated) subject: Organization and Equipment Authorization and Equipment Authorization Tables.

c. AR 310-44, Hq DA, 4 December 1958, subject: Organization & Equipment Authorization Tables - Responsibilities, Manpower Standards, and Priority Control Schedules.

d. Logistics Directive Number 173-1, Hq DA, 15 July 1959, subject: Engineered Performance Standards.

e. Draft, FM 8-55, February 1959, subject: Army Medical Service Planning Guide.

f. FM 101-10, February 1959, Staff Officers Field Manual Organization, Technical and Logistical Data, Part I.

g. FM 8-10, November 1959, subject: Medical Service, Theater of Operations.

h. FM 8-5, October 1959, subject: Medical Service Units, Theater of Operations.

i. TOE 7-2C, Headquarters Company, Infantry Division.

j. Draft, TOE 7-12D, Headquarters and Headquarters Company Infantry Division Battle Group.

k. TOE 8-7C, Medical Company, Infantry Regiment.

l. Draft, TOE 8-17D, Ambulance Company, Infantry Division Medical Battalion.

m. Draft, TOE 8-18D, Clearing Company, Infantry Division Medical Battalion.

n. TOE 8-77C, Medical Company, Armored Division.

o. Draft, TOE 8-15D, Infantry Division Medical Battalion.

p. TOE 8-75C, Armored Medical Battalion.

q. TOE 8-571R, Surgical Hospital (MA).

r. TOE 8-581R, Evacuation Hospital (semi-mobile).

s. TOE 8-510, Field Hospital.

t. TOE 8-565, Station Hospital.

u. Applicable TOE's of the 5, 6, 7, 8, 17, 33, 44, 51, 54 and 57 series.

2. Request that an operations research study be undertaken to develop a method for the determination of staffing criteria for selected TOE medical units. The Combat Arms have and are developing new organizations and operational concepts at a rapid pace. In order to complement the developmental accomplishments of the Arms, The Army Medical Service must exert maximum effort toward the development of an effective medical support. The determination of realistic staffing criteria through scientific methods and techniques is essential to this effort.

3. Objectives and scope.

a. Objectives are to:

(1) Develop the essential theory and general method for establishing realistic criteria for staffing selected TOE medical units, applicable for use during the various time frames in the Transition and Long-Range Plan.

(2) Prepare an experimental design for field testing this method.

b. Scope. Conduct essential research studies and analyses of field medical unit effectiveness. The principle immediate objective is the development of methods of measurement of time requirements and engineered standards suitable for professional, medical ancillary and service support activities. A theoretical method will be developed and an experimental design devised directed toward establishing realistic manpower criteria for use in the development of future field medical units consistent with future warfare concepts as well as for evaluation of current organizations and concepts. Study will be limited to the development of a method for determining staffing criteria for combat medical service support units. Specific type units to be included are:

(1) Medical Detachment - Division Level

(2) Medical Platoon - Battle Group

(3) Medical Company - Division Level (Airborne)

(4) Medical Battalion - Division Level

(5) Field Hospitals - Army Level

4. Assumptions. It is assumed that:

a. The organizational and operational concepts depicted in MOMAR are adequate for guidance.

b. The current austere personnel and equipment policy will continue.

5. Guidance.

a. Mission of each selected type organization will be broken down into major functions, i.e., administrative functions, recovery of wounded, treatment and evacuation.

b. Responsibilities:

(1) The USAMEDS Combat Development Group will be responsible for:

(a) Provision of Project Officer(s) to coordinate the study and serve as liaison between the civilian agency and the army.

(b) Determination of representative patient loads for each of the units.

(c) Furnishing casualty assessment tables as are available.

(d) Introducing environmental variables and concept modification as appropriate.

(2) The Operations Research Incorporated will be responsible for accomplishing a research study to provide:

(a) A method which will serve as a basis for determining medical personnel requirements of selected type units to support the combat forces envisioned by current and future concepts.

(b) A means by which the mission and functions of the selected type medical units can be correlated with personnel requirements by MOS and number.

(c) An aid in the identification of functions presently performed by combat medical support units which may need to be eliminated, modified, or expanded. May further identify areas which require greater emphasis in unit training.

(d) The first step toward the eventual preparation of a staffing guide for the development of TOE's of medical units required to support the Army of the future.

(e) A plan for field testing the theoretical method for determining staffing criteria of selected TOE medical units. This plan may also be used for field testing the effect of current concepts and new developments on the capabilities of medical units.

6. Administrative Instructions:

a. Agency having primary interest. The United States Army Medical Service Combat Development Group.

b. Agencies with whom coordination is recommended.

(1) Medical Research and Development Command.

(2) Medical Plans and Operations Division, OTSG.

(3) Personnel and Training Division, OTSG.

(4) Supply Division, OTSG.

c. Funding Information. To be supplied by Medical Research and Development Command.

d. Desired date of completion. 30 June 1960.

e. Distribution desired of draft.

To be determined at a later date.

f. Distribution of final report.

Same as para 6e above.

g. Reports.

(1) Compliance with R&D Directive Nr 26.

(2) Monthly Progress Report USAMEDS Cmbt Dev Gp.

FOR THE SURGEON GENERAL:

Charles E Tegtmeyer

CHARLES E. TEGTMEYER
Colonel MC
Deputy Special Assistant to The Surgeon General
for Combat Development

OPERATIONS RESEARCH INCORPORATED

DEVELOPMENT OF A METHOD FOR THE DETERMINATION OF STAFFING CRITERIA FOR SELECTED TOE MEDICAL UNITS

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Program Director	Barry G. King
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ABSTRACT

A model has been devised for the medical support system for a field army. It consists of a comprehensive, detailed computer program for the combat command and division, and a model for hospitalization in the field army. To date, primary emphasis has been placed upon the simulation of the combat command. This has enabled completion of a program for a computer-simulation routine which has a high degree of flexibility in the analysis and comparison of competing combat medical support systems.

The simulation model follows the course of the patient from acquisition to final disposition. It predicts the outcome for the patient based upon the timeliness and quality of care prior to admission to the hospital and upon the assumption that he receives appropriate care upon admission. The flexibility of simulation permits many different kinds of examination of the number and qualification of personnel, equipment and facilities, and medical organization mobilized to meet the exigencies of the patient workload. It permits consideration of tactical dispositions, operations, and environmental and logistic limitations. The simulation of the medical platoon in support of the combat command is directly applicable to the medical detachment in support of the division headquarters. Simulation of the medical battalion in support of a division can readily be extended to cover the proposed medical company in support of the air transportable brigade.

The hospital model describes the workload for army hospitalization in terms of the output from a simulation model as well as from patients generated by supporting units to the division.

The staffing of army hospitals is related to the workload and the variations in workload resulting from stochastic variability of incidence in disease and injuries.

The consequences of a particular level of staffing and organization on patient outcome can be measured in terms of duty days lost, permanent disability, and survival.

SUMMARY

1. The operational concepts and weapons system of present and future armies are in a continuing state of development. The expected burden of patients and their requirements for medical management differ both qualitatively and quantitatively from those in past wars. Consequently, past experience and previous methods of patient management are likely to be inadequate guides for decisions in the future.

2. The overall objective of the combat development system is an effective military force and the medical combat development planners need to devise methods to support this mission within tactical and logistic constraints as well as those imposed by training and manpower requirements. Information must be made available to medical planners showing the relative cost in terms of manpower and equipment of accomplishment of different levels of medical care for sample battlefields. Finally the contribution of the medical service must be related to the overall combat efficiency of the Army.

3. It is assumed that the mission of the Medical Service will not be altered in the future. While the operational concepts and weaponry will impose problems of medical management of casualties differing both qualitatively and quantitatively from previous wars, the responsibilities of the Medical Service in the field of operation will continue to be that of providing measures for safeguarding the health of the troops, effective medical care, and early return of patients to duty.

4. It may be anticipated that disease and non-battle injury will continue to contribute a substantial, continuing and variable medical workload constituting the base line for the medical support requirements. To this chronic load will be added battle casualties from conventional weapons, their vastly more effective evolutionary developments, and, in unlimited

war, those generated by atomic weapons and chemical and bacteriological agents.

5. The objective of the present study is to develop criteria and methods for determining staffing requirements of selected TOE medical units. The method is to relate the patient needs for processing and care to the ability of a staff to satisfy those needs.

6. Application of the method will provide results which may be stated simply and concisely as the total number of days lost from duty, number of cases with permanent disability, and number of DOW for a given patient workload, military situation, and degree of staffing. This will permit comparison with optimal achievable outcomes and between alternative TOE.

7. The method is designed to measure the effectiveness of medical support units to the army and to enable planners to evaluate new concepts. It permits quantitative description of the important features of medical support and a quantitative estimate of the success of such support. For any given tactical situation the ability of specified medical units to care and treat patients can be evaluated. The evaluation is in terms of (1) survival rate, (2) days of duty lost (or days hospitalized), and (3) proportion of those returned to duty. These measures of effectiveness can be used to evaluate the performance of other medical units in the same tactical situation.

8. The model is a computer program simulating patient processing in the combat command and division and an analysis of hospital requirements in the MOMAR army. The simulation model follows the course of the patient from the original trauma or illness to the hospital. It assumes that in the hospital the patient will receive appropriate care, and it predicts the outcome in terms of the treatment that the patient had before hospitalization. The simulation is planned for a high-speed computer with large storage capacity. For each segment of the computer program there is an accompanying text setting forth in concise explanatory statements the scenario being simulated.

9. Monte Carlo simulation is a technique that has been successfully used to permit analysis of complex systems. The program describes the system in detail, case by case, and pools the results from the examination of the totality of cases. With respect to the medical support to the combat command and division, the machine explicitly describes the important steps in patient management from the first occurrence of the sickness or wound to the admission to the field hospital. As each patient is processed through these steps, a record is maintained of when he received treatment and the level of competence of the therapist. From pooling the results of such kinds of information on each patient and relating them to the final outcome in terms of duty days lost, survival rate, and permanent disability, it is possible to

describe the effectiveness of a particular organization in handling a given casualty load. Subsequently the machine simulation can be instructed to simulate the same casualties and the same tactical situation, varying only the medical organization. A comparison of the outputs resulting from the two organizations indicates their relative effectiveness to support the combat arms. The medical organizations specifically simulated are the medical platoon, the medical battalion, and the patient transport facilities of the Field Army Medical Service. The simulation permits tactical considerations, weaponry effects, and environmental influences as well as medical processing procedures.

10. The tactical situation is described in computer language by reference to a map on which the units to be examined are located at each time interval, which in this simulation will be every five minutes. It is thus possible to describe the degree of dispersion and the forward or backward movement of FEBA. In the simulation FEBA is considered as moving entirely for a single combat command.

11. The casualties used in the simulation are generated by the computer according to specific instructions. It selects randomly from tables of expected casualties associated with the expected weapons that will be used. The casualty type, its location within the combat command or along FEBA, and its time of occurrence are random events selected by the computer from distributions describing the relative frequency of these events. On any single case it is impossible to predict the type of casualty or its location and time, but for the total number, the selection approximates the distributions put into the computer. The aid-evacuation teams are specifically included within these casualty probabilities.

12. The environment enters into the simulation in two ways: first, because it changes the patient load primarily with respect to sickness, and secondly, because it involves the ability of the medical services to support the units. Considerations of the effect of terrain, lighting, and weather on the time required for the acquisition and evacuation of patients to take place are involved.

Medical Processing Procedures

13. Following the generation of a casualty, the first step to be simulated in the computer is the processing of acquisition of this casualty. It is necessary to consider the speed and capacity of the ambulance in getting to the casualty and evacuating the patient. The ability to communicate or to monitor communications nets is also explicitly described in the simulation, as are the movement of aid-evacuation teams. Possible variations permitted within the simulation involve the movement of aid-evacuation teams, the speed of ambulances, the ability to use communications, and the frequency of ambulance breakdown.

14. The capability of the aid-evacuation team for treatment of this casualty type is described in the computer simulation by relating the expected outcome of the patient to the qualifications and training of the aid man. A possible variation in these qualifications associated with a greater level of training or more equipment can be examined by a further re-run of the computer simulation.

15. Patients are brought back to the treatment and collection station either individually or, depending upon the simulation, collectively; that is, the aid-evacuation team acquires and treats a single casualty or attempts to get nearby casualties before returning to the treatment and collection station. The aid-evacuation team can be coordinated by communicating with an NCO control post, or it can follow established doctrine.

16. Treatment and collection stations (T&C's) are set up within the combat command according to the procedure established in the simulation routine. They are located with respect to FEBA and the flanks of the combat command, and they move from their location according to specific practices, such as when the distance to FEBA exceeds a given amount. Any such movement of T&C's is permitted to be simulated in the combat command, including stations designed to take care of casualties generated far behind FEBA.

<u>The T&C Station</u>

17. The ability of each of three levels of medical competence to handle a patient type is specified, as is the number of such individuals required, and how much time is needed for each. The record that the computer maintains is ultimately in terms of the effect of the level of medical competence on the final outcome of the patient. The number of people of each level of competence is a fixed quantity for any single simulated run, but is variable from one such run to another. For example, it would be possible to simulate a Treatment and Collection Station of homogeneous personnel by eliminating two levels of competence.

18. The priority of treatment of each patient at the Treatment and Collection Station is specified, and all those of a higher priority are worked on before those of a second priority, beginning with the earliest admission in a given class. Depending upon the previous treatment, a given casualty type has a particular probability of dying.

19. The process of evacuation from the T&C involves a number of decisions: first, the appropriate destination, whether to a division clearing station or to a hospital; second, the appropriate transportation, whether by ground or air ambulance, and last, the echelon from which these ambulances are to come. Such simulation is complex, and requires that the division echelon ambulances be considered simultaneously with army echelon ambu-

lances. To do this, the simulation resorts to the use of an Army slice for the division. The delay in getting one method of transport is balanced against that of getting another by examining the two arrival times and by considering the relative riding qualities and capacity of the ground and air ambulances.

20. The simulation of patient processing is taken up to hospital admission. It is assumed that when the patient is admitted to the hospital, he will receive appropriate care provided the correct decisions have been made on hospital capacity and organization.

Hospitalization in the Field Army

21. The requirements for hospitalization in the field army have been examined: the patient load is the output from the simulation routine for all the divisions, as well as patients acquired from support units. The admissions need to be considered by geographic distributions, patient type, and the time distribution of arrival. The inherent variability of processes requires that the hospital cannot be designed in terms of averages of these types but rather from a knowledge of their probability distributions. Patient processing and care requirements are heaviest when he is first admitted, and accordingly the time of admission as well as total patient load enter into the probability formation. Some of the tasks, for example, routine maintenance, can be postponed temporarily; this permits staffing for such functions in terms of average demands. Other staff requirements reflect the variations in patient load, and consequently the probability functions associated with these duties mu be spelled out.

22. In determining staffing requirements for military hospitals it is necessary to take into consideration problems which do not enter into counterpart civilian installations. The problems unique to the military include the necessity for conducting the peculiarly military duties of the personnel, bringing the patient to the level of fitness for full resumption of duty, and determining and spelling out the disposition of patients upon discharge. In a field hospital, additional requirements are laid out associated with such problems as sanitation and mobility. It is necessary to estimate the influence of weaponry and tactics upon the special problems of field hospitalization.

Classification of Patients

23. A classification system has been developed to describe the various medical conditions comprising the patient workload. It has been designed to convey the information to make decisions for treatment and disposition at each stage of the sequence of medical management, reflect the course of condition in terms of deterioration and recovery, and to permit definition of medical management requirements in terms of treatment, times for treat-

ment, and disposition. It is intended for all types of casualty spectra. The successive stages of classification are designed to eventuate in the standard diagnostic nomenclature utilized in final records.

Inputs

24. The method is independent of the quantitative values and certain aspects of doctrine which have been assumed as a frame of reference in thinking. Means for refinement of quantitative data and pertinent concepts exist. This will enable more precise definition of support requirements measurement of medical effectiveness.

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I. INTRODUCTION

1.1 Both the operational concepts and the weapons systems of present day armies, and of armies conceived for the future, differ markedly from those employed in previous conflicts, and both are in a status of continuing, accelerated development. The expected casualty burdens, and the medical management of these casualties differ both qualitatively and quantitatively from those in previous wars. Thus, previous experience alone is an inadequate basis for decision on the medical support system.

1.2 The design of the medical support system must be compatible with and complement the Army-wide combat development system of the combat arms and other technical services. Further, it must be consistent with the existing policy of austerity and manpower resources utilization. In consequence, objective, definitive criteria for development of medical TOE are required for reconciliation of medical support requirements for manpower and equipment with all other competing organizational demands in order to optimize over-all combat development.

1.3 Before 1952, the Army-wide combat development system, concerned with new weapons and new tactical organizational concepts, was represented only by combat arms. In 1955, participation was extended to include the Technical and Administrative Services. Accordingly:

a. In 1955 the Department of the Army directed The Surgeon General to establish an AMEDS Combat Development Group. At that time an effort was made to handle this activity within Medical Plans and Operations.

b. In 1958 this function was reassigned and the Office of the Special Assistant for Combat Development became operational.

c. In 1959 the Army Medical Service Combat Development Group was organized at the Forest Glen Section of WRAMC to serve as a link between the AMS world-wide and the Army-wide Combat Development System.

Mission of Medical Service

1.4 It is assumed that the mission of the Medical service will not be altered in the future in spite of great changes in the workload. This mission is to support the combat elements of the Army and is primarily concerned with the maintenance of the health and fighting efficiency of the troops. In a theater of operations the mission of the medical service is to conserve man-power by recommending and providing technical supervision of the implementation of measures for safeguarding the health of the troops, effective medical care and early return to duty; and to contribute directly to the military effort by providing adequate medical treatment and a rapid orderly evacuation for the sick and wounded. 1/

Future Tactical Concepts

1.5 The MOMAR Concept is designed to combine mobility and fire-power to give a dynamic effective fighting force. The Field Army consists of 6 combat divisions, 4 medium and 2 heavy, together with supporting units. Additionally, the MOMAR concept includes strategically and tactically deployable air-transportable units. The Field Army consists of approximately 165,000 men with divisions of about 13,000 men each.

1.6 The area to be covered by a division in the MOMAR concept has a frontage and depth far larger than World War II or Korea. Such dispersion imposes a load on medical acquisition, transport and treatment capabilities. New weapons will possibly be used, drastically altering the numbers and types of casualties and their distribution over the battlefield from the casualty spectra of past wars. Additionally, the great tactical mobility and possible isolation of self-sufficient units implies new problems in acquisition, care and evacuation of patients.

The Medical Workload

1.7 In the future as in the past, the greatest source of patients may be expected to be the sick rather than wounded. Variations in incidence of sickness are a function of many determinants such as degree of acclimatization of the troops and the endemic diseases of the environment. Consequently, average rates do not reflect the changing medical load associated with sickness; the

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1/ FM 8-10, Department of the Army Field Manual, Medical Service Theater of Operations (Washington: U.S. Government Printing Office, 1959), p.164.

continuous but varying load from sickness is perhaps best exemplified by the term "chronic". To this chronic load is added an acute load caused by acts of the enemy that in general is more urgent than the problems of diseases.

1.8 In the following sections the acute load will be stressed. The necessity for handling wounded patients is superimposed on the baseline established by care of the sick. In an adequate description, patient load from all sources must be considered and appropriate data for disease and injury utilized. The effects of inadequate staffing on the ability to handle both sick and wounded need to be spelled out.

1.9 It is proposed to use the word "patient" for those individuals under medical care and to reserve the word "casualty" to those who have not yet received medical attention.

The Medical Support Model

1.10 The method for determining staffing requirements for medical support units to the Field Army consists of relating the patient needs to the ability of a staff to satisfy those needs. It assumes that given enough time, every patient could receive optimum care, but that the patient has to go through a chain of processing before receiving such care. The analysis of this process before definitive treatment constitutes the proposed "Method". Such analysis implies a description of the important determinants leading to patient recovery, and involves not only purely medical treatment problems but also medical management procedures. A large factor in the model is the non-medical, i.e. tactical, determinants that constrain both medical treatment and medical management.

1.11 The object of the study of TOE medical units is to establish a methodology for quantifying the consequences of a particular degree of staffing. This method should be general enough to permit prediction over wide ranges of patient loads, medical management procedures and tactical situations. It is not necessary at this time to have precise figures to enter into the model because the Method is to a large extent independent of the magnitude of the numbers involved. What is required is that the concepts utilized are so defined as to permit quantification. In some cases the means of quantifying is obvious, in others more difficult. Part of the method proposed by Operations Research Incorporated includes a description of the solutions by which these difficult numbers can be obtained. No attempt is given in this report to present accurate data; the concern is strictly with methodology. At the same time there must be familiarity with existing sources of such data and of new sources for their development in order to set up a meaningful procedure.

Model Building

1.12 A model is a simplified representation of a system which takes into account those factors that significantly affect its operation. Where the workings of a system are familiar, experience gives evidence of such significant factors. For relatively new and untried methods experience is a less helpful guide, and it is necessary to try out such methods in an appropriate fashion; for example, by simulating them in a field test.

1.13 The model of medical support to the MOMAR Army is consonant with the preceding observation. The medical support to the Combat Command involves a medical system relatively unlike any used heretofore; divisional medical services approach more closely those of the past. Hospitalization in the Field Army poses a problem similar to, if not identical with, that encountered in World War II and Korea. Accordingly, the medical platoon is carefully simulated in detail, along with a number of possible alternative organizations; the medical battalion is simulated primarily in terms of its gross functions rather than in individual detail. Field hospitalization is represented in terms of its ability to handle patients by large groups according to types. The overall model is thus made up of three sub-models of differing degrees of fine structure.

1.14 The method or model contains three sections: it describes first, medical support in Combat Command; second, medical support in the division area; third, hospital service in the Field Army area. The output of one part becomes the input to another (combined with direct admissions). It is not enough to reflect the patient load at each echelon and the medical tasks associated with this load; it is necessary to relate the need for adequate and timely treatment.

1.15 Neither "adequate" or "timely" are useful words in defining staffing criteria. They may represent goals or standards but do not permit quantitative analysis. On the other hand, the consequences of a known kind of treatment combined with a given delay in treatment can be stated quantitatively. Since the suitability of treatment is related to the qualifications and equipment of those administering it, it should be possible to describe the clinical course and disposition of a patient, given information on the capability of the man who administers the treatment, what he has to work with, and the time of treatment in relation to time of injury or illness.

Stochastic Variability

1.16 It should be pointed out that the foregoing assumption is a statistical concept. The effect of a given treatment of a particular disease is a distribution of outcomes, although in any single case the patient's responee is uncertain. The concept of stochastic of random variability will be used extensively in this paper and refers to the probabilistic nature of events. Such a concept is especially appropriate because the medical service is designed to produce the most favorable outcome for all patients considered in toto, and must be so organized. Stochastic variability also applies to many other situations such as casualty types, ambulance breakdowns and the ability to locate a casualty.

1.17 The so called "Monte Carlo" technique consists of chance selection of events from distribution functions. In the long run the results obtained will approximate the original distribution. Because of the necessity for many samples, such a technique is only profitable with a high speed computer.

Simulation of Medical Service

1.18 War Gaming. The history of war gaming is a history of simulation of battle. In a war game the important determinants to the outcome are traced through in detail. Consequences of a particular tactic are pursued with all factors bearing on that tactic being examined. These battles can take place either on a map or in the field, and in varying degrees of detail. Because of the relative economy of paper studies, field exercises usually are supplemented by a great deal of map gaming.

1.19 Simulation is also used to examine hypothetical tactics and new concepts. Although the inexorable logic of war is the ultimate decider, it is possible, given enough insight, to foresee some of the consequences of one kind of tactic in only a sham war. This technique has come prominently to the fore in recent years and in large part is responsible for the change in Army organizations and tactics. The field exercises are currently being used to illuminate areas of uncertainty that appear from the war games.

1.20 A medical "war game" is perfectly feasible; casualties and their treatment can be simulated in a tactical situation. Such a field exercise is being conducted in the CDEC medical test at Ford Ord, California. In these tests the treatment, evacuation, and management of casualties are being processed in as realistic a fashion as possible.

1.21 Computer Simulation. The development of high-speed computers makes another kind of simulation possible. In this case the map used in war games becomes a stylized "map" in which only numerical coordinates are used. The computer can be instructed to go through the same logical steps with such a map as would be used in a hand-played game, e.g., measure the distance to an objective and determine how long it would take to get there. Actually, because of the great speed of the computer and its ability to store large amounts of information, the fine structure in a computer simulation is likely to be in much greater detail than in a hand game.

1.22 Computer simulation has a unique advantage not possessed by field exercises or even by an actual war - it is possible to replicate conditions in all particulars. This feature makes possible an examination of the contribution of each factor to the final result. Different tactics and procedures can be tried out and their influence compared.

1.23 If the instructions that the computer follows are a faithful representation of what is being simulated, then the output from the computer will represent the actual situation. The program followed by the computer needs to be spelled out in logical detail. An example is given to illustrate such a process (Figure 1).

Computer Flow Chart.

1.24 The first and most complex step in programming for a computer is to describe the logical steps involved. From such description it is possible to code specific instructions for a computer. An example has been selected to illustrate the procedure, that of the relocation of T & C stations. This example is one of the simplest of all the charts.

1.25 The arrows in a flow chart represent the successive steps for the computer to accomplish. At the upper left is D; this is a link to a previous action already completed. The numbers are labels for reference only; they do not represent the sequence because the computer is expected to take different routes depending upon the answers to the question at each step.

a. Set up first T & C data set. In the "memory" of the computer information is stored about each T & C; as many such sets as the assumed doctrine requires can be accommodated. The data set for T & C is shown. Of all the data listed only 1, 2, 4, 5 and 7 are used on the relocation routine. Note that the information stored in this data set starts out according to the original inputs on location, personnel, etc., but is progressively modified depending upon occurrences elsewhere, e.g., movement of FEBA and numbers of patients brought in. In the MOMAR I concept there would be 4 such stations.

b. Are both sections of the T & C at the same location? If the answer is "no", the next command to the computer is (10): Add 1 to T & C counter. The reason for this is that the rules for movement of a T & C permit two sections only, and no relocation of the first section is permitted. (The movement of the second section has to await on being patient-free and is not simulated at this time).

DATA SET

Treatment and Collection Station (identified by fixed address of first work in set)

1. Location of first section of station (x_1, y)

2. Location of second section of station (x_2, y)

3. Is an officer present at first section? yes, no.

4. Minimum desired distance of T&C station from FEBA.

5. Maximum desired distance of T&C station from FEBA.

6. Numbers of different types of medical personnel currently available:

   A. Enlisted Type A

      a. Second section (available fulltime, halftime)

      b. First section (available fulltime, halftime)

   B. Enlisted Type B

      a. Second section (available fulltime, halftime)

      b. First section (available fulltime, halftime)

   C. Officers

      a. Second echelon

      b. First echelon

7. Counters for keeping track of relocation time I.) First section; II.) Second section

8. List of aid teams at T&C Station by:

   a. Address of aid team data set,

   b. Whether at first or second section of station.

9. List of patients at station (use Patient Marker II).

10. Does T&C station service forward companies? Yes, no.

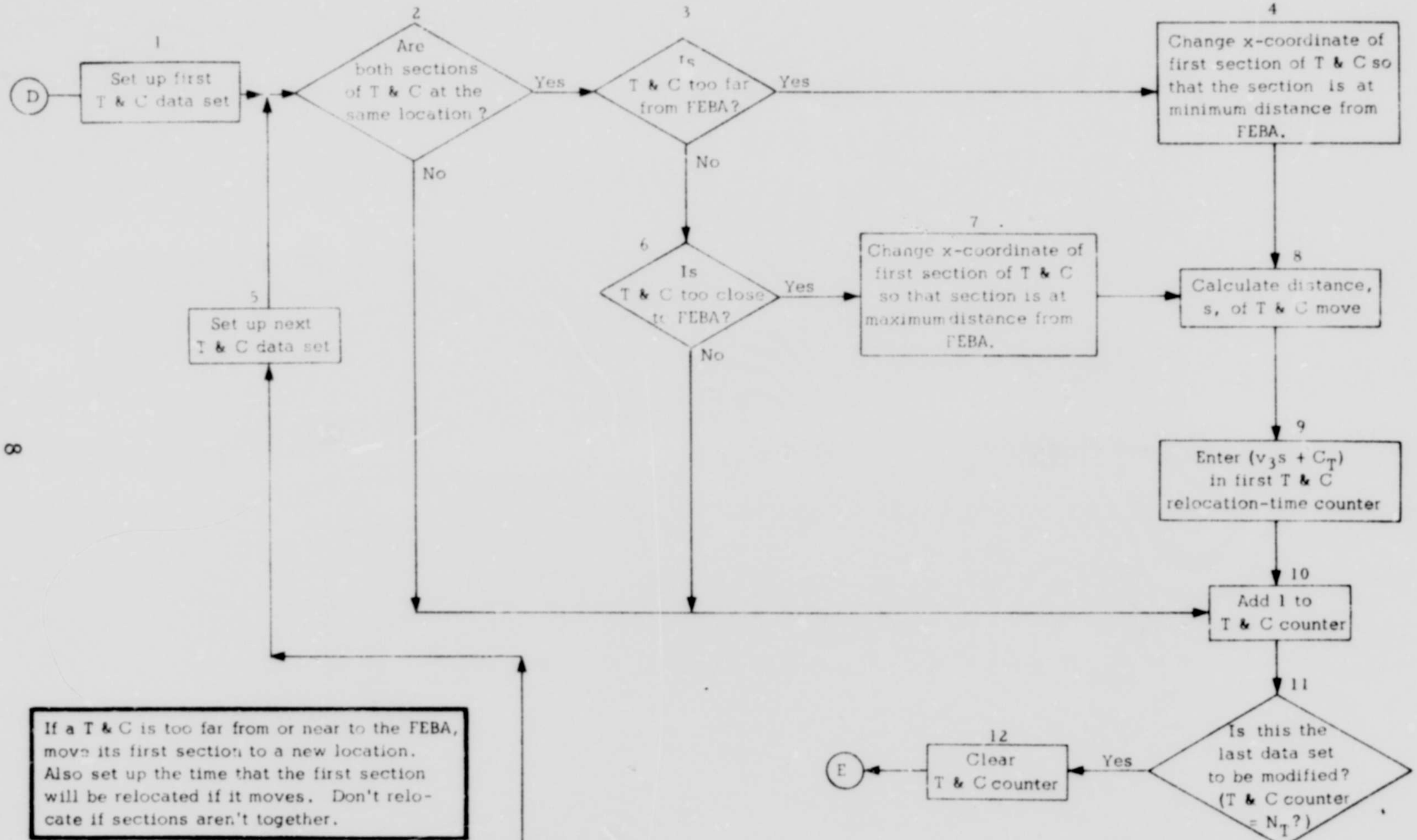


FIGURE 1. COMPUTER FLOW CHART

1.26 If the answer to (2) is "yes", then a pair of questions emerge: (3) is T & C too far from FEBA and if not (6) is it too near FEBA? A "yes" answer to either of these questions requires that the T & C first section be relocated. (If the whole T & C is patient-free it would nominally still be relocated in two sections, but the second section would leave and arrive at the same time as the first section).

1.27 The permissible distances of the T & C from FEBA are quantities stored in a part of the computer "memory". They may be varied to investigate doctrine on location. Note that only the x-coordinate of the T & C is changed. This is because the simulation permits movement toward or away from FEBA but not toward or away from the flanks. In each T & C data set is information as to how near or far it may be located from FEBA. If desired, each T & C may thus have different rules for movement.

1.28 When the first section is relocated it moves a distance (8) and in (9) the time required to do this is added to C_T. C_T is the time required, over and above travel time, for the first section to relocate. This input value is stored in the computer and presumably indicates the setting-up time in a new location.

1.29 Ten (10) tells the machine to look at the next T & C, if there is another, question (11), and the machine moves to (5) which represents the new T & C. The computer continues to run through all the T & C stations until the answer to question (11) is "yes". Finally the machine clears the T & C counter and moves in to the next instruction. The next routine deals with the company aid posts in the forward companies.

1.30 The required inputs to the above action are (1) the number of T & C stations, the closest distance each forward T & C can be permitted to FEBA, the farthest distance each forward T & C can be permitted from FEBA, the velocity of a moving T & C, the setting up time in a new location.

Example of Monte Carlo Simulation

1.31 One assumption in the model is that a given level of staffing determines the quality and timeliness of medical care and consequently, the course of diseases and injuries. This is a statistical statement; any individual case is unique and the quality of treatment and the speed of its arrival become a very personal matter.

1.32 From all the individuals whose records are maintained by the computer simulation a hypothetical happening has been chosen to illustrate the relationships between the particular case and the general computer simulation. It should be recognized that the computer output in a Monte Carlo simulation is based upon an analysis of a large number of individual items or cases. Each of the circumstances and eventualities described is simulated in the computer according to instructions.

1.33 Case of Machine Gunner and Assistant. The light machine gunner and his assistant in the second platoon of I Company were running across an exposed spot, when an opposing machine gun or automatic rifle hit them both. The machine gunner was hit in the stomach, and his assistant in the leg. Both of them fell into a defilade position and called for a medic. This was at 0800.

The computer makes a random selection from the following information stored in it:

A distribution of casualty types.

Frequencies of each type that can be expected in the sort of battle under consideration.

Casualty rates for this battle.

Probabilities that 2 or more casualties will occur at the same time in the same location.

1.34 Two aid-evac teams were stationed near company headquarters, listening in on the tactical net, and heard the platoon leader notify the Executive Officer of resistance in the area, and quite incidentally, that his best machine gun squad had been hit. One aid-evac team started at once for the tactical area, but threw an APC track crossing a ravine; it radioed back and the other team was immediately dispatched. The APCs averaged about four miles an hour over the rough terrain. The second team reached the platoon front at 0830, put their APC in a sheltered position and took a litter to cover the remaining 50 yards to the two casualties.

The machine computes the time each casualty waits for aid man treatment by processing the following additional information.

Frontages and depths of units under consideration.

Location of FEBA and rules for its movement.

Vehicle velocities.

Vehicle breakdown.

Numbers of aid evacuation teams and rules for their dispatching and use.

Times required to transmit messages concerning existence of casualties to medical system.

1.35 The machine gunner, wounded through the abdomen, appeared seriously hurt, but not as immediately in need of medical attention as his assistant, who was bleeding from an artery in his thigh and had a broken femur. While one aid man applied pressure with his thumb, the other put on a tourniquet, and subsequently the two of them splinted his leg and carried him back to the ambulance. They gave him morphine, an antibiotic, and a canteen of water with a salt tablet. They went back for the abdominal case and treated him with antibiotics and fluids. Both men were loaded in the APC which headed for the T&C station. By now the time was 0900.

> The computer does not keep track of details of treatment provided a casualty by each member of the medical team; only of the administration of treatment.
>
> The computer keeps track of time required for treatment of each type of casualty by aid man.

1.36 On their way past the company aid post, the aid team stopped to pick up a man with a gunshot wound in the left shoulder. They reached the T&C station at 0940, an hour and 20 minutes after the original wounds.

> The computer generates casualties according to distributions stored in it. Some of these are "walking wounded" who get themselves to the company aid post.

1.37 The two casualties acquired first were high-priority cases and were treated immediately, while the shoulder wound was ignored for the present. The man with the leg wound was in mild shock, and the surgeon applied a hemostat to the injured artery, replaced the tourniquet with a pressure bandage, and ordered a blood transfusion. The splint needed no immediate adjustment. At 1000 the surgeon turned to the abdominal case.

> The computer has compiled a list of all patients arriving at the treatment and collection station, by time and type. With each patient is also tabulated time of wounding and time spent waiting for aid.
>
> The computer has stored priority rules for treatment by the surgeon and calculates at what time the surgeon begins to attend to each patient.

1.38 He ordered a transfusion and large doses of antibiotics, and scheduled both men for immediate helicopter evacuation to an Army Hospital. Heavy casualties in the area had already produced a waiting list for the two operational helicopters, and it was evident that the delay would last several hours. The request was radioed from the Army to the Division helicopter platoon, taking another 25 minutes. A further delay of half an hour ensued before a Division helicopter was free. When it reached the T&C station, both patients were sent out, and they arrived at the Army Surgical Hospital, 20 miles to the rear, at 1340.

The computer selected this transport from a list of:

Transportation facilities to be used for evacuation from T&C stations.

Rules for the use of this equipment including priorities and policies for choosing destination for each casualty type.

Velocities and travel distances between the relevant destinations.

Communication transmission times.

1.39 Two more hours of preparation were spent before the machine gunner with abdominal wound could undergo surgery. His condition necessitated operating in two stages, which took place three weeks apart. He recovered without involvement, and in four months was back on duty. The leg fracture of the assistant was operated on almost immediately after the patient's admission to the hospital, and he was returned to duty after a convalescence of 90 days.

The computer now has a tabulation for each casualty of:

Type of wound.

Time spent waiting for aid man.

Time to treatment at T&C and type of medical personnel administering the treatment.

Type of treatment facility patient is sent to from T&C and time of arrival.

The computer has stored in it the medical information appearing in Appendix B of this report. By putting all this information together the computer compiles a distribution of outcome for each case and selects the duty days lost.

II. THE MEDICAL SUPPORT MODEL

2.1 A model has been devised describing the medical support to the combat command, the division, and the field army in the 1965-1970 time frame. The anticipated tactics and especially the wide dispersion, combined with the high degree of mobility, force a new examination of the solutions to the familiar problem of acquisition, treatment, and evacuation of patients. Since the major revisions in proposed tactics affect the lower echelons more than the division and the division more than the field army, it is imperative to examine in detail the medical support service to the lower echelons.

2.2 The combat command is the basic maneuver element of the MOMAR army and has organic to it a medical platoon. Accordingly, the medical platoon has been examined in detail, the medical battalion supporting the division in less detail. With respect to the field army the assumption is that previous methods of fulfilling its responsibilities for patient care will be generally applicable in the future.

THE COMBAT COMMAND

2.3 The combat command exists in several types, depending upon weaponry and mobility. A generalized combat command is represented in Figure 2. From the stand-point of the medical platoon this scheme can represent the medium or heavy division, motorized or mechanized, ground-based or air-transportable. Differences exist between these units with respect to logistic problems and number of personnel, but the basic structure of the combat command is constant.

2.4 The tactics of the combat command reflect the need for dispersal in the Atomic Age. It may occupy territory from 10 kilometers frontage

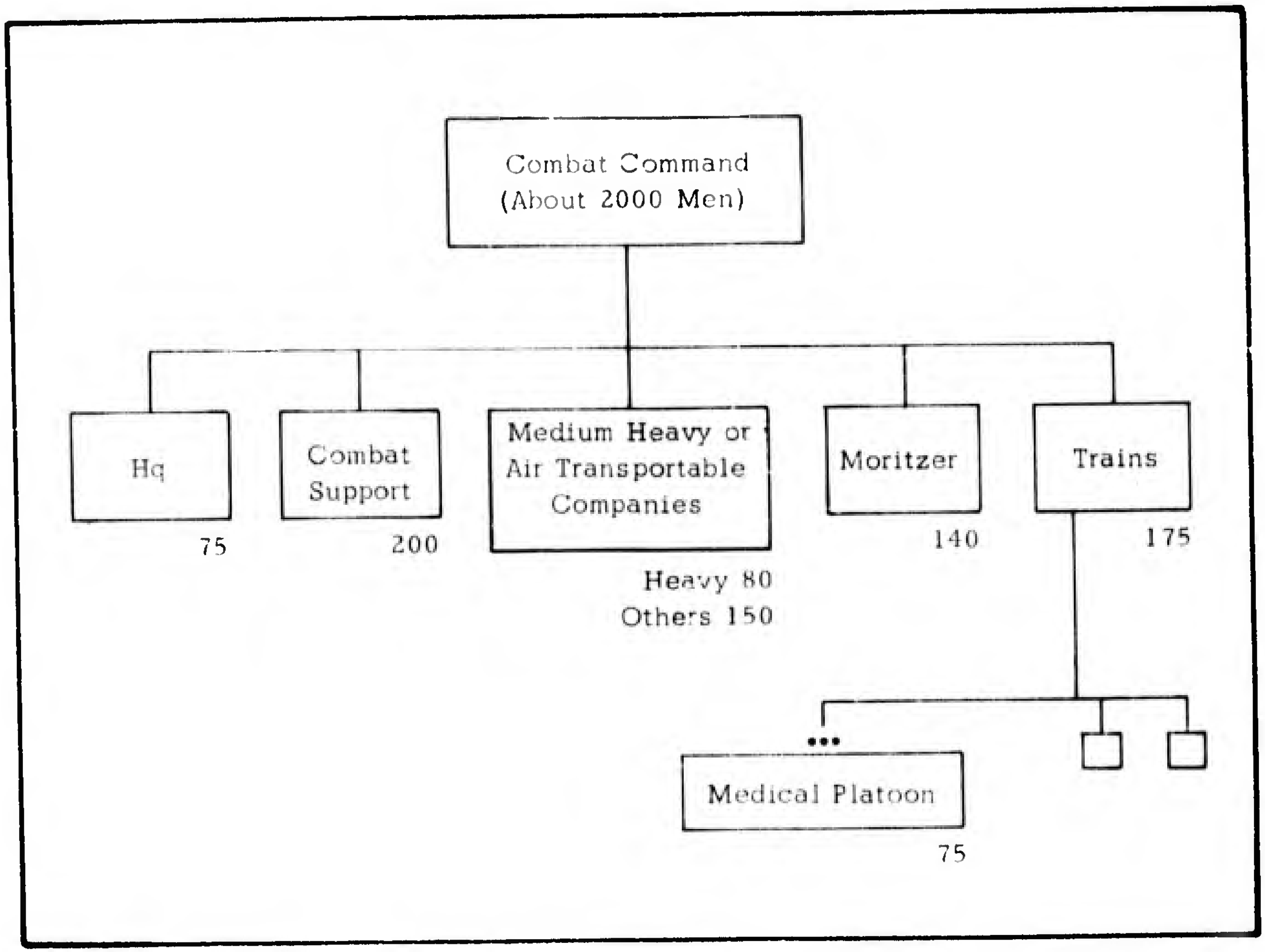


FIGURE 2. GENERALIZED COMBAT COMMAND

to 30 kilometers depth and may include within this area divisional and even army elements in support of the tactical operation. The necessity for rapidly acquiring and processing casualties spread over such an area would place a severe strain on the medical system, even aside from the number of casualties involved.

2.5 Combat commands of different types may be deployed as a single unit for a particular operation in a task force. In such a case the organic medical elements for the combat commands involved would also presumably function as one unit (to be similarly joined together), and the problems facing the medical support service would be similar in scope to those facing the medical service supporting a division.

Medical Platoon

2.6 The medical platoon in support of combat command is organized under the Trains company and its members range according to different concepts from approximately 50 to approximately 80 individuals of different types. An example of the organization proposed in substitute of the MOMAR I concept is given in Figure 3, which represents a variation proposed by CDG-USAMEDS. This concept does not differ substantially from that proposed by the CONARC study, but includes in general more personnel to handle the tasks facing the medical platoon. It consists of three sections: headquarters, treatment and collection stations (T&C) and aid-evacuation teams (A-E). These are coordinated in this particular concept by a non-commissioned officer in charge of a control post, who directs the aid-evacuation teams in support of the companies of the combat command.

2.7 The equipment given to the medical platoon in the MOMAR I concept is changed in the USAMEDS-CDG study to give the medical platoons the same mobility as the combat command they support and also communications equipment to monitor the company net and communicate with other elements of the medical platoon.

2.8 A schematic representation of the model for medical support to the combat command is presented in Figure 4. It illustrates in gross form the logical processes involved with respect to the medical support in the combat command area. Details of these features have been adduced and analysed for computer simulation; they are discussed more fully below and in Appendix A.

THE MOMAR DIVISION

2.9 The division in the MOMAR concept has much the same function as in the past - an administrative and organizational entity. The different varieties of divisions have been reduced; there are only two basic

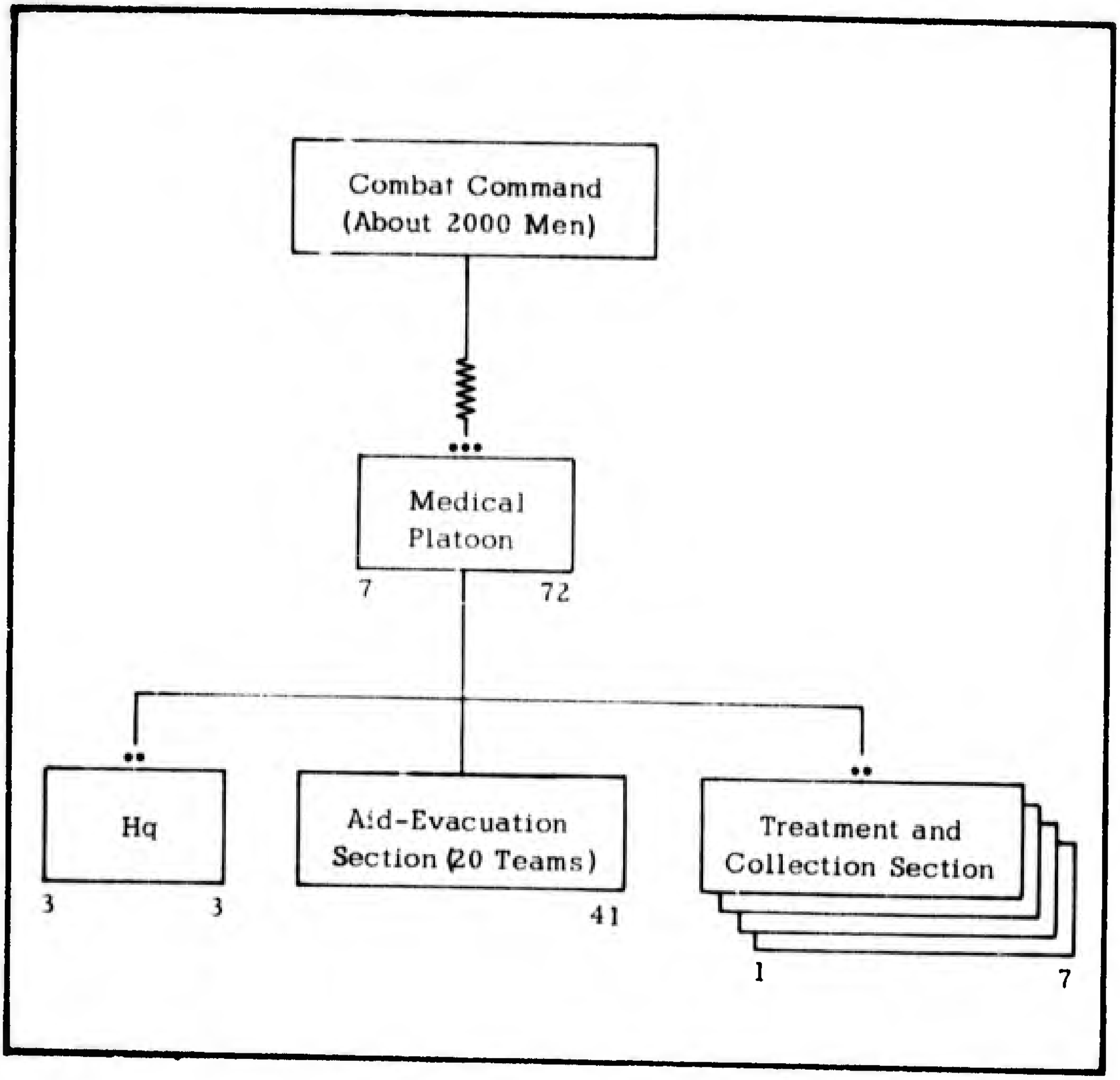


FIGURE 3. THE MEDICAL PLATOON

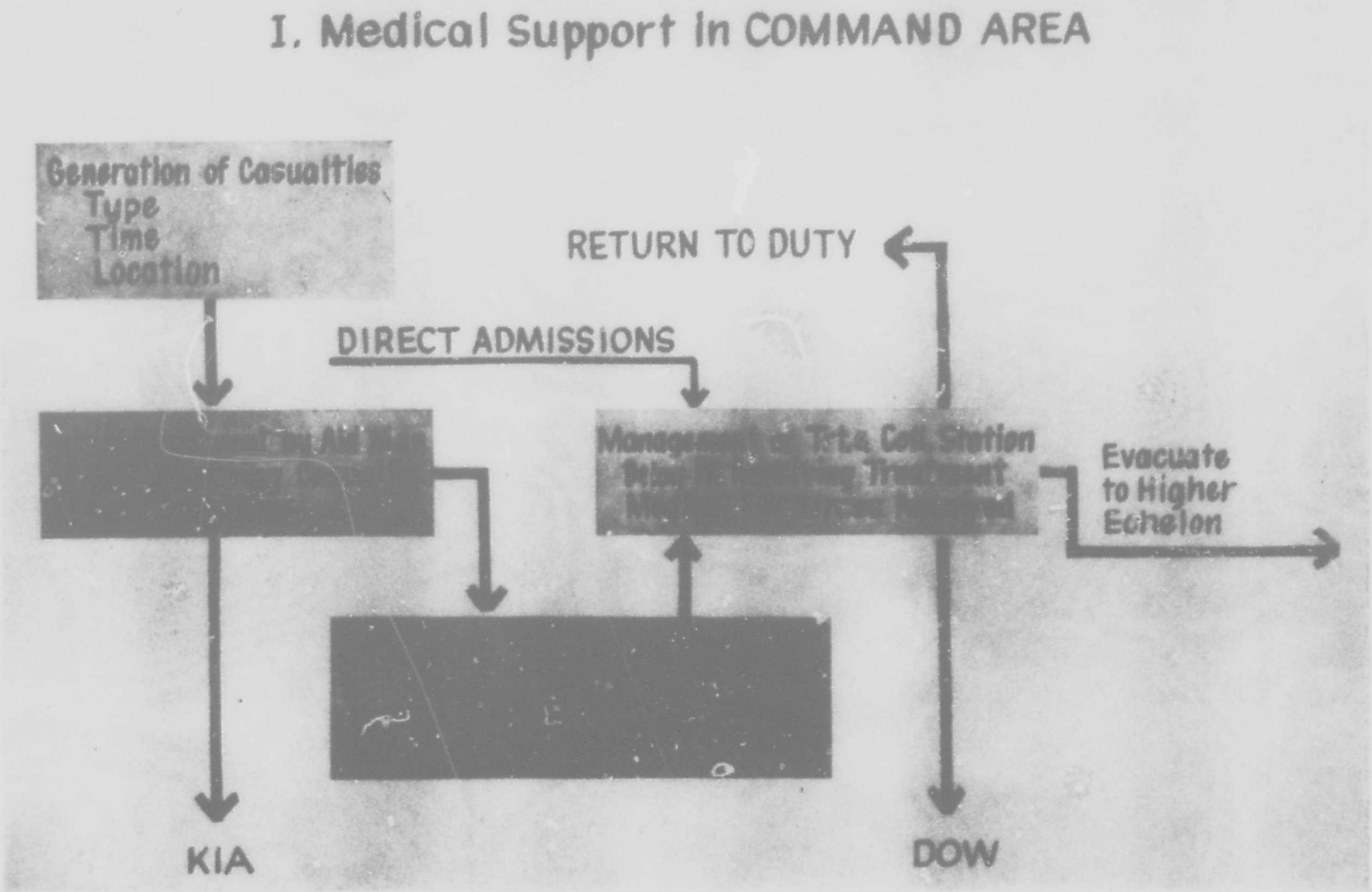

I. Medical Support in COMMAND AREA
Generation of Casualties
Type
Time
Location
DIRECT ADMISSIONS
RETURN TO DUTY
Evacuate
to Higher
Echelon
KIA
DOW

FIGURE 4

types, heavy and medium - and the number of men per division is also smaller, between 12,500 and 14,000 men. Divisions also differ with respect to mobility. The organization of the division with special reference to the medical support is shown in Figure 5. The number of men in each unit is approximated because no final decisions as to personnel have been made. The medical units illustrated in this and the subsequent figure are those recommended by CDG-USAMEDS.

<u>Mission</u>

2.10 Divisional medical service in the MOMAR concept is similar to that previously utilized. Its mission includes evacuation of patients from unit medical installations, receiving, sorting and providing temporary medical and surgical care, and the furnishing of medical supply and emergency dental service for the division.

<u>Medical Battalion</u>

2.11 The divisional medical battalion is a part of the service command and is organized as shown in Figure 6. It consists of an ambulance company, a clearing company and a headquarters platoon. The ambulance company has the capability of evacuating by air or ground; the single air ambulance platoon has 6 helicopters; each of the 6 ambulance platoons has 6 wheeled and 2 tracked ambulances. The helicopters are presumably aided by those assigned to the Army Medical Brigade.

2.12 The clearing company consists of 5 clearing platoons, each with messing facilities. Each has a holding capacity of 80 patients.

2.13 A schematic presentation of the problems associated with medical support in the division area is given in Figure 7.

2.14 Divisional responsibilities for sick and wounded start at the T&C stations of the medical platoon. Except for those who bypass these stations, so-called "direct admissions", these represent the division workload. Accordingly, in the model all the patients that have been processed by the medical platoons of the divisions need to be accounted for. The outputs from the medical platoon model include a list of all such patients by type; these patients serve as part of the divisional workload.

2.15 The divisional medical problem also can involve transport of patients to army field hospitals. This function is not represented in the diagram because, according to doctrine, such transport is the responsibility of the Medical Brigade.

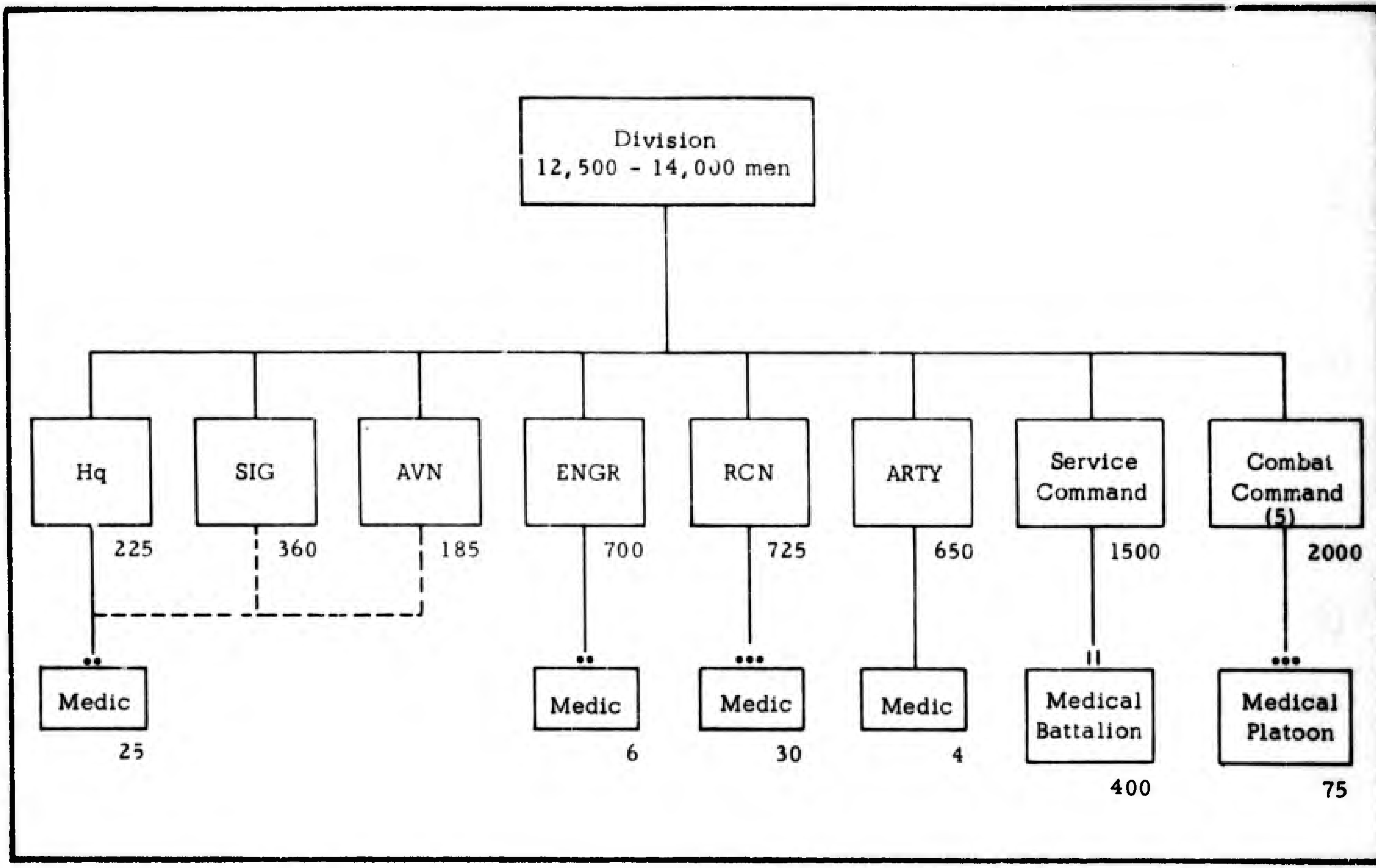


FIGURE 5. GENERALIZED DIVISION

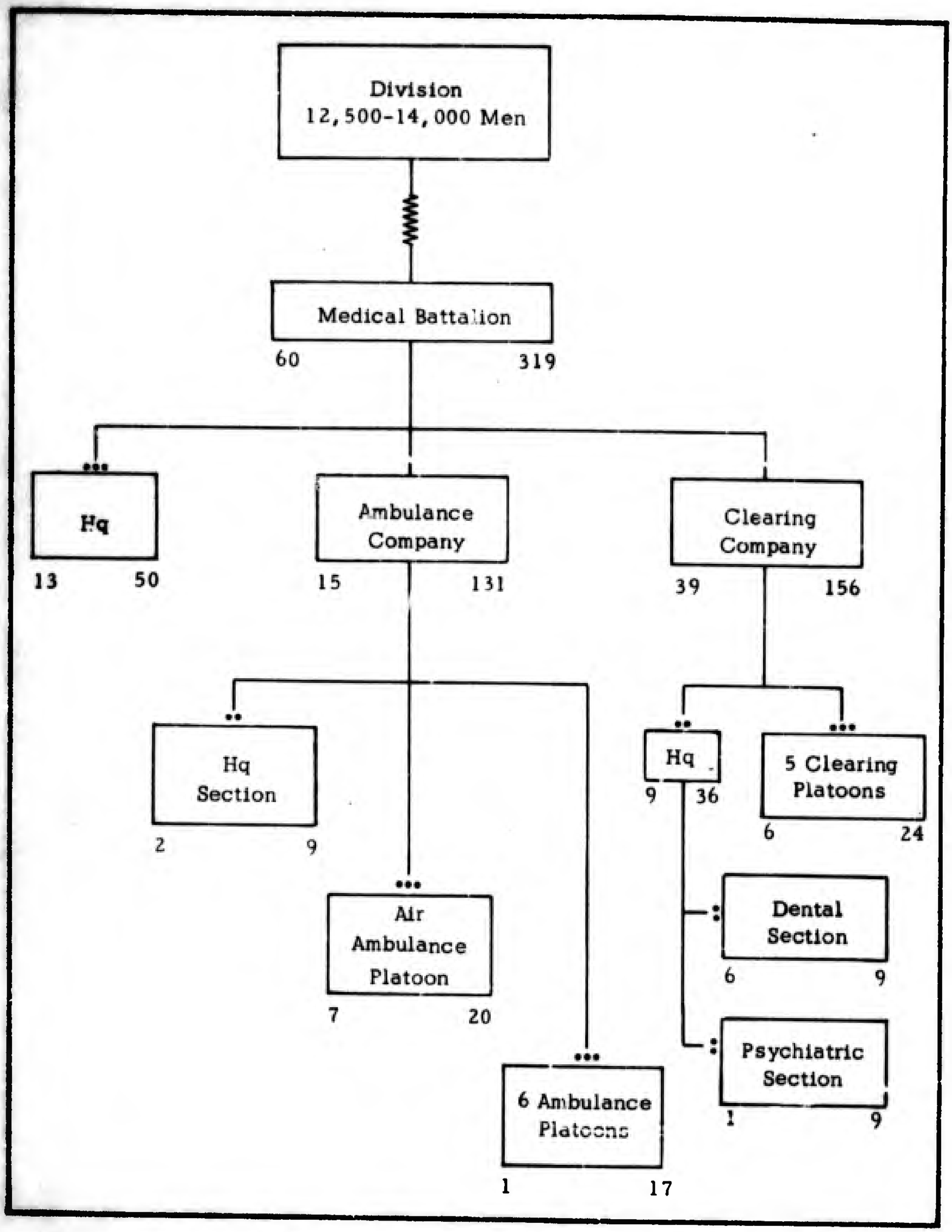


FIGURE 6. MEDICAL BATTALION

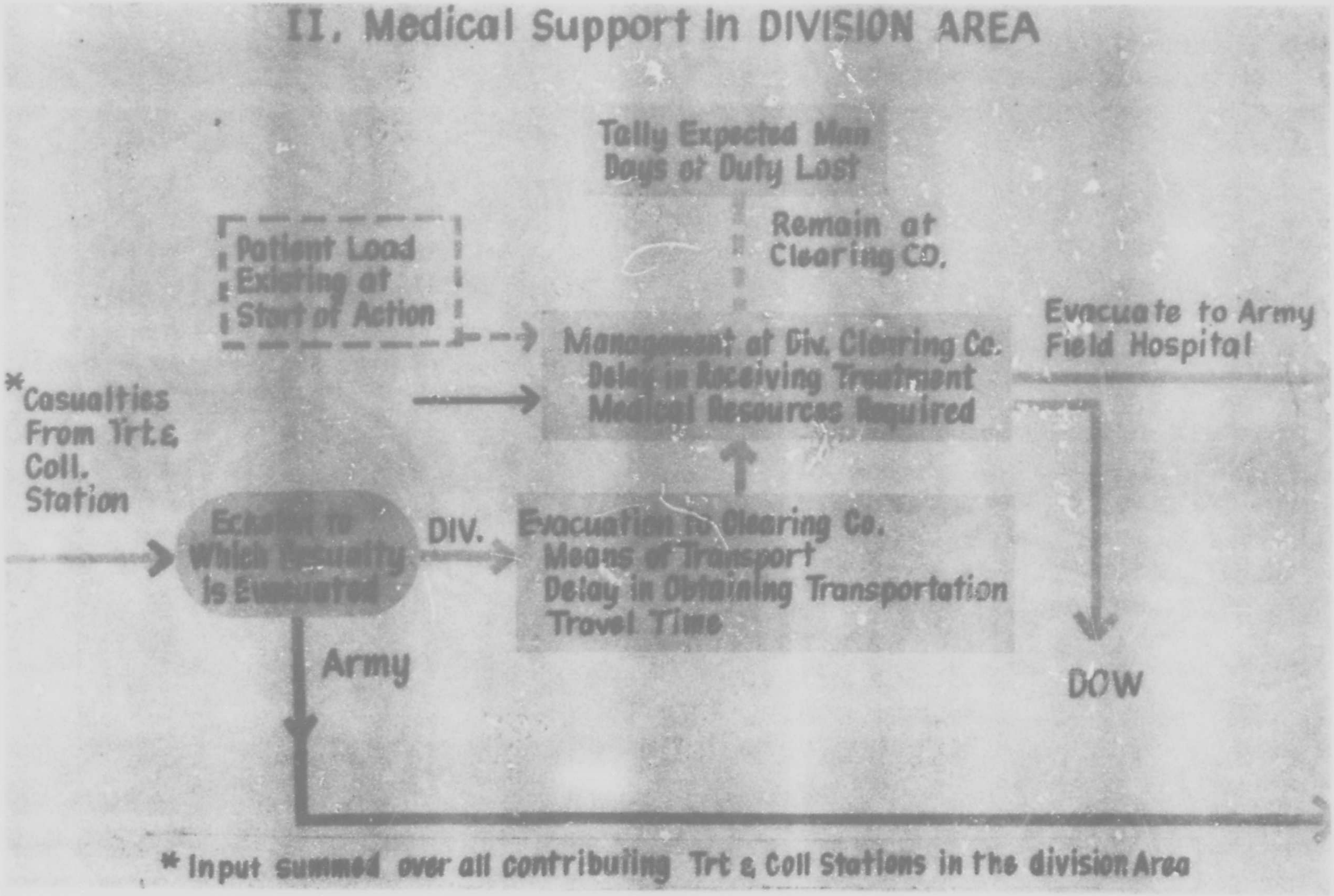

II. Medical Support in DIVISION AREA
Tally Expected Man Days of Duty Lost
Remain at Clearing CO.
Patient Load Existing at Start of Action
Management at Div. Clearing Co.
Delay in Receiving Treatment
Medical Resources Required
Evacuate to Army Field Hospital
*Casualties From Trt.& Coll. Station
Echelon to Which Casualty Is Evacuated
DIV.
Evacuation to Clearing Co.
Means of Transport
Delay in Obtaining Transportation
Travel Time
Army
DOW
* Input summed over all contributing Trt & Coll Stations in the division Area

FIGURE 7

FIELD ARMY HOSPITALIZATION

2.16 The MOMAR field army contains six divisions, representing approximately 165,000 men. Each division has a similar type of medical service. Divisions will have an evacuation policy of 2 or 3 days; the field army 14 days. Organic to the Medical Brigade supporting the army are a number of hospitals which in the MOMAR concept have a capacity of 150 beds each.

Hospital Workload

2.17 The patients served by the medical units of the army come in not only as the output of the division medical services, but also from the supporting units to the combat divisions. A schematic representation of the MOMAR field army hospitals appears in Figure 8. Note that the patient load from the combat command and the divisions is added to the patients from the army area as well as to the already existing patient load in the hospital.

MEDICAL SUPPORT MODEL

2.18 The three schematic charts, when taken in toto, represent a model of the medical service to the field army. The methods of analysis in this model differ in detail because of the objective involved. For the combat command, a detailed simulation of the tactical environment and the processing of patients is required. For the division, less minute detail of action of each individual is necessary, and for the field hospital no simulation has been made. It is proposed to substitute an analysis of the staffing requirements based on the ability of staffs in other hospitals to support their patient load and extending such staffing to the special problems of field hospitalization.

2.19 The simulation model follows the course of the patient from the original trauma or illness to the hospital. It assumes that in the hospital the patient will receive appropriate care, and it predicts outcome in terms of the treatment that the patient had before hospitalization.

2.20 The basic assumption in this model is that the timeliness and quality of medical treatment will determine the nature and schedule of disposition of the patient -- delay in return to duty resulting from complications, chronic disability, death or medical discharge. The quality of the medical treatment is identified with the capabilities of the administrator of the treatment and the medical facilities, and the time at which appropriate treatment was given. Knowledge of capability and time

III. Medical Support in FIELD ARMY AREA

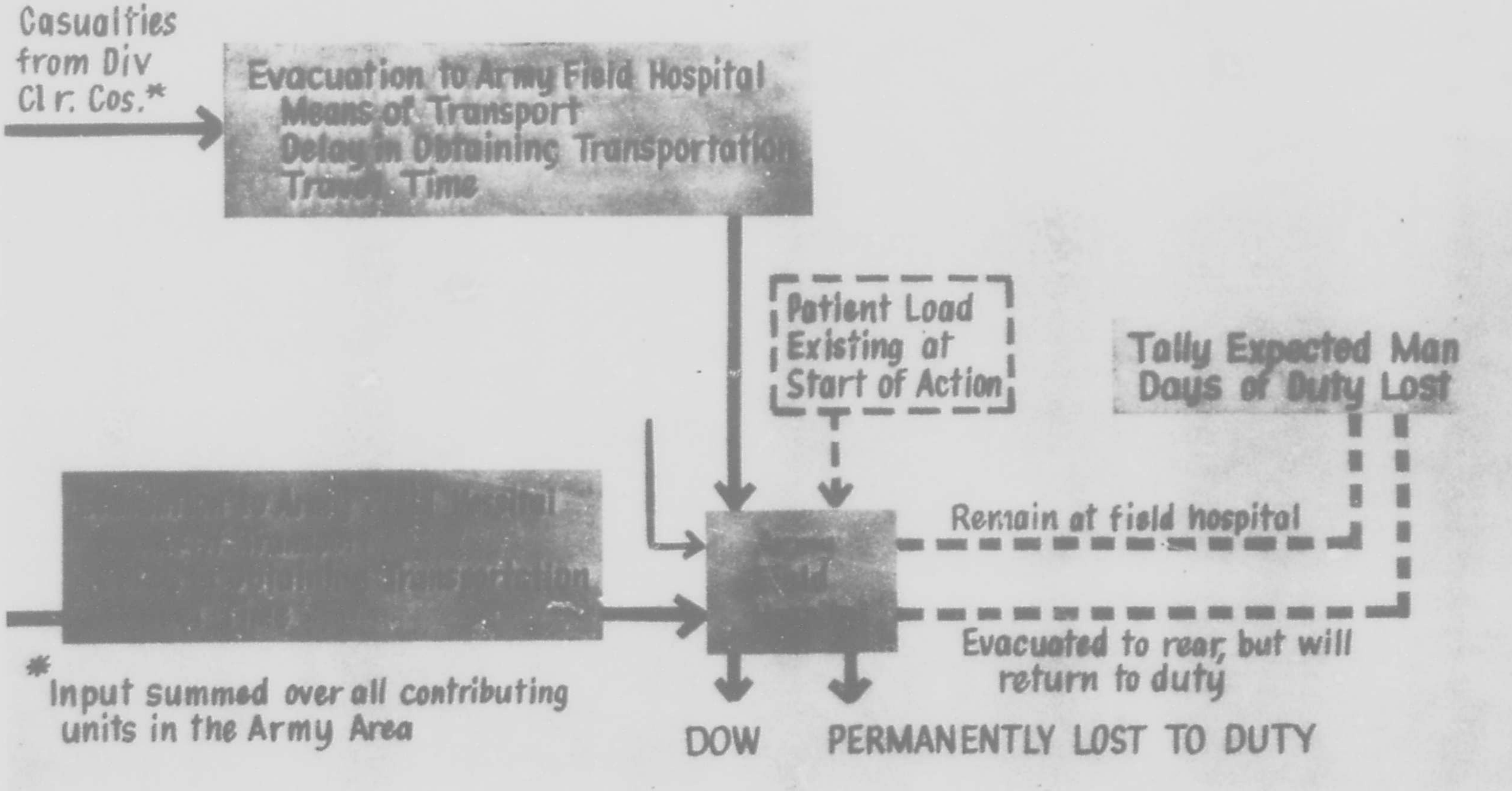


FIGURE 8

of treatment serve as the basis for determining the disposition of patients with a specific type of class of medical condition.

2.21 The medical realities can be conceptually divorced from the tactical realities, but the tactical situation determines the kinds of patients and the ability of the medical service to process them. Accordingly, it is necessary to examine these in detail. An especially important factor is the great increase in dispersion and movement anticipated for the future, and the possibility of new and different weaponry. The new weapons will change the numbers and types of battle casualties and the proposed tactics will change their geographic distribution. Along with these kinds of patients must be considered the sick and injured who contribute greatly to the load, and whose numbers and types need to be carefully estimated.

MEDICAL SERVICE IN THE COMBAT COMMAND

2.22 The medical service in the combat command in the future army during the time of combat involves primarily the acquisition, treatment, and evacuation of patients. There is no holding capacity implied or planned for the combat command. Accordingly, the task of the medical platoon supporting the combat command is one of processing patients while maintaining their condition as well as possible.

2.23 In the simulation, the medical platoon is given tasks appropriate to the combat command problem, and methods of handling these tasks appropriate to their capabilities. Wounded people occur on the battlefield; sick people occur within the combat command area, and both of these are considered as inputs; that is, the patient load imposed upon the medical platoon. The staff and equipment used by the medical platoon to process these patients is also simulated within the model.

Tactical Constraints

2.24 The tactical situation of the combat command determines in large measure not only the battle casualties, but the method by which the medical platoon can process its patients. As distances to FEBA alter, they imply changes in ambulances runs. Casualties occur with great density in some parts of the battle zone or at one time during the conflict, changing the loads of individual aid-evacuation teams (A-E teams) and of the treatment and collection stations (T&C). Other factors which influence the execution of the medical platoon's task include weather, time of day, terrain, and enemy action. All these are specified and simulated in the computer.

Generation of Casualties

2.25 The casualties that occur need to be specified with respect to their location, time of occurrence, and type. The types, proportions and degrees of severity of conditions in anticipated casualty spectra can be entered as a table in the computer and the computer given instructions to select randomly from these varying proportions. This technique is commonly utilized in the so-called Monte Carlo simulation which assigns probability ranges to the selected type of wound. When the machine generates a random number falling within a particular range, this number is associated with that type of wound. The outcome from such simulation approximates the overall distribution of wound types in the computer table, but in any single case the wound type is unpredictable, except in a statistical fashion.

2.26 Rate of Occurrence of Casualties. The distribution of casualties as a function of time, i.e., the frequency of occurrence of casualties on the battlefield, is also expected to follow a pattern that would be predicted from historical records or from analyses of expected weaponry and tactics of the future. The simultaneous production of group casualties are similarly treated as random occurrences in which the randomness follows a probability pattern. For example, if multiple casualties are likely to occur from single explosions, then the relative frequency of such multiple casualties can be used as instructions to the machine to produce multiple casualties at the expected rate. A distribution of expected casualties must be entered into the computer in the form of a table and instructions given to the machine to select randomly from this distribution.

Location of Casualties

2.27 The locations of casualties on the battlefield is determined by the tactical situation and the scenario being simulated. The computer is given instructions to generate casualties again in a random fashion within the limitations imposed by the tactical situation. These distances in the computer can be expanded or contracted by a single instruction that changes the overall frontage of the combat command.

2.28 Type of Casualties. The casualties as the medical platoon sees them are designed to represent in location, timing and type the expected distribution of casualties in the battlefield of the future. Insofar as this distribution is made up from current probabilities of occurrences by type, by time and by location, the casualties facing the medical platoon will be an accurate reflection of the anticipated medical workload. It is important to identify these casualties as precisely as possible in all three designations, and consequently a high degree of refinement of these probability tables is required to achieve the maximum accuracy in casualty generation.

Acquisition of Casualties

2.29 The behavior of the medical service in acquisition of casualties is simulated in the machine in considerable detail because it appears that time is a critical factor in the early processing of patients.

2.30 Communications. The first task in the simulation is to get information on occurrence and location of casualties to the medical units. It is assumed that information given the medical service deals only with location, not casualty type. The delay in transmitting such information needs to be explored in the communication's networks expected in the future, and such information is being generated at CDEC in the fall of 1960 experiment. There is an initial time lapse before the medical units know of the casualty, and this delay depends upon the communications capabilities of the individual medical units as well as upon tactical operative procedures. The simulation of the acquisition of patients permits two options, one involving the ability of the medical units to minitor the company net, the other requiring that the information be obtained from the company headquarters area. In addition, it is assumed that casualties near the radius of the path of the ambulance will be seen and evacuated. There is no assumption with respect to these other casualties about which information has not yet been received by the company commander. While these casualties need to be seen by the evacuation team it is perfectly possible to have voice communication within the computer routine; accordingly the width of the area of surveillance of the evacuation team is variable within the simulation.

2.31 It is assumed that the aid-evacuation teams, in the absence of any casualties, are located at the company headquarters area. Given information concerning the presence of a casualty, the team goes off in its ambulance to treat and evacuate the casualty. If the team has a radio it will hear of other casualties, and provided those casualties are within a certain distance and there is space in the ambulance, will proceed to the next casualty. The ambulance then returns to the company headquarters area.

Treatment

2.32 The time required to treat the casualty on the battlefield enters into each one of these factors as time associated with a particular casualty type. Some casualties are lightly wounded and do not require treatment on the battlefield from the aid evacuation team: it is assumed that they will get to the company headquarters area themselves. These so-called "walking wounded" are a variable quantity depending upon the instructions to the computer that can be anywhere from zero to a large portion of the casualties generated. The remaining casualties are either litter cases or sitting cases. The only distinction made between these with respect to the method of evacuation relates to the amount of space available in the ambulance. This space is a variable quantity and can be adjusted to either the present size ambulances or any considered for the future.

Litter Carry

2.33 Sometimes the casualties on the battlefield can be picked up without a long litter carry problem. That is, the ambulance can come close to the side of the casualty. With others, due to terrain or tactical limitations, the casualty has to be evacuated some distance by hand from the spot where he was wounded to where the ambulance can come. This distance is a variable quantity depending upon the instructions to the computer; so is the proportion of such cases. For example, there can be many, a few, or no litter cases carried by hand; and they can be carried a long or a short distance.

Aid-Evacuation Teams

2.34 Another factor of the delay associated with treating the casualty and evacuating the patient is the number and constitution of aid evacuation teams. The simulation permits any number of aid evacuation teams to work at their assigned tasks, and they can be either 2-man or 3-man teams. The medical capability of the individuals in any of the teams is assumed to be equal. That is, a patient treated by a 2-man team is assumed to be in the same condition as if he were treated at the same time by a 3-man team. The teams do differ, however, in other ways, namely, communications capability, acquisition capability and time for treatment of multiple casualties. It is assumed that a 2-man aid evacuation team cannot monitor the company net when both members of it are out carrying a litter, while a 3-man aid evacuation team has no such "dead time". Information concerning casualties on the company net thus by-passes the 2-man aid evacuation team for part of the time they are acquiring patients, and consequently, they may evacuate a number of patients from an area without having treated and carried out others nearby because they missed hearing about them. It is assumed that any delay related to finding the casualties on the battlefield is cut in half for a 3-man aid evacuation team as compared to a 2-man team. It is further assumed that the treatment of multiple casualties by a 3-man team can go on concurrently so that the time taken to treat such casualties is shorter for a 3-man team. The next differential between the 3-man and the 2-man aid team deals with the possibility of injury to a member of the team itself. It is assumed that the probability of casualties occurring when the aid evacuation team is in the front line is identical with the probability of occurrence of a casualty in FEBA. Accordingly, some of the members of the aid evacuation teams would be expected to become casualties themselves. In such a condition a 3-man team becomes a 2-man aid team, but is still an effective treatment and evacuation unit. Loss of a single man from a 2-man aid team renders this team ineffective, and the simulation requires that it return to the company headquarters area and remain there functioning only as an aid man, but not as an ambulance until the wounded member is replaced from the aid evacuation section of the medical platoon.

Company Aid Post

2.35 In the past, a company aid post was usually established from which patients could be evacuated and to which casualties could come or be brought. It was judged desirable to retain this option in the simulation because the tactics of the future do not clearly obviate the need for such a procedure. In the simulation of casualties, many options exist.

Casualties can be brought to the company aid post by the aid evacuation teams. Following this, the casualties wait until an ambulance from the T&C station picks them up and carries them back to the T&C. A second option is for the aid evacuation teams themselves to bring the casualties to the T&C station. It should be noted in this connection that the route taken in the simulation by the aid evacuation teams is directly through the company aid post area. That is, the time required to make this trip is equivalent to the time required to bring the patients to the company aid post plus bringing them from the company aid post to the treatment and collection station without any waiting in the company aid post. A third option is available, namely, the evacuation of these casualties to the company aid post is coordinated by an NCO.

2.36 The company aid post can also function as an area where casualties, the so-called "walking wounded", can receive treatment and be evacuated directly. It is assumed that a certain proportion of casualties will not receive any medical care until they arrive at the company aid post.

2.37 The company aid post is placed within the company headquarters area because ambulances without radios must get all their information on casualty location within this area; consequently, the aid post functions both as a collection place for casualties and as a source of information. It should be pointed out that the location of the "headquarters area" can be varied within the simulation routine so as to examine the desirability of placing company aid post near or far from FEBA. In this case it should be recognized that the "movement" of the company headquarters area is actually achieved by varying the time relationships.

Platoon or Company Aid Man

2.38 In the past, the dual function of the aid evacuation teams was handled in some instances by two types of individuals, the aid man and the evacuation team. Because it is not entirely obvious that the combined concept of aid evacuation is optimal, it has been judged desirable to include the option of dividing this function between an aid man and an evacuation team. This can be done quite simply in the computer by changing the delay before treatment of the casualty and retaining the evacuation ability of the ambulance team.

THE TREATMENT AND COLLECTION STATION

2.39 The patients that come to the T&C station are of two types, the majority of which have already been seen and treated by an aid evacuation team. Some of the patients however, are direct admissions, and consequently, their first contact with medical service is at the T&C station. The capability of the T&C station involves 3 degrees of medical competence, associated with 3 MOS types. Provision is made in the model varying the number of people within each of the MOS types. For example, the possibility of having only senior aid men to run the T&C station could be encompassed by reducing the number of officers to 0 and the number of aid men to 0. To determine the differences in effectiveness between the MOS types it will be necessary to give the computer information regarding the requirements for each type of patient and how these requirements can be satisfied by each level of medical capability. With some types of ailments, the aid man will be no less effective than the medical corps officer, and these variations in medical requirements with respect to the different kinds of patients must be spelled out to the computer.

2.40 Medical capabilities of personnel are clearly determined by their experience and training and the assumptions regarding capabilities with respect to MOS must be adjusted whenever the training procedures are altered. One of the by-products of the simulation will be information concerning the desirable changes in the medical qualifications of enlisted personnel associated with the T&C station.

<u>Number of Stations</u>

2.41 The number of T&C stations within the combat command can be varied in the computer simulation. At least one is required, but any number greater than one can be represented. It is necessary to direct the computer where to set up the T&C stations or give as an alternative the rules whereby they would be set up, and subsequently the computer follows these instructions. It is often necessary for T&C stations to move either forward of backward to be close to the source of casualties. It is possible to specify the rules for such movement. For example, when the distance between a T&C and FEBA becomes greater than 5 kilometers, the T&C is given instructions to move to 3 kilometers from FEBA. Details of such movement include consideration of any patients waiting to be processed or evacuated; in such a case a 2-stage move is provided with part of the personnel and equipment going to establish a new T&C and the remaining part following when the patients have been cleared out. It is possible in the computer routine to vary the frequency of movement and the distance from the source of patients.

<u>Acquisition of Patients</u>

2.42 The patients arriving at the T&C are brought there by T&C ambulances. It is possible within the simulation routine to use T&C ambulances in direct support of the companies by giving them aid-evacuation team capabilities and accordingly, to assess the desirability of using ambulances to support combat companies rather than organic to T&C stations. It should be noted in this connection that the ambulances need to go through the same procedures as the aid evacuation ambulances because the computer simulation would equate the two completely. The importance of communications in the T&C station can be examined by permitting knowledge of casualties to be included in the simulation only when an ambulance arrives at the T&C at one end or the company aid post at the other. This limitation will imply further delays in the acquisition and evacuation of patients.

Triage

2.43 The establishment of priorities for treatment is simulated in the computer routine by patient type. All patients of the highest priority will be treated before any patient of the next priority, and the earliest patient in each priority will be treated before later patients within that priority. This permits the simulation of triage. Priorities exist for treatment and also for evacuation, and provision is made in the simulation for these two priority classifications to differ so that it is not necessary to evacuate patients in the order that they were treated.

2.44 Qualifications of medical personnel information is given to the computer concerning the time required for treatment of each patient type by each MOS type. It is assumed that the medical capabilities of the doctor include all those of the senior aid man and aid man and the medical capabilities of senior aid man include all those of the aid men. The times required by each type to work on the patient is assumed to be identical but in the simulation the lowest possible qualification will be used on each patient.

2.45 The priority in which patients are transferred to the higher echelon will be established by a comparison of the patients waiting at all the T&C stations within the combat command area and will be further considered in the model of the division to determine whether the patients are to be evacuated to the divisions or straight to an army hospital.

Treatment and Collection Stations in Rear Areas

2.46 The T&C station located in rear areas does not pose so severe a problem in simulation because there are fewer restrictions on the behavior of its personnel. In general, the aid evacuation teams are not nearly so overworked and consequently simpler description than that of the T&C in a forward area might be anticipated. It should be noted in this connection that the possibility of casualties due to atomic weapons in the rear area has not been properly simulated by the present routine because the acquisition and processing of patients in such an instance would differ in a number of details. These are not presently spelled out in the prototype model.

MEDICAL SERVICE IN THE DIVISION

2.47 Divisional medical service has been simulated as indicated in the schematic chart (Figure 7). The patients requiring treatment involve those not previously treated as well as those from T&C stations. The simulation includes the logistic capabilities of the division to acquire and transport patients, and the medical capabilities to treat them.

Comparison of Division Simulation to That of Combat Command.

2.48 Simulation of divisional medical service is less complicated than that of the combat command because details of the simulation require fewer alternatives and because many of the problems encountered at combat command level are repeated at division level. A special problem exists in the overlapping function of divisional and army elements in evacuation from the T&C station.

2.49 That computer alternatives are fewer is perhaps not obvious until the logical process is analyzed. The computer is not concerned with details of medical treatment, merely with the individual capabilities of the man administering the treatment and the time required for each type of ailment. No information is processed concerning any of the medical details essential to the treatment since these are accepted as proceeding; what the computer does is to adjust probabilities for each type of patient depending on who provides the care.

2.50 The choices available to the ambulance company are similarly less complex than in forward elements. There is less of a problem of destination in finding the T&C, communications problems are reduced, and there is no movement in or near FEBA.

2.51 Many of the routines employed in the model of the medical platoon are directly applicable to the medical battalion. As an example, consider the movement of the clearing station. Insofar as the clearing station has only two sections the routine described in the first chapter for the location and relocation of the T&C stations is directly applicable. The velocity of travel when relocating would be different and the time to set up again different, but otherwise the two routines are identical. To permit relocation into more than two sections requires a slight modification in only one computer instruction. Such relocation would also require certain decisions on doctrine or on priorities.

2.52 A second example illustrating the similarity of computer simulation in the division to that in the combat command is the problem of allocating division ambulances to service T&C's. This is like the NCO control post simulation routine.

Evacuation from T&C Stations.

2.53 The major new problem in simulating divisional medical service is that of evacuation from T&C stations. A number of decision rules are required (and alternative ones tested). These include: patient priority in evacuation by type of disease or trauma, destination, i.e., clearing station or hospital, by type; means of evacuation, i.e., wheeled ambulances or helicopters by type.

2.54 When wheeled ambulances are available and helicopters are not readily available, the decisions as to means of evacuation would probably change; the conditions under which a different means of transport would be used need to be defined.

2.55 A special problem exists with respect to the evacuation to Army hospitals. This is nominally an army responsibility, but presumably this would be shared by divisional transport if necessary. Probably the time when such sharing would be necessary is when army helicopters are not available, but simulation of the division does not include these helicopters. For the purposes of the analysis it is necessary to assign some army transport to the division and accordingly an army slice is required. This slice does not need to be uniform from one division to the next, e.g., it could be related to the number of casualties being received.

Clearing Stations.

2.56 The clearing platoons can set up clearing stations according to doctrine anywhere within the division area. This has been simulated in the computer, and the movement of sections of clearing stations and the holding capacity of each can be varied. It is assumed that sections will only move when patient-free. The number of stations into which a clearing station may be divided is one, two, or three in the computer operations, and there is no restriction on their location within the division area. The number of clearing platoons is also varied in the computer simulation, and their support for combat command or attachment to a combat command is an operational doctrine.

MEDICAL SERVICE IN THE FIELD ARMY

Mission

2.57 The mission of the army medical service has been to relieve division medical services of continued care and treatment of their sick and injured in such a manner that their medical services may retain maximum mobility. The army medical service also provides support to lower echelon medical service in the army area. So stated, this mission is concerned primarily with evacuation and hospitalization. The other specific missions are concerned with the efficient maintenance of the health of the troops.

2.58 Hospitalization for combat elements is a prime problem of the army medical service but the most effective solution is not clear. The simulation of the combat command and division medical service produces as an output a part of the medical load in the field hospitals. The rest of the hospital load comes from local units. The geographical source of the hospital load is spread over the whole army but in periods of active conflict tends to be more heavily weighted toward the combat arms. Furthermore the type of patient is not a random variable.

2.59 The hospitals to service this patient load must then be set up, ensuring rapid treatment and return to duty, making efficient use of staff and equipment and reducing logistic and material support. The optimal size must be determined before TOE's are set up.

2.60 Military hospitals have special requirements for personnel in comparison to civilian hospitals, e.g., disposition of discharged patients, and field hospitals have additional requirements, e.g., sanitary problems. In order to systematize future army hospitalization, these factors must be evaluated in the light of proposed tactics and weaponry. Evacuation policy enters in as another variable.

2.61 The staffing of a given field hospital is a problem of first deciding how many patients of what type and then relating the ability of the staff to manage the expected patients. The overall number and type of patients can be described by a probability distribution and the load on the different professional, ancillary and supporting services by other probability distributions.

2.62 The variability inherent in some of the tasks required of a hospital can be smoothed out because they can be postponed temporarily, e.g., routine maintenance; other tasks must fluctuate with the workload. For these tasks the probability distributions can predict how often the capacity of the staff to handle its load will be exceeded.

III. SELECTED MEDICAL UNITS

THE MEDICAL PLATOON

3.1 The medical platoon supports the combat command that is organic to the medium and heavy MOMAR divisions and to the air transportable brigade. These combat commands all have the same kind of organization and permit tailoring of organizations into task forces for particular missions. The medical platoon is presently organic to the Trains company. The staffing proposed by the CDG-USAMEDS for the medium combat command is shown in Figure 9.

3.2 It is assumed that the mission of this platoon is the same as that currently accepted, i.e., to provide unit medical service to include emergency medical treatment and to establish and operate a station(s) for the reception, sorting and temporary care of patients.

3.3 The simulation model of the medical platoon is designed to permit many alternative solutions to this mission. Comparisons of alternative arrangements can be made by varying the numbers of personnel in each section, and the capabilities of the personnel and equipment. In addition some of the non-medical procedures for acquisition and processing of patients can be changed. It is convenient to discuss the above alternatives by sections of the platoon.

Headquarters Section

3.4 The administrative, supply, clerical, and training functions do not enter into the simulation. It is assumed that these tasks contribute to the ability to handle a heavy workload but that they are held in abeyance during periods of peak medical load. These functions can be determined directly without recourse to a complex simulation. For example the lo-

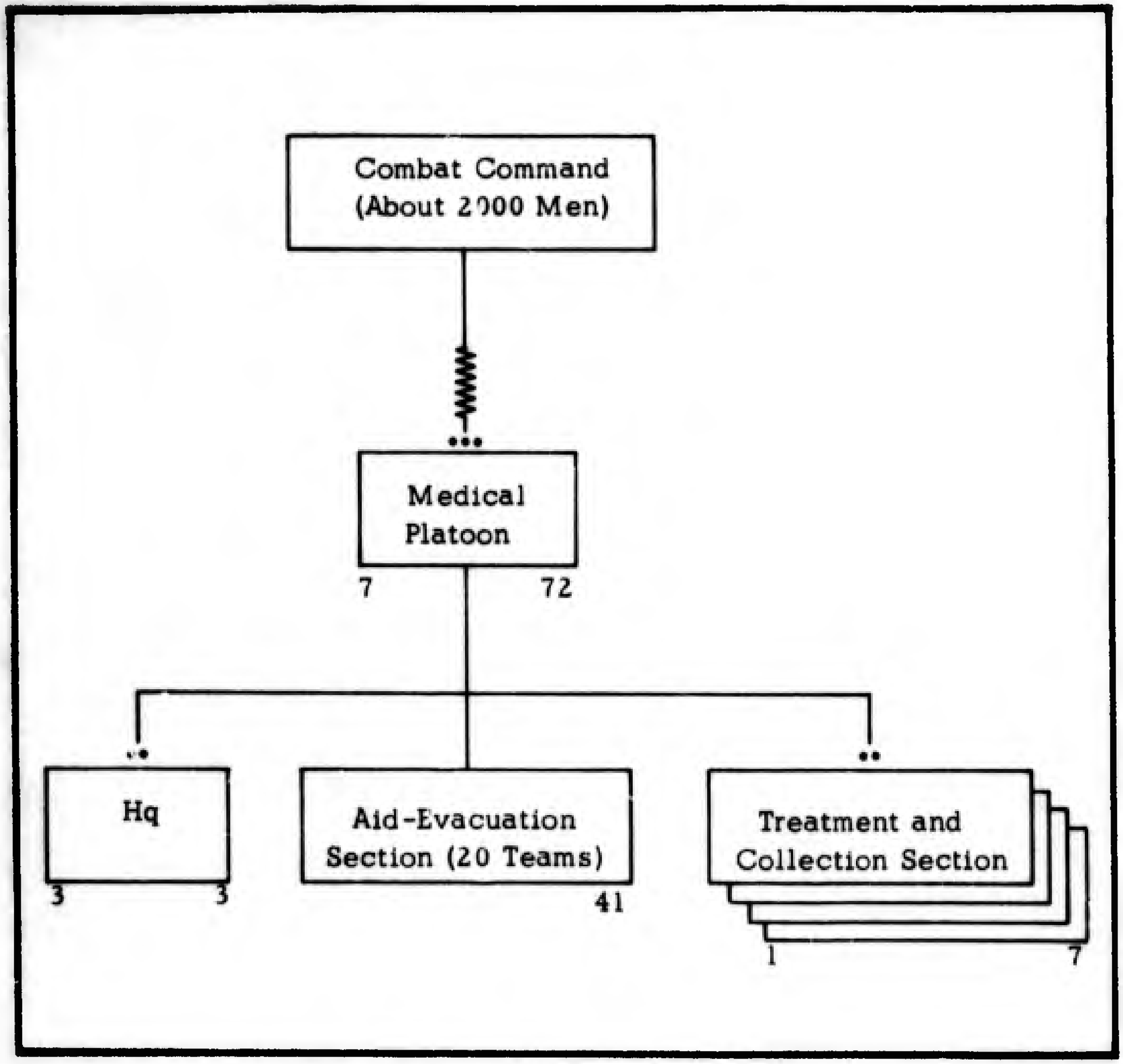


FIGURE 9. THE MEDICAL PLATOON

cation of a dental officer and assistant can be determined in terms of chronic needs for dental service.

3.5 During peak casualty periods the headquarters personnel would be expected to assist in the functions of the aid-evacuation and treatment and collection sections: acquisition, treatment and evacuation. Insofar as this is the case they enter into the simulation routine under those sections. Any command functions, other than medical decisions or treatment and triage, are not simulated.

Aid-Evacuation Section

3.6 The function of the aid-evacuation teams is to find, treat, and evacuate patients. Each of these functions is simulated in such a way as to permit examination of many changes in staffing, procedures, or equipment.

3.7 Acquisition of Patients

a. Information as to occurrence and location. The first task is to find a casualty that has occurred. Information needs to be provided for the appropriate medical individual(s). In the case where the aid team has communications equipment this information can come from monitoring a tactical net or from a special coordinator. Both considerations can be utilized when all or a portion of the section teams are attached directly to companies. Information becomes available, even if not yet reported on a tactical net, when a casualty occurs near the path of an ambulance. In such a situation, information presumably comes from other members of the platoon or squad. The ambulance team without radios retains the capability of getting information of nearby casualties but must return to company headquarters area in order to learn of distant casualties.

3.8 It should be noted that the distance a casualty can be in order to be within voice or sight-range is a variable in the computer so that the possibility of other means of notification being developed can be encompassed easily in the routine.

3.9 Tactical reporting delays are placed in the simulation from data gathered in the field, notably CDEC.

a. Getting to the Casualty Location. For each casualty the time to arrival is computed by relating distance from aid-evacuation team to casualty in respect to ambulance and/or litter-bearer speed. This time to arrival is modified if the ambulance breaks down (stochastically determined by computer data on ambulance breakdowns) or if the tactical situation precludes it. A proportion (variable from 0 to 100%) of casualties is not accessible to the ambulance and therefore litter-bearers are required.

The speed of ambulance and litter-bearers is set into the computer as an input.

b. Finding a Casualty. Delays in locating due to inability to find a casualty need to be determined. No simulation of the aid-evacuation team in this respect is planned at this time other than reducing the time for a three-man team to find a casualty as compared with a two-man team.

3.10 Treating of Patient. Once the casualty is located he is given emergency treatment (as a patient). This treatment is spelled out to the computer in terms of the time required for the aid men to accomplish this task according to inputs relating patient type to time requirements. The level of treatment by the aid man is a function of his training and equipment but the computer does not calculate this; instead the input to the computer assumes a level of competence dependent upon these factors. It would be possible to change such inputs in order to determine the effects of variations in training and/or equipment.

3.11 Note that the function of locating and treating a casualty does not necessarily require a team, and accordingly it is possible by slight alteration to assign these capabilities to an aid man attached to the unit reserving the evacuation function for an ambulance team. For multiple casualties, the aid-evacuation team is given the capability of working on two patients simultaneously.

3.12 Evacuating the Patients. The patient is carried to and loaded on the ambulance by two aid men. If the ambulance has room and if another known casualty is within a given distance (variable) then the ambulance will proceed to the next casualty. Otherwise, the patient is evacuated to the company aid post. Here the patient may be left to be picked up by a shuttle ambulance from the T & C station. Another option that the computer can examine is to continue to evacuate the patient via the company aid post (where it will, if space is available, pick up "walking-wounded") to the T & C station.

3.13 Aid-evacuation teams are given casualties at the same rate as the units they support. Permissible variations in the computer routine are shown in Figure 10.

Treatment and Collection Section

3.14 The functions of the Treatment and Collection Section of the Medical Platoon are simulated in detail. They establish and operate

Aid-Evacuation
Teams

Number:	Variable (1 or more)
Staff:	Number of men per team: 2 or 3
	One level of medical capability
	One level of driver/radio operator capability Note: A platoon aid man for treatment supplemented by a 2-man evacuation team can also be simulated.
Equipment:	Ambulance's capacity variable by patient type (1 or more)
	Velocity variable
	Medical equipment implied in assessing medical capabilities
	Communications equipment implied in communications capabilities
Doctrine:	Attachment to Company optional
	Coordination by platoon NCO optional
	Establishment of Company aid post optional
	Division of aid-evacuation teams, into aid man and evacuation teams optional

FIGURE 10

a number (variable in the computer) of stations where they render resuscitative medical care under the direction of the officer. They have ambulance capability, communications capability to tactical units of the combat command and to medical units of the combat command and division. They establish priorities of treatment and of evacuation.

3.15 Establishment of T & C station. Any number of T & C stations can be set up in the simulation according to instructions. As an example, the coordinate of a T & C would be given; it would move depending on the distance to FEBA. The rules for such establishment and such movement are variable. Option is given to a T & C to move in two sections, but not more, when a portion of it is patient-free. During such movement the traveling section cannot treat patients.

3.16 Personnel within T & C. Provision is made in the simulation for three levels of medical capability, each presumptively associated with a MOS. Data given to the computer by patient type are related to these levels of capability. The number of personnel of any type is variable and it is not necessary that one section of the T & C have the same number of personnel or the same medical capabilities as the other section. It is planned, however, to have each of the different T & C stations staffed alike.

3.17 Patient Care. The medical capability of the three types of staff is spelled out by patient-type along with the time required for such treatment. Priorities are established: All those of the highest priority are treated first, starting with those that have been waiting longest. It is assumed that as soon as a patient enters the T & C stations he is examined to determine such priority and no time is assessed for such examination. Following treatment, the priorities for evacuation by patient-type are established. Records are made of DOW's and return to duty. Both of these are established by inputs stochastically determined by patient-type and previous treatment.

3.18 Acquisition of Patients. Patients arrive at the nearest T & C station in either aid-evacuation ambulances or T & C ambulances depending on doctrine and the tactical situation. Provisions are made to establish an ambulance shuttle between company aid posts if desired. Lastly, patients arrive at stations without previous medical attention, so-called "direct admissions".

3.19 No assessment of casualties is made against T & C personnel.

3.20 Permissible variations in the computer routine are shown in Figure 11.

Treatment and Collection Station

Number:	Variable (1 or more)
Staff:	Number of officers (1 level of capability) 0 or more Number of enlisted men (2 levels of capability) 0 or more Note: It is possible to have no officers or no enlisted men in a T & C but not together; some staff is required
Equipment:	Medical equipment implied by medical capabilities Communications equipment implied by communications capabilities
Doctrine:	Locations variable within combat command area Movement permitted in one or two sections per T & C Priorities for treatment and evacuation can be different

FIGURE 11

THE MEDICAL DETACHMENT

3.21 The medical detachment is a part of the division headquarters company. The organization, as proposed by CDG-USAMEDS, is shown in Figure 12. Its function is similar to that of the medical platoon in support of the combat command.

3.22 The three sections correspond to the three sections of the medical platoon except that the two aid stations are not given medical officers as a part of their formal organization. It is assumed that the two officers in the headquarters section would in practice give the aid stations a medical capability commensurate with the T&C stations of the medical platoons although they would still differ from the T&C stations with respect to ambulances. The aid-evacuation teams have the same functions as those of the medical platoon, namely, the acquisition, treatment, and evacuation of patients to the aid (or T&C) station.

3.23 One other function of the medical detachment is the support of other elements, specifically signal and aviation companies in the division. Insofar as these elements are in the division headquarters area they do not alter the tasks of the medical detachment. If some of the detachment are assigned to elements remote from the rest of the headquarters they would have a slightly altered function and this function would not be directly simulated.

Patient Load and Acquisition

3.24 The patient load can be expected to be similar in type and distribution to those in the rear area of the combat command. No tactical limitations preclude immediate evacuation and no hand-carrying of litter patients is assumed to be necessary. The aid-evacuation team would probably evacuate directly to the aid station for treatment. Here the treatment and patient priorities would be identical to those embraced in the T&C section of the platoon model.

3.25 In practice it would probably not be necessary to simulate this detachment on the computer. One of the products of the variations in staffing of the medical platoon should be information that would be applicable to the detachment requirements without direct simulation.

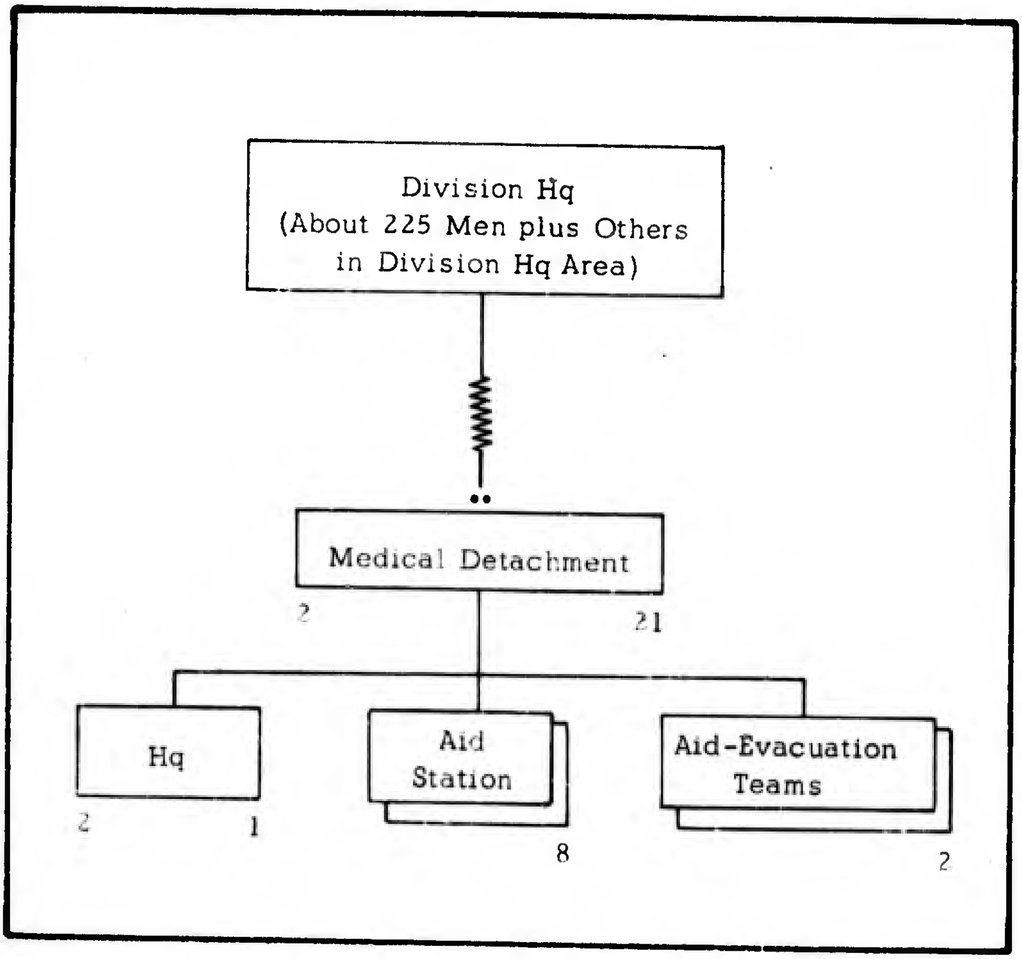

Division Hq
(About 225 Men plus Others in Division Hq Area)
Medical Detachment
2
21
Hq
2
1
Aid Station
8
Aid-Evacuation Teams
2

FIGURE 12

THE MEDICAL BATTALION

3.26 The Medical Battalion supports the medium and heavy MOMAR Divisions and is a part of the Service Command. The staffing proposed by the CDG-USAMEDS is shown in Figure 13.

3.27 It is assumed that the mission of the battalion will be the same as that at present: receiving, sorting, and providing temporary medical and surgical care for patients, evacuating patients from T&C stations, emergency dental service and medical supply and medical equipment maintenance.

3.28 The simulation model of the battalion deals with the care of patients; it is designed to permit alternative solutions to this mission. The capacity to transport and hold patients can be varied, the medical capabilities of the personnel can be varied, and the doctrine for locating clearing stations and hospitals can be changed.

Headquarters Detachment

3.29 The simulation model is concerned with the ability to handle a heavy workload and the data collected deal with delays in receiving treatment. Staffing requirements for administrative, supply, clerical, training, dental and a number of other primary functions of the Headquarters Detachment can be determined without recourse to complex simulation. For example, the need for motor vehicle maintenance is known. Once a policy has been established that such maintenance should be the responsibility of the Medical Battalion, then the maintenance staffing requirements are determined by considerations such as the number and type of vehicles.

3.30 Where the procedures and functions are similar to those in the past, they may be used as a basis for extrapolation to determine tentative staff requirements during this stage of study of method and criteria. Probable changes in tactical and logistical plans give indications as to how the original staffing needs to be altered.

3.31 During emergency periods the headquarters personnel would presumably be expected to assist in the functions of the other sections. In this case they would be involved in the simulation.

Ambulance Company

3.32 The headquarters section is not simulated.

Air Ambulance Platoon

3.33 One function of the air ambulance is the rapid and gentle transport of patients. Within a period of active hostility it is assumed that

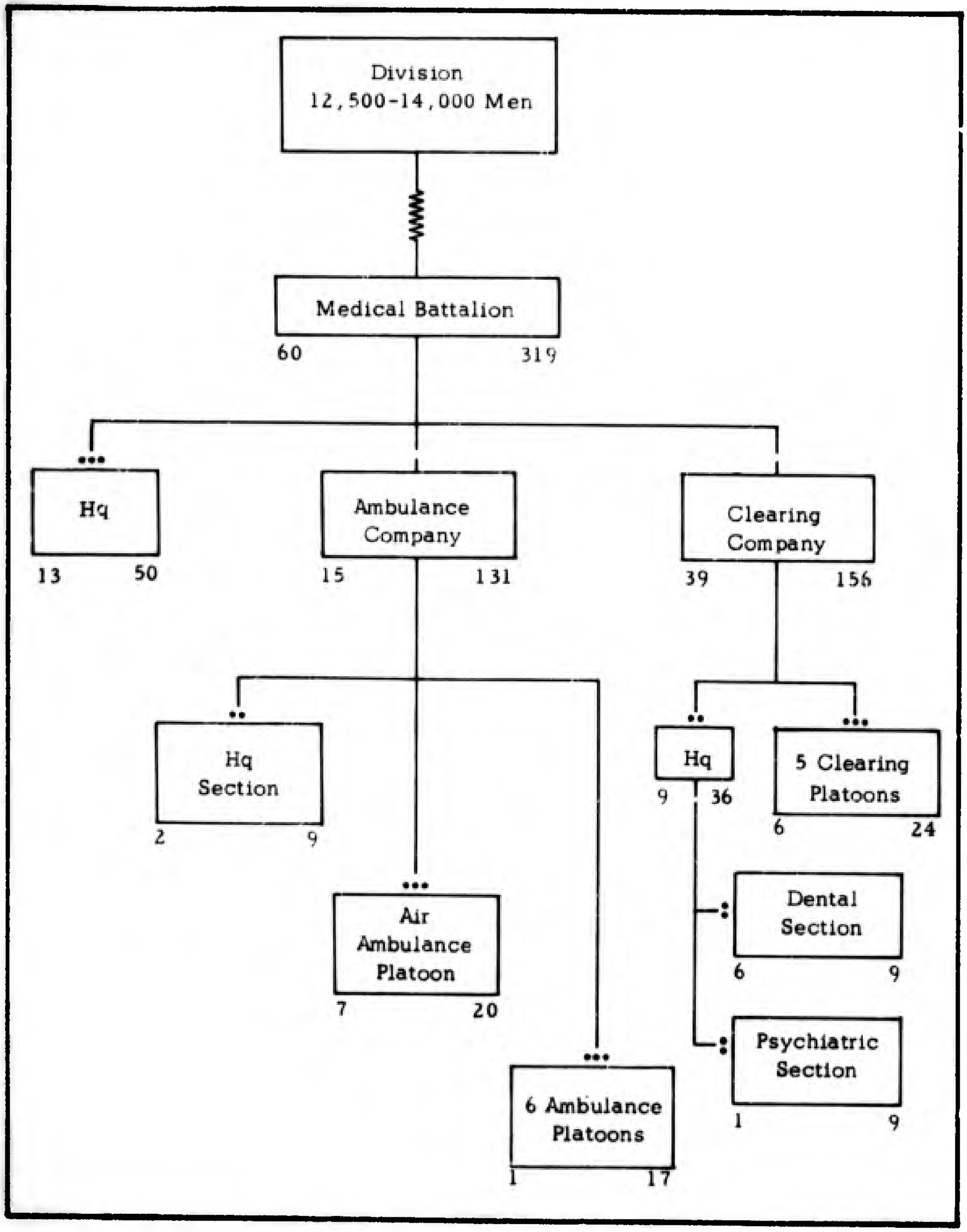


FIGURE 13. MEDICAL BATTALION

these patients would be moved back to higher echelons, i.e., there would be no shuttling of patients between facilities of the same echelon level.

3.34 The other major function of the air ambulance is that of rapid replacement of medical supplies to forward echelon units. This function has not been examined, but because of the characteristics of the model it may be introduced for future studies.

3.35 The movement of patients by air ambulance has been simulated in a general fashion so that many different numbers of such ambulances and procedures for assignment can be examined in the simulation. The number of such helicopters and the distances they have to fly may also be varied. It is possible to vary the locations of T&C stations, clearing stations and field-type hospitals and see the effect, if any, on patient outcome.

3.36 Procedures for assignment of patients to helicopters by priority types or by expected delays can be examined.

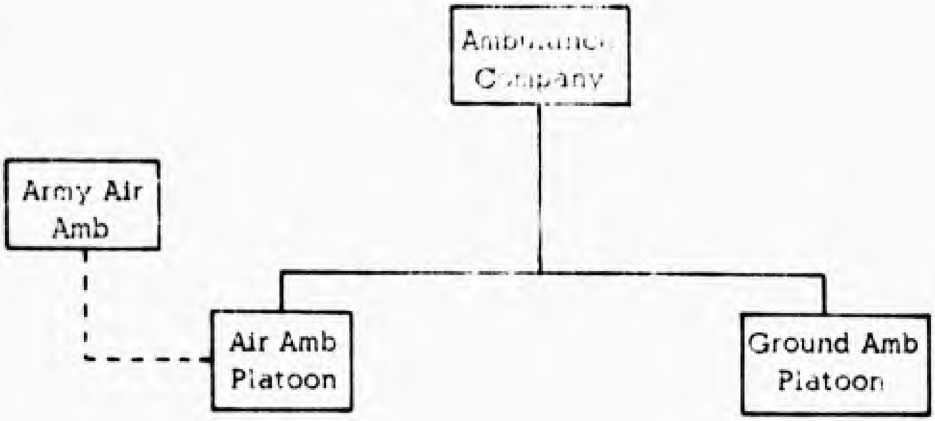
3.37 All of the functions of the divisional air ambulance platoon need to be balanced against those of the army helicopters and Divisional ground ambulances. Army helicopters are nominally expected to be used to transport patients to Army hospitals: despite the doctrine it is probable that both divisional and Army helicopters will be used for this function. The two helicopter services must be considered together.

3.38 Air and ground ambulances have the same function, patient transport. Both of these can be varied in the computer runs. (See Figure 14).

Ambulance Platoons

3.39 Ground based ambulances are presently organized into 6 platoons. A number of possibilities exist for utilizing them effectively, i.e., assignment of each platoon to a combat command or the support of individual T&C stations as needed. It will be possible to compare such procedures.

3.40 The numbers of ambulances within an ambulance platoon can be varied and the numbers of ambulance platoons also. The organization into platoons is an administrative function which need not be defined for purposes of the model. Analysis of ground ambulances is most significant in terms of total numbers of such ambulances not in terms of their organization for administrative purposes.



Number: Variable (1 or more)
air variable
ground variable

Staff: Not varied per team.

Equipment: Capacity variable by patient type, velocity variable

Doctrine: Decision rules on assignment of ground and air ambulances variable.

Decision rules on divisional or Army helicopters variable.

Decisions on hospital locations and clearing locations variable.

FIGURE 14

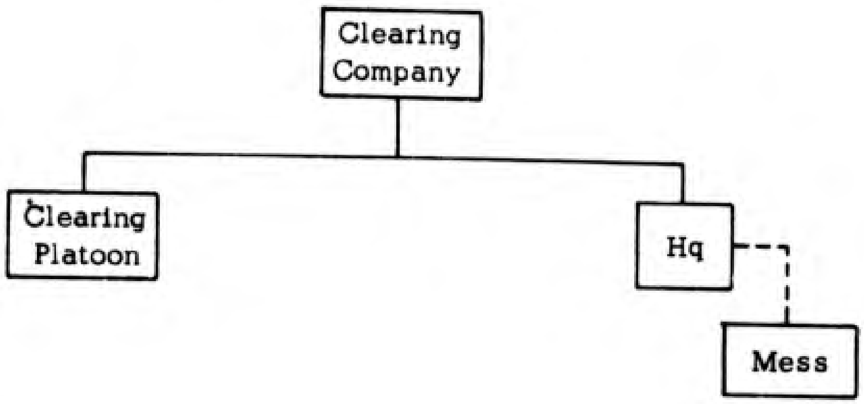
Clearing Company

3.41 Headquarters Section. The functions of this section are of the type that do not require representation in the model. The need for hot food is subsumed under proper medical care and is one of the treatment procedures. Once the policy to establish messing facilities at a clearing station is set up then the patient load determines the number of cooks required.

3.42 Clearing Platoons. The function of the clearing platoons is to set up clearing stations for the receiving, sorting, treatment, and evacuation of patients. All of these functions are simulated. Evacuation policy enters as another variable. It is assumed that a certain number of patients arrive without being transported by medical units; some patients are already there at the start of the action. Accordingly, the battle and sick workload is superimposed on the workload from these other sources.

3.43 Medical treatment procedures as such are not considered in the simulation.

3.44 A number of options are considered. The number of clearing stations and their locations can be varied and the doctrine for support can be examined. (See Figure 15).



Simulated

Clearing Platoons

Number:	1 or more
Location:	Variable
Capacity:	Variable
Relocation Time:	Variable
Number of Sections per Platoon:	1
Doctrine:	On location variable.

FIGURE 15

THE MEDICAL COMPANY

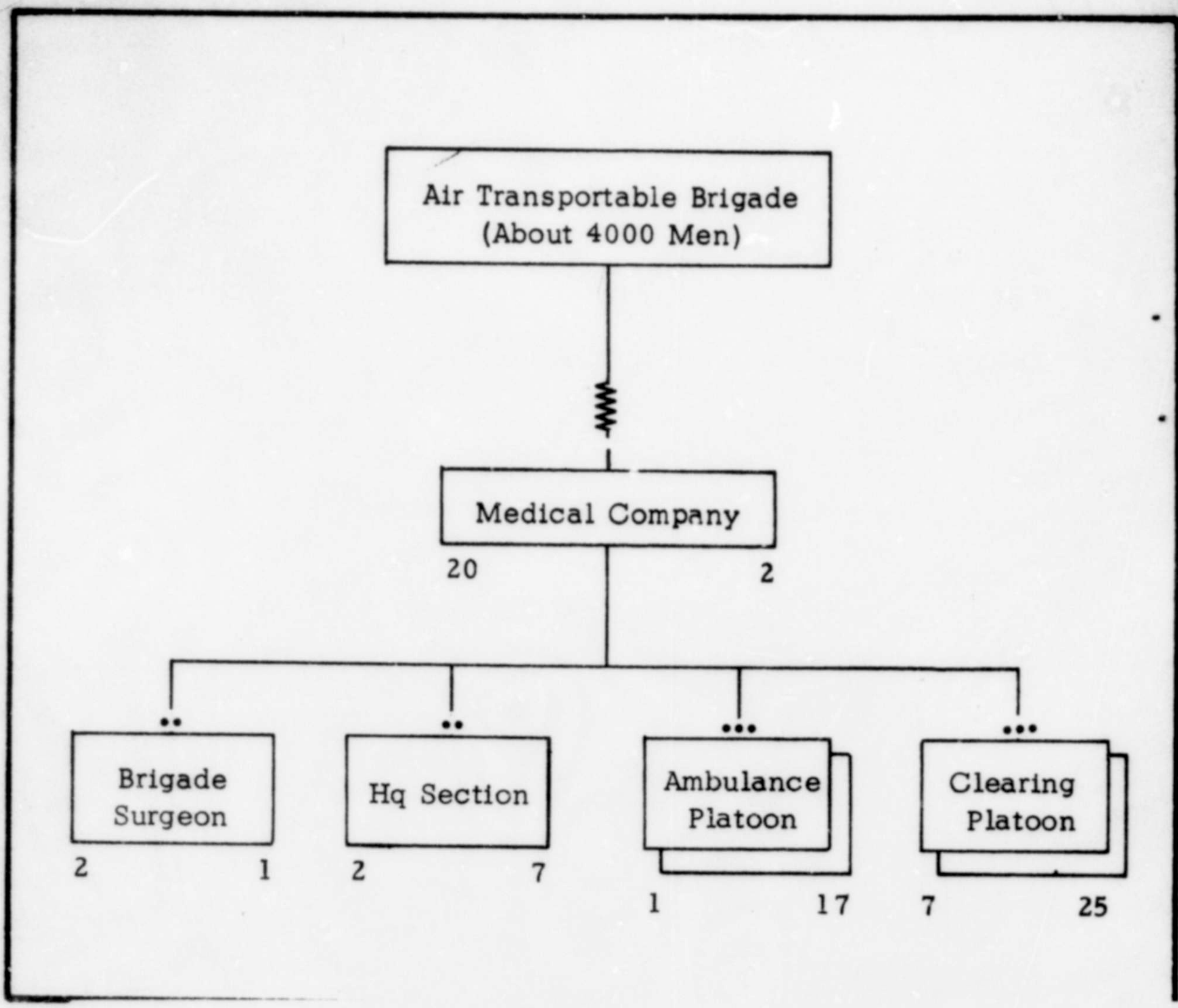
3.45 The Medical Company supports the Air Transportable Brigade. The concept of operations of this Brigade involves the possibility that continuously available transport for patients is unlikely because surrounding terrain may be held by the enemy. In addition, distances to the nearest hospital and enemy action may preclude evacuation until ground link-up is made and a closer hospital is established.

3.46 The function of the medical company is similar to that of the divisional medical battalion, namely: receiving, sorting, treating, and evacuating patients. All of these functions are simulated. The possibility of greater need for holding does not enter into the simulation.

3.47 The organization and staffing of the Medical Company as recommended by CDG-USAMEDS is given in Figure 16. It is organized in a similar fashion as the divisional medical units for the obvious reasons that it has the same functions. It supports two medical platoons (of combat commands) rather than the five that are organic to a division and is consequently smaller.

3.48 Since the functions and behavior of this company are similar to the divisional medical battalion, it can be subsumed almost completely under the divisional model. The number of clearing platoons in the divisional simulation can be reduced to one with other permissible variations, also ambulance platoons, accordingly the model already embraces these aspects of the Medical Company. The only additional feature is that of greater requirements for a holding capability.

3.49 Computer simulation of evacuation from the Air Transportable Brigade to the Field Army is difficult because the ability to evacuate probably is controlled by enemy action and the governing factors are not within the decision of the medical officers and barely within that of the tactical commanders.


Air Transportable Brigade
(About 4000 Men)
Medical Company
20
2
Brigade Surgeon
2
1
Hq Section
2
7
Ambulance Platoon
1
17
Clearing Platoon
7
25

FIELD TYPE HOSPITAL

3.50 Doctrine provides for hospitalization as close as practicable to the troops requiring it and for the maximum number of personnel to be returned to duty within the combat zone in order to conserve the fighting strength of combat troops. [1] The basic principle is that the disabled must be evacuated to a point where they will not interfere with the fighting forces, but upon their recovery can still be returned to duty without delay.

3.51 The criterion which determines the over-all effectiveness of the medical service is the ability of the sick or injured soldier to return to duty in the shortest possible time. Because of prompt and effective medical care, (1) the recovery period is shortened, (2) the number dying of wounds is reduced, and (3) the number who receive medical discharges is reduced.

3.52 The acquisition of battle casualties in the field, their movement, hospitalization, and the levels of treatment they receive, must be considered as parts of an integrated whole in order that the mission of the medical service be most effectively fulfilled.

3.53 Before staffing criteria for Army Field Hospitals can be developed, it will be necessary to resolve the problems and make decisions concerning the forward echelon medical units. The outputs of the model for the collection, treatment, and transportation of battle casualties, and other injuries and medical cases, will determine the inputs of patients to the field hospitals. In consequence, studies of these patient workloads, organizations and staffing are pre-requisite to final solution of TOE for Army field hospitalization.

3.54 This section discusses the factors affecting the staffing of field hospitals, which are related both to patient workloads and to problems inherent in the hospital per se which have been given preliminary consideration. The patient-oriented factors include the distribution of patient categories, the types and severity of patient conditions, variations in workload, the effects of delay in care within the hospital, and the evacuation policy. Those factors more closely related to the hospital include determinants of size, number and distribution, mobility, and type.

3.55 These factors are all interrelated and interdependent and hence cannot be developed separately.

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[1] FM 8-10, Department of the Army Field Manual, Medical Service Theater of Operations (Washington: U. S. Government Printing Office 1959) p. 164.

3.56 It is recognized that disease has consistently been the overwhelming cause of hospitalization and that non-battle injuries represent a sizeable factor. Battle casualties are discussed with due regard to consideration of disease and injury as the chronic workload.

3.57 The effects of atomic, chemical and bacteriological warfare upon patient loads are recognized to be a major factor in considering organization and staffing for future wars.

THE PATIENT LOAD

3.58 The degree of efficiency in the management of patients in the field as measured by the level of medical care possible for the sick and wounded at each echelon and the logistics of their transportation, will influence input to the hospital by number, time of arrival, nature of and degree of seriousness of the ailment, and the treatment already administered.

Distribution of Patient Categories

3.59 Although it cannot be assumed that any future war will be fought with the same kinds of weapons or under circumstances similar to those of past wars, analysis of the experience of World War II and the Korean Conflict can serve as a point of departure.

3.60 Tables of the incidence of disease, non-battle injuries, and wounded by Theater and Army in World War II and the Korean Conflict are available. Data on the frequency of wounds by location and their allocation to surgical specialties have been included by Beebe and De Bakey. [2/] These data assist in developing approximate predictions on the size and composition of casualty loads resulting from disease, accidental injury and from conventional weapons and proportional estimates of different specialized surgical personnel required for their care. Patients of all types are basically a problem of appropriate input to the field model, for the output of the model will supply the data upon which estimates for the field hospital are made.

3.61 The medical officer is the reference point in the Army system for medical and surgical care. All other activities are, in effect, ancillary to or in support of him. For instance, the number and kinds of surgical teams in a hospital determine the number of surgical patients who can be effectively handled. Beebe and De Bakey state further that the accepted average daily operating capacity of surgeons is seven operations per day which can

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2/ G. W. Beebe and M. E. De Bakey. Battle Casualties, Springfield Illinois: Charles E. Thomas, 1952.

be increased 50% to ten and one-half per day for three-day peak loads or to nine per day for nine-day peak loads. During these peak periods, the surgeon is considered to be working at his physiological limit. A rough approximation of the number of surgeons of different specialties required in a theater of operations can be made by relating these data. The number of operations he is capable of performing within a given period determines the amount and kind of pre-operative and post-operative care necessary. The degree of back-logging of surgical cases caused by inadequate numbers of surgeons increases the likelihood of clinical complications and reduces the efficiency of the medical service. Staffing which is established solely on numbers of beds and without primary consideration of optimum proportion of ancillary and support staff to medical officers is not realistic. It appears to be essential that staffing criteria for both medical and surgical functions be established on a basis of pyramidal units of the medical officer and the optimum number of personnel required to support him at different levels.

Methodology for Estimating Variations in Workload

3.62 It is not sufficient to estimate the variation in admissions of each category of patients in estimating hospital staff requirements. This information must be combined with the medical requirements of the various categories of patients. A method of combining these requirements for the purpose of prediction of staffing needs is described below.

3.63 The variation with time of patient admissions from a certain population (division, theatre, local area) might form some pattern as shown below in Figure 17.

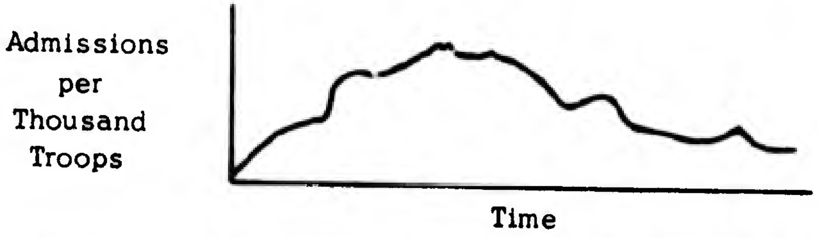

Figure 17. Variations with Time of Patient Admissions

3.64 If data are available, computing the proportion of days on which a certain number of admissions occurred will give a probability histogram similar to that shown in Figure 18. The decimal values for the ordinate represent the empirical probability of occurrence of a given number of daily arrivals, shown by numbers along the horizontal axis. These probabilities

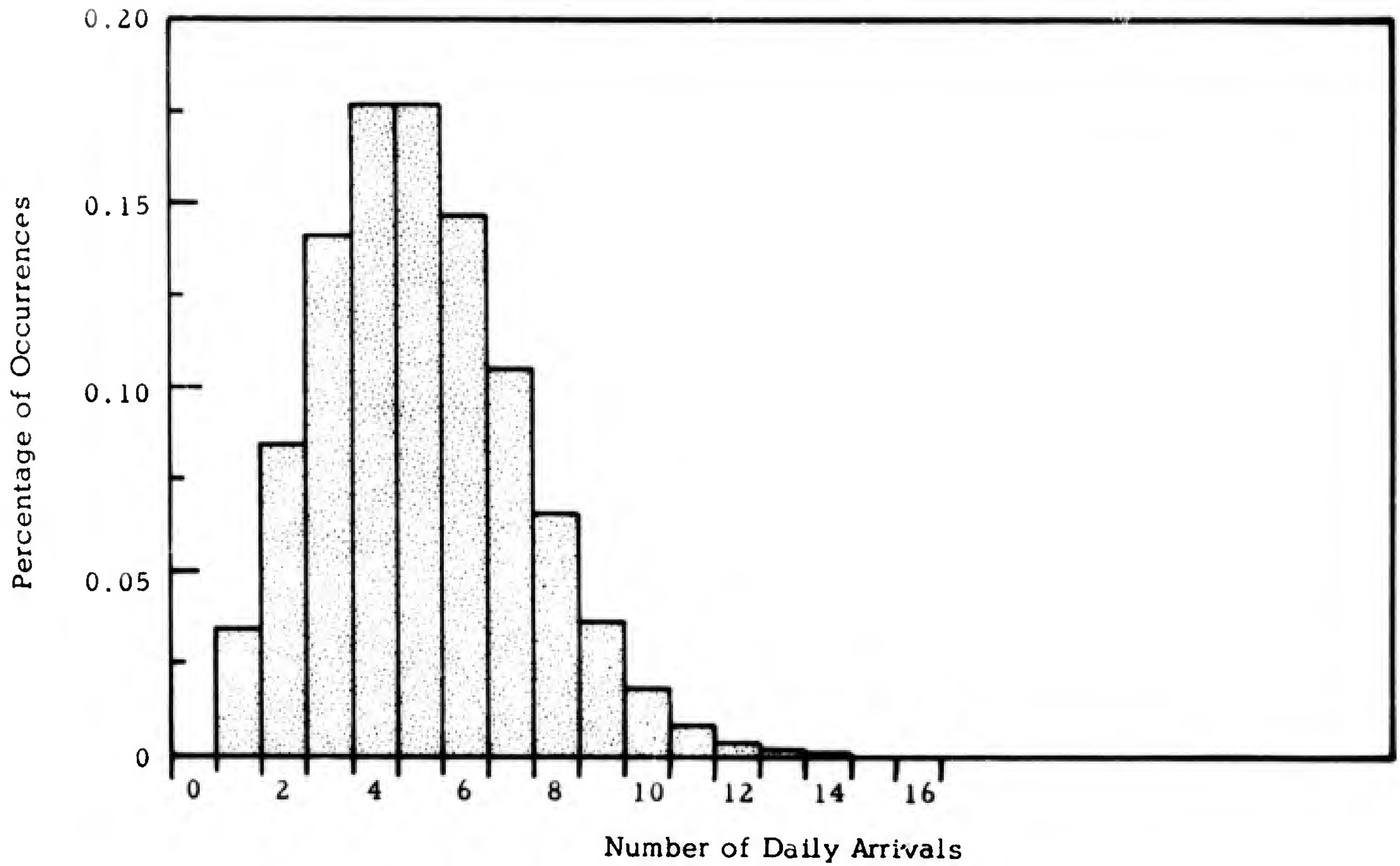

FIGURE 18. DISTRIBUTION OF DAILY ARRIVALS

can be used with a random number table to generate a new series of arrivals. The new numbers representing total daily arrivals will vary in sequence, but they will occur with the same relative frequency as in the original data.

3.65 This method does not pretend to give answers of high precision; the amount of error involved varies with the extent to which the distributions used agree with the actual distributions. What is important is that the method yields more reliable estimates than those from methods based on average admission rates and average length of stay.

3.66 In addition to simulating the total hospital census on any given day, it is possible to estimate the variation in medical, ancillary and support staff necessary to handle this number of patients if the relationship between length of stay and hospital workload can be determined. For example, suppose that the amount of care required by a patient (including doctors, nurses, aides, administrative officers), is greatest on the first day of admittance. Assume further that slightly less care is required on the second and third days and that after the third day the care required drops off significantly and then remains at some approximately constant level. By way of example, for purposes of simulation, the patients can be divided into these three broad categories and a number which will be called the equivalent hospital workload assigned to each category. As shown below, it is assumed, by way of illustration, that patients on the first day require 5 times as much care as those who have been in the hospital 4 days or longer, and that those on the second and third day require three times as much.

Category	Hospital Days	Equivalent Hospital Workload
I	1	5
II	2 or 3	3
III	4 or more	1

Methods which, for expedience, utilize simple averages to approximate admission rates or care required serve a useful function toward allocation of resources but they fail to account for variation in the processes involved. Another important factor in workload is the variability in the size of the groups of patients arriving from day to day. The requirements for medical care in itself would not present any problem if the numbers of intensely ill and less ill patients remained a constant proportion of the population. However, these proportions vary widely, and studies have shown that the proportion of intensely ill patients plays a dominant role in determining workload.

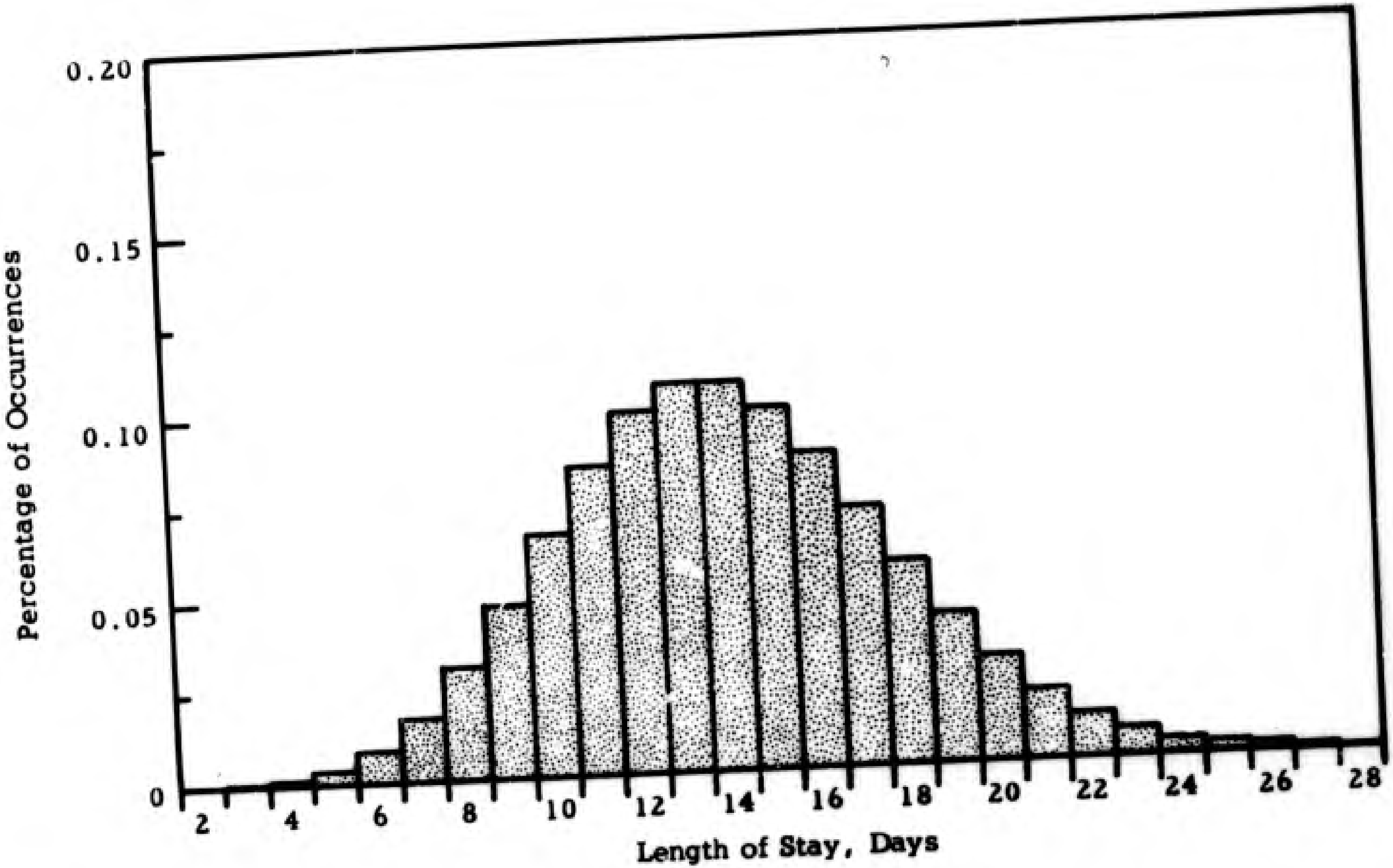

FIGURE 19. DISTRIBUTION OF LENGTH OF STAY

3.67 If the distribution of number of patient arrivals and length of stay can be determined, or approximated, then the system can be simulated using Monte Carlo techniques. The technique which will be described here is a general method for simulating variations in hospital admissions and hospital census. It is not limited by the character of the distributions involved and provides a means of realistically describing fluctuations in the workload produced by patients. The routines involved can be readily programmed for a computer. The calculations are set up to duplicate the features of the problem under study, whether it be the arrival distribution of patients from a particular disease, from a combination of diseases or from causes other than diseases. If data sufficient to build distribution of arrivals and length of stay are available, they can be used. If sufficient data are not available, then reasonable assumptions can be made as to what the distributions might be. The calculation process is entirely numerical; numbers are generated as input and numbers are obtained as output. The rationale behind the use of this technique is that each number from the data of interest will occur with about the same relative frequency in this synthetic process as in the "real world" situation, but their arrangements will be randomized.

3.68 If data are not available, either the histogram can be constructed from best available estimates or a theoretical frequency distribution selected which is believed to approximate the actual conditions. Figures 18 and 19 were constructed using tabulated probability values of the Poisson distribution. The distribution of admissions has a mean of 5 per day and the length of stay distribution has a mean of 14 days.

3.69 The new series of total arrivals per day are generated by choosing numbers from a set of random number tables and using each random number as a decimal probability. Each time a random number is chosen, the interval into which it falls on the histogram is noted and the corresponding number of arrivals, say x, is determined.

3.70 Having selected the total arrivals for a given day, the length of stay for each of these x arrivals must be determined. Accordingly, x more random numbers are chosen and used as decimal probabilities of length of stay, shown in Figure 19. Figure 19 is constructed in the same general manner as Figure 18.

3.71 By repeating the procedure described above many times, (one trial run) a pattern of daily arrivals and discharges is obtained which may be plotted as the variation in daily census, Figures 20 and 21. The accuracy of the results produced by this technique increases with the number of trial runs, and a number of trials should be made before drawing any conclusions. This is a simple matter if the problem is programmed for a computer.

3.72 Figures 20 and 21 were obtained by making two trial runs of 60 days each. The first 15 days of each run were not tabulated in order to account for the transition period produced by using a mean length of stay of 15 days. The daily variation of patients in categories I, II and III is also shown in Figures 20 and 21.

3.73 To illustrate how the results of this simulation technique may be used in determining optimum hospital staffing, two figures have been constructed.

3.74 If hospital planners wish to know what percentage of beds will be filled under a given admittance rate and length of stay, Figure 22 can be used. This shows that 99% of the time not more than 80 beds will be filled, and that about 50% of the time less than 66 beds will be filled.

3.75 If it is desired to know how the hospital workload varies, Figure 23 can be used. This shows that if the hospital is staffed to provide a total equivalent hospital workload of 140, this will be sufficient 99% of the time. Note that the penalty for under-staffing is also determined from this Figure. For example, staffing to provide a total equivalent hospital workload of 110 would be inadequate about 33% of the time.

Effects of Delay in Hospital Care

3.76 Basic to the problem of patient loads and the severity of conditions as they affect staffing is the evaluation of the consequence of delay in medical care within the hospital. In other words, within what period of time, considered medically safe after arrival at the hospital, must patients of any category and condition receive care so there will be no injurious effect or retardation of recovery? Known data would be the time elapsed since the injury or onset of illness, the kind of treatment received and the time of last treatment.

3.77 The problem of delay has been discussed in an earlier section of this report, but must be considered as a variable in developing the model for staffing field army hospitals.

Evacuation Policy

3.78 Another variable important in the consideration of patient loads on hospitalization is the evacuation policy. When the maximum period a patient is allowed to remain in a field hospital is established by policy, a restriction on types and conditions of patients who can be admitted is determined. The shorter the period that patients can be retained in hospitals in a zone, the fewer beds will be required in that zone. Also, the shorter the evacuation time, the greater the turnover for any particular hospital and hence the greater the staffing demands because of differences in the initial and subsequent times for patient care.

3.79 Detailed evaluation of the effects of different evacuation policies upon field hospitalization are essential for developing satisfactory TOE medical support in future contact.

Category *	Hospital Days	Equivalent Hospital Workload
I	1	5
II	2 or 3	3
III	4 or more	1

* Number of Patients on the particular day indicated.
** Computed by summing the number of patients in each category times the equivalent hospital workload.

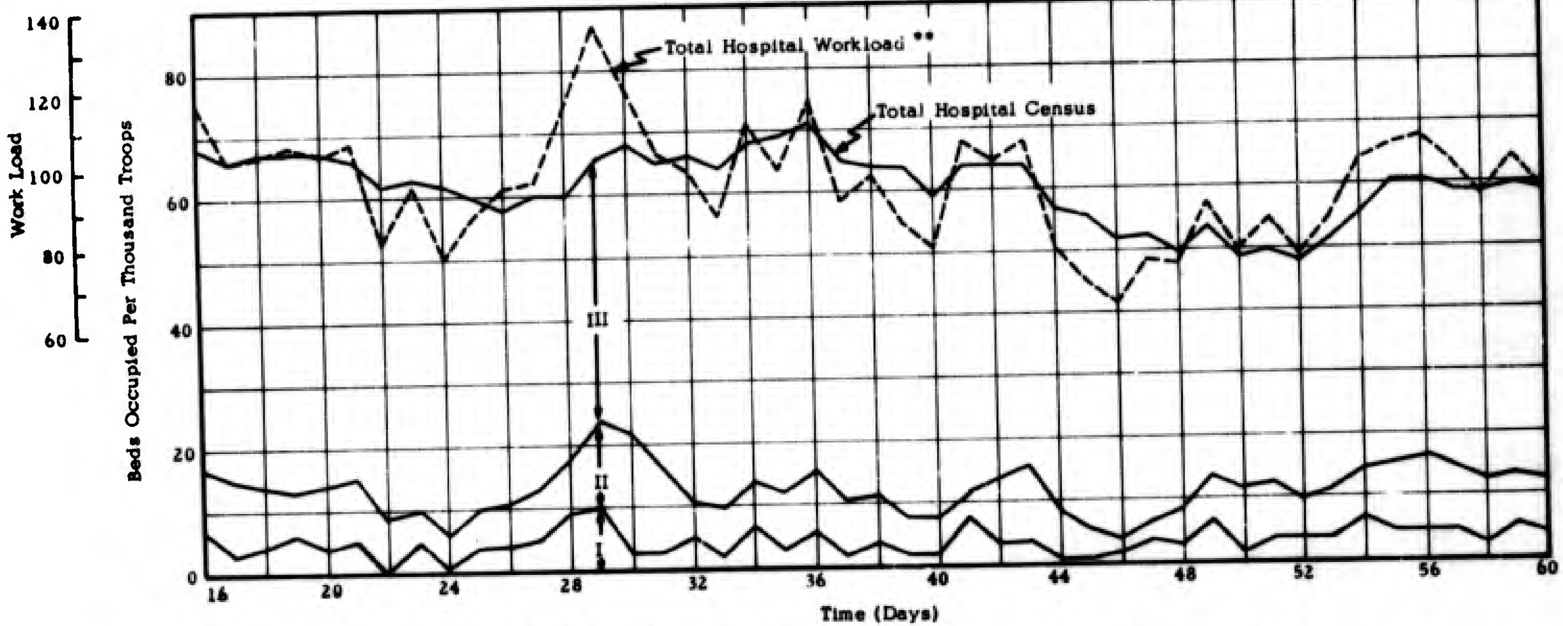

FIGURE 20. RESULTS OF TRIAL #1. SIMULATION OF TOTAL HOSPITAL WORKLOAD AND PATIENT CENSUS OVER A 60-DAY PERIOD.

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Category *	Hospital Days	Equivalent Hospital Workload
I	1	5
II	2 or 3	3
III	4 or more	1

* Number of Patients on the particular day indicated.
** Computed by summing the number of patients in each category times the equivalent hospital workload.

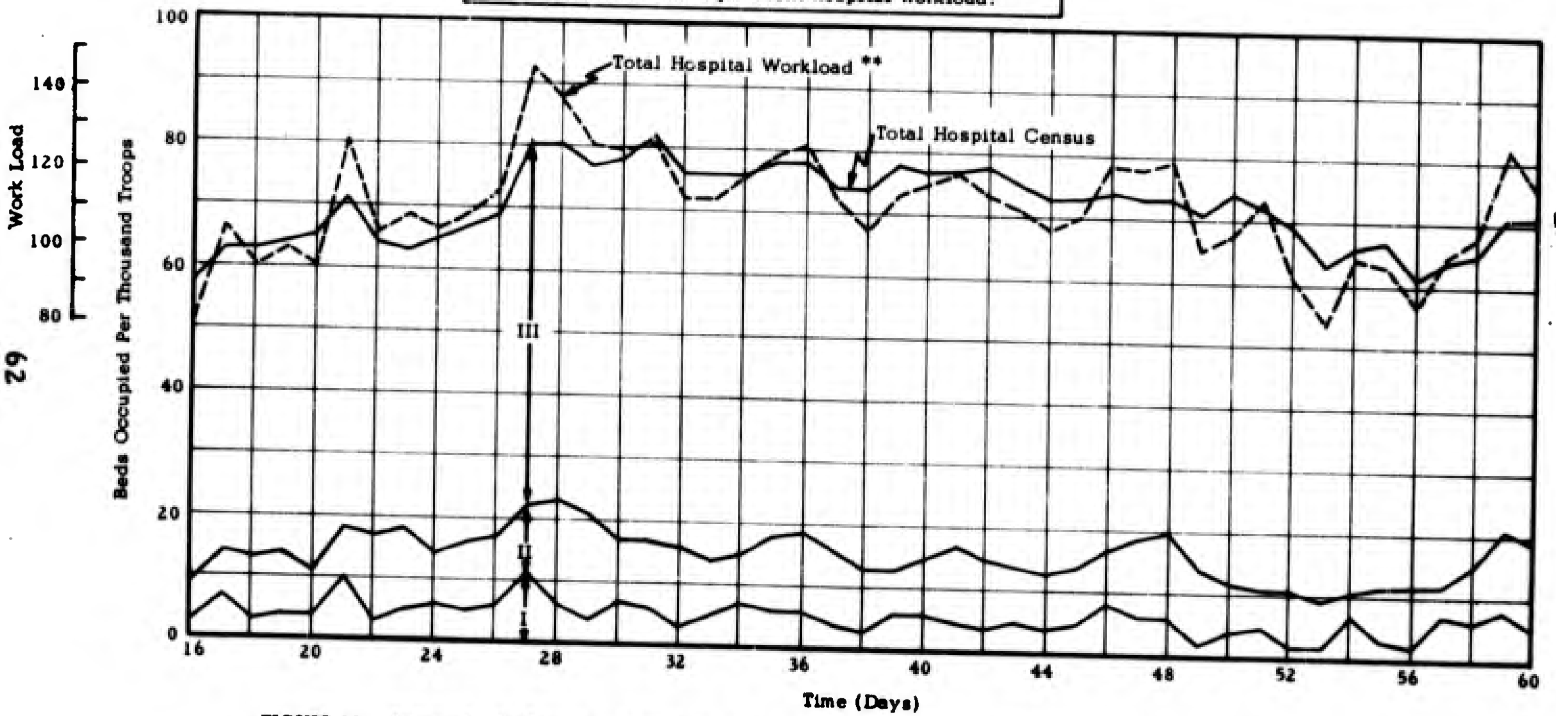

FIGURE 21. RESULTS OF TRIAL #2. SIMULATION OF TOTAL HOSPITAL WORKLOAD AND PATIENT CENSUS OVER A 60-DAY PERIOD.

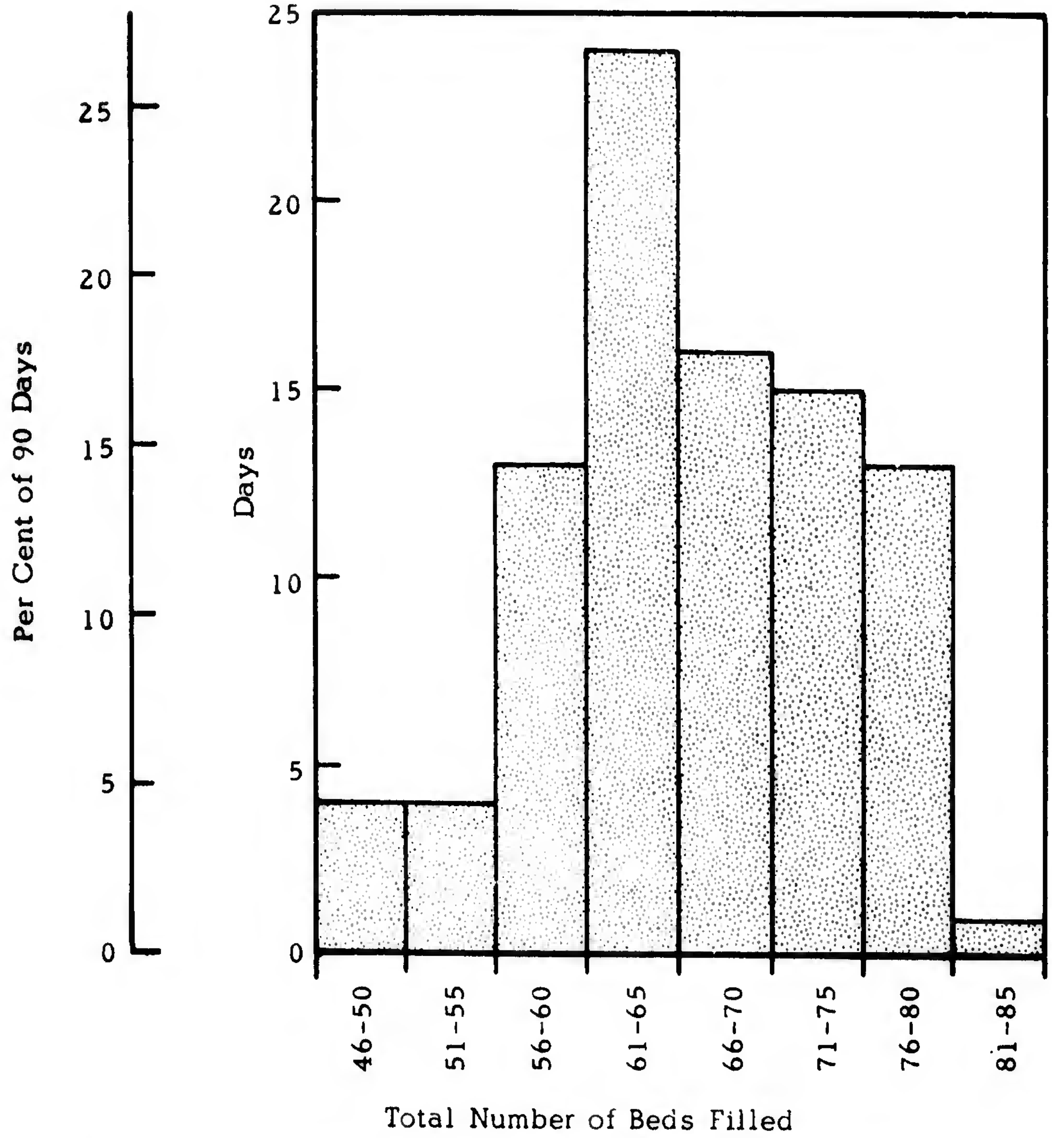

FIGURE 22. FREQUENCY DISTRIBUTION OF NO. OF BEDS FILLED OVER A 90-DAY PERIOD

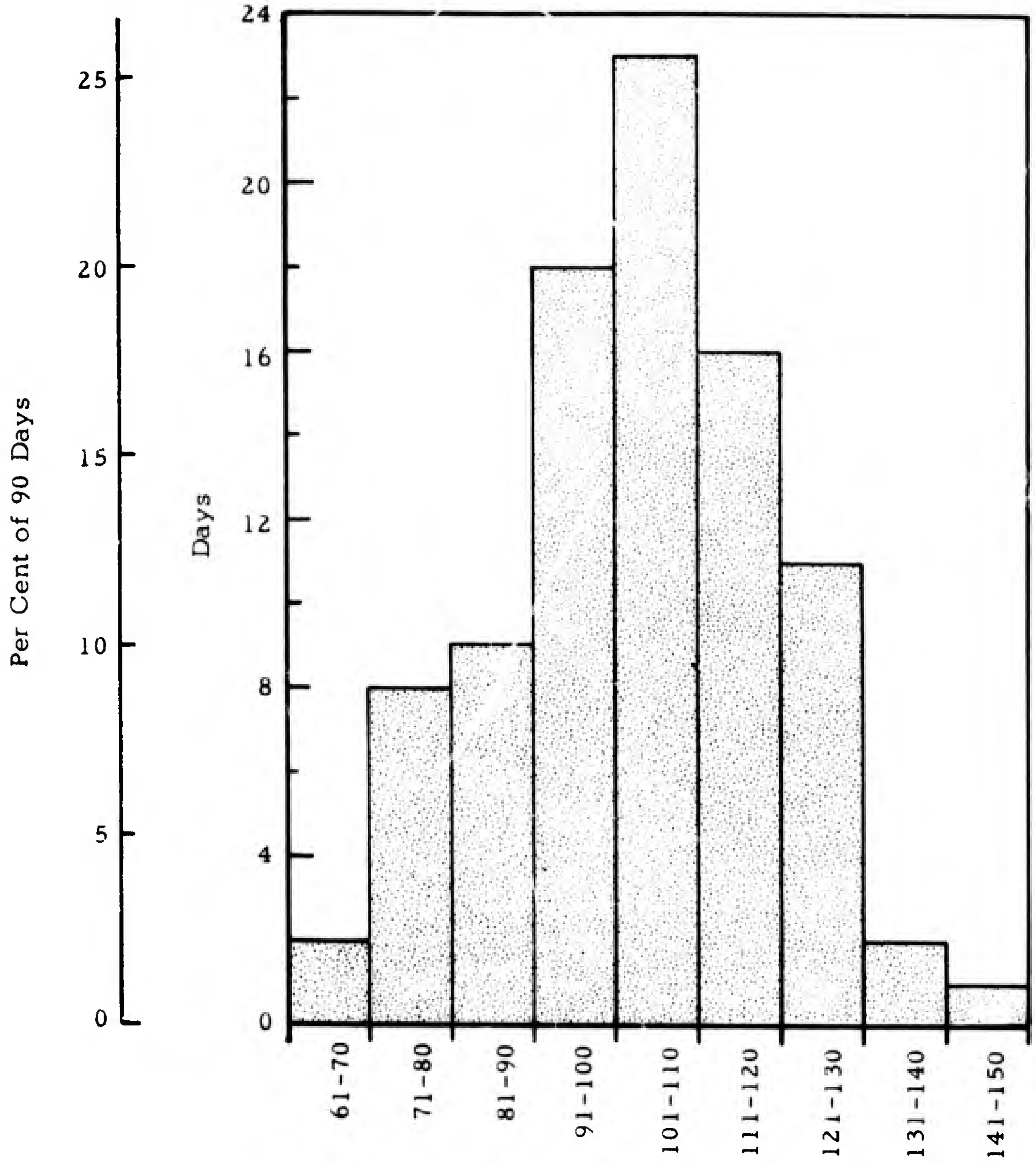

FIGURE 23. FREQUENCY DISTRIBUTION OF WORKLOAD OVER 90-DAY PERIOD

THE HOSPITAL - GENERAL CONSIDERATIONS

3.80 A number of variables relating to the hospital per se are important in determining requirements for Medical Service operating in the field and problems of staffing. These are size, number, type location, and mobility, which in turn are influenced by the tactical environment (weather, terrain, type of operations, types of weapons employed by the enemy). These variables can only be considered as interrelated and interdependent factors.

3.81 Size. If hospitals are established to support units too small in number, then at any given time, most would have no patients, while others would be seriously overloaded. Medical resources would be idle or so overtaxed that the quality of patient care would deteriorate. Where greater numbers of troops are supported by a single hospital the unit size of the hospital and relative variation in load at each hospital is less from day to day.

3.82 A consideration for size can therefore be found in the principle that larger units will experience smaller relative fluctuations in the requirements for support. Because of this, medical resources tend to be more efficiently utilized and the maintenance of patient care standards is favored by a reduced severity and frequency of overloads.

3.83 An approximate measure of the reduction in relative fluctuations of casualty rates by increase of the supported population is given by the quantity $\frac{1}{\sqrt{N}}$. That is to say the relative fluctuations in load are inversely proportioned to the square-root of the supported population size. Thus, the variation of casualty rates in a hospital supporting 40,000 troops should be one-half as great as that experienced by a hospital supporting 10,000 troops. The ratio of variability is:

$$\frac{1}{\sqrt{\frac{40,000}{10,000}}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

3.84 The field hospital system proposed by CONARC (February 1960) n support of the Modern Mobile Army, 1965-70, contains twelve similar hospitals of one hundred and fifty beds each per MSB or a total of 36 per field Army. The hospitals would care for medical, surgical, and neuropsychiatric cases. The TOE calls for a staff of 94 (staff/patient ratio of .62). This number has been challenged by The Army Medical Service Combat Development Group and a staff of 132 has been proposed (staff/patient ratio of .88). More recently, a Universal Hospital of 540 beds (staff/patient ratio of .68) has been presented which comprises three modules of 180 beds each and capable of operating independently. 3/

3.85 The 150-bed field hospital as proposed in the MOMAR organization appears to have been chosen arbitrarily. In the case of the Universal Hospital, the number of beds has been determined through a carefully developed analysis of the experience of the ten currently authorized hospitals in the theatre of operations. However, the staffing requirement of the hospital, 368, is arrived at by a "flash estimate", although recognition is made of the fact that this is a tentative figure and that valid criteria should be established before definitive assignment of staff is made.

3.86 This practice of establishing the number of beds in a hospital and then estimating staffing requirements on this basis is open to question. Analysis of the TOES of current hospitals in the theatres of operation does not reveal any consistent staffing pattern either by number of personnel, professional care personnel, physicians, nurses per patient or the percentage of personnel in administration. This is especially evident when rank order distributions of the above are made for the five station hospitals which vary only in size. 4/ It would appear, if judging only from the round numbers of beds (100, 200, 300, 500, 750) that the size of these hospitals was determined without regard to staffing requirements.

3.87 When the many other variables relative to size are considered and the approximate desired size arrived at, the final decision on size should be based upon the optimum balance of staff to patient-load carried. That is, there should be established a minimum number of staff by function in relation to the corresponding patient-load which would be carried by a hospital with the number of beds closest to the number required for other reasons.

3.88 Number and Distribution. The number of hospitals required in support of a field army is quite logically related to their size and to the number and distribution of troops supported. In supporting widely dispersed and mobile forces, the distribution or location of hospitals as they effect the logistics of transporting patients must be considered. As the number of such hospitals increases the problem of logistic support becomes very large in a fashion similar to the requirement for spare parts in maintenance operations. These considerations lead to the optimum size which would make for the most effective distribution.

3/ USAMEDS Combat Development Group, Amscd 57-6, Universal Hospital Organization Base.

4/ Amscd 57-6 op.cit.

3.89 Mobility. A hospital is ineffective when it is moving. In order to gain maximum effectiveness from the resources available for medical services it is necessary, therefore, that the location of hospitals be shifted with the least possible frequency. Thus, hospitals must not relocate with the ebb and flow of tactical maneuvers which are the exemplification of tactical mobility, but should only re-deploy when the main current of a campaign has carried the center of mass of the troop population so far that relocation is essential to maintenance of effective medical support.

3.90 Moreover, since the increased utilization of air vehicles contemplated in future military operations makes possible the evacuation of hospitalization casualties over greater distances than were previously feasible, it appears that greater shifts in the center of mass of supported populations can now be tolerated, without relocation of hospitals, than formerly. The critical medical factor in evacuation is not distance, per se, but rather the severity and duration of stress incurred. Thus, the more extensive use of air transportation may on the one hand increase the tactical mobility of combat forces, while on the other hand it reduces the required frequency of relocating hospitals.

3.91 The foregoing comments emphasize essential differences between the concept of tactical mobility of combat forces, and the tactical re-deployment of non-combatant supporting units. To provide a combat unit with fewer combat and organic transport vehicles than are needed for simultaneous movement of all its elements is to deny it full tactical mobility. To provide the same capability to a non-combatant, supporting unit that re-deploys only occasionally is to commit a considerable excess of transportation resources over its requirements for daily maintenance.

3.92 Indeed there appear to be some grounds for speculation that a functioning hospital could not utilize 100% organic transport for re-deployment except in circumstances under which the rapidity of its relocation would be of little consequence. This suggestion assumes that simultaneous movement of an entire hospital unit would require it to be essentially free of patients. In circumstances of hospital bed scarcity, it would seem preferable to re-deploy by elements, in which case 100% organic transport would not be required.

3.93 The point of the argument is a suggestion that concepts for hospital organization, equipment, and operations to support future combat tactics do not necessarily have to mirror the characteristics of the combat units.

3.94 Type. The type of hospitals proposed to support the Modern Mobile Army has the capability of caring for medical, surgical, and N.P. patients. Investigation should be made to determine whether this is functionally sound in terms of staffing or whether single-purpose hospitals and/or hospitals made has been presented which comprises three modules of 180 beds each and capable of operating independently. [3]

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IV. EXPERIMENTAL TESTS

4.1 This section is concerned with testing the model of the medical support system of a field army as a device for evaluation of alternative candidate TOE medical units. As presently conceived the test program would include analysis, computer simulation and field confirmation trials.

4.2 The model is a systematic and quantitative description of the important features of medical support units. Its validity rests upon the validity of the logic, the accuracy of the inputs and the degree to which the important determinants are identified. Each of these three aspects of validity can be checked.

Logical Validity

4.3 Complex systems require complex analysis and it is possible internal inconsistencies may be introduced in the model. Continuous reference to the real system, descriptions of system components prepared by various sources, and the medical field trials at CDEC, during the development and operation of the model assist in establishing validity of content and interrelations. The greater use of mathematics tends to reduce internal inconsistencies, but not to obviate them. Careful reexamination of assumptions with free and open discussion are very helpful in testing. The validity of a model should be challenged just as vigorously when its operation supports expectation as when contrary to it.

Accuracy of Inputs

4.4 The value of a model is not necessarily limited by low precision input data. In many cases models are used to predict outcomes, e.g., the effect of radiation on man, when some input data must be estimated. At the same time it is important to know what is unknown and to be able to make an estimate of the error of prediction. Some input data play a significant part in increasing the errors or over-all inaccuracy of the conclusions; such data need to be identified and estimates made of their precision.

4.5 Determining the contribution that variation in each input makes to the over-all outcome is the first step in such analysis. If the outcome is highly sensitive to such input variation, an estimate of the precision of the input is desirable so that a certain level of confidence can be attained. Some types of inputs can be tested experimentally under rigidly controlled and under field conditions, as well as by comparison with accurate accounts of real-life experience.

Degree of Completeness

4.6 When the process has been described and relevant variables quantified there is still no assurance that all important aspects have been determined. For example: a description of management of casualties that includes medical personnel but not the difficulty with communications will be deficient, but unless this deficiency is recognized, the model will not be properly predictive. Areas of omission are more likely to exist with new procedures. If proposed methods do not have their counterpart in experience then it is imperative to try them out in as real and complete a simulation as possible. This leads to a field test.

4.7 Field tests are of two types: those designed to supply data and those designated to test a new method. Often field tests for the first objective are inefficient; for example, transport times as measured in the field are only narrowly applicable to other regions and possibly less precise than those that could be predicted by transportation experts. Sometimes field tests are the only source of some data because of the lack of historical records or simpler means of determination. In general, however, field tests for the specific purpose of obtaining data should be avoided when more efficient means are available.

4.8 In the case of a new method, a field test is necessary as a means of assessing completeness in the model. The use of a field test should, in general, be restricted only to systems that have presumptive merit. If a model is tested on one system there is no assurance it is applicable on another system.

Input Data

4.9 Two important inputs to the model are treatment times and the effects of delay on disability, duty days lost and survival. Both of these are more easily determined without field experimentation.

4.10 Treatment Times. Time distributions for treatment can be developed by compilation of existing data from clinical studies and records, both from military experience and from civilian sources. While it may be expected that certain supplementary items may be required, these can be identified and appropriate arrangement made for their determination at military installations. Times for simulated forward echelon treatment are also of value.

4.11 They may be obtained by measurement of times required for aidmen to administer specific types of resuscitative care during periods of initial or refresher training. This type of experiment could be conducted as a group or class exercise, so that individual time measurements could be accumulated rapidly. Special emphasis would be on the quality of performance. Motion picture time records should be made of at least one exercise as part of the experimental protocol and for demonstration purposes. The recorded times will represent distribution of probable minimum values because of the relatively ideal test conditions. As such, they are of very real value. Under conditions of excessive patient workload, the time devoted to the treatment of a given condition may be significantly reduced at the expense of the quality of treatment to compensate for inadequate staffing. Since effective medical support for a field army optimal level of care achievable in the field is expressed in terms of maintenance of combat strength, it is essential that minimal time distribution be unequivocally established.

4.12 It can be expected that field conditions will be such as to require longer times for treatment, so that consideration of maximal values is likewise necessary. Information on this point can be obtained by a comparison with CDEC field trials with respect to time requirements and quality of treatment.

4.13 Effects of Delay. The refinement of data on effects of delay will be accomplished by a study of a sample population of patients in the Korea War from individual records which are sufficiently comprehensive to provide the essential information on the clinical courses of disease, non-battle injury and wounds from conventional weapons. These data will be considered in relation to best estimates of future development in the medical arts and sciences which are considered likely up to the period under consideration.

4.14 A considerable volume of data pertinent to the clinical time course of the medical conditions is being considered. Time distributions for classes of conditions and for closely similar clinical time courses can be developed. Since complications are considered as new cases in operation of the model, they will be considered in the same manner as other medical conditions.

Field Trials

4.15 "Paper" Simulation. Numerous "paper" field tests, i.e., computer simulations, must be conducted for selection of the most promising candidate systems to be considered for field trials. Such paper tests are the most feasible and effective means of challenging the adequacy of a model and for comparative evaluations of alternative solutions. It permits tests of many possible systems under many possible situations rapidly and inexpensively.

4.16 CDEC Tests. The trials which have been conducted at CDEC, as well as those being planned for the spring, satisfy the principal requirements for testing at this time. They have provided insight in the development of the model for combat command medical support system. In turn the model which has been developed will provide guidance in elaboration of the details of the test plan for the spring trials. The CDEC test program can be expected to provide essential information prerequisite to validation tests of the complete system model following computer simulation, refinement of inputs, and completion of such modification as may be warranted. The results of these earlier CDEC trials have already provided a basis for consideration and decision as to effective measures to be considered in establishment of medical doctrine. An example of a major consideration in developing concepts for future operations support is that of medical communication provisions; this problem is being studied during the fall exercises. The present "study-in-depth" approach utilized in the CDEC trials, i.e., the major emphasis being placed upon a single important variable such as communication, provides an essential background of experience and strength for validation of the combat command model.

4.17 Confirmatory Trials. As mentioned above the results of present studies will provide some basis for guidance for elaboration of detail, and for component tests in the CDEC trials currently scheduled.

4.18 After testing the model by means of paper simulation, and identifying the promising candidate system by this process of screening, confirmatory field tests will be desirable for validation of the model, visualization in a real-life framework, and for purposes of demonstration.

4.19 The test plan should be developed with due regard for consistency in the selection of interdependent variables such as weapons effects, tactics, duration of the operation, casualty spectrum, total patient workload, medical doctrine and the maintenance of optimal achievable standards for resuscitative treatment at the forward echelons. Trial of alternative TOE for medical support to combat command have and can be conducted with the facilities available at CDEC. Tests of the total system of medical support of a field army will require very extensive facilities so that consideration will have to be given as to how these may be met.

4.20 The field confirmation trials would provide a comparative evaluation of two candidate units. The schedule of tests should be established with due regard for the influence of sequence of performance; for example, the influence of "learning" factors both in regard to terrain, improvisation, and pratice should be minimized.

4.21 The observed results can be compared with anticipated results derived from computer simulation. Such trials provide for a comparative evaluation of the two systems and a general evaluation of machine prediction to indicate deviations which may occur either as the result of field factors, estimates requiring re-adjustment, or revision for inconsistencies or omissions.

APPENDIX A

INTRODUCTION

A.1 The following pages represent successive segments of a flow diagram and the data being utilized in the simulation of a forward medical system. Those elements of the medical system which are being examined in the simulation are discussed in the main body of the report.

Flow Charts

A.2 These segments of the flow diagram may be examined to indicate the detail of simulation and the factors that are left as parameters to be chosen upon running any one game. Changes in numbers of equipment and personnel may be handled as well as actual changes in certain operating procedures of the system.

A.3 These flow diagrams are condensations of more detailed ones which would be used in actually coding for a computer. These presented here are easier for the mind to follow in studying the logical steps than the working papers from which these were prepared.

A.4 The flow diagram represent the simulation of medical support of a combat command. It includes the routine which tabulates patients and the various factors considered about them through the medical system organic to the combat command up to, but not through the T&C station.

A.5 Data Set. Relevant information about the element that enters into the routine is grouped together. These are generated and modified during the simulation and sorted in the computer "memory", e.g., time of wounding. Some of the entries to a data set may represent information given to the computer, e.g., travel speed of ambulances.

A.6 Input Values. Permanent information is stored in the computer memory in the form of constants that are referenced according to the computer instructions. They are grouped under a number of categories and, where applicable, referenced to the data sets.

A.7 Temporary Values. Constants used in the computer for a particular run are listed under markers, counters, registers, and input constants.

Patient-Class Data Set[a]

1. Highest random number (between 0 and 1) signifying the patient class.
2. Priorities of patients in this class for:
   a. Treatment.
   b. Evacuation.
3. Is the patient ambulatory? yes, no.
4. Units of transport space required by the patient.
5. Expected time required for initial treatment by aid men.
6. Treatment at a T&C station:
   a. Expected total time required for treatment (from beginning of treatment until patient is ready to leave the T&C station).
   b. Number of each type of medical personnel required for treatment of the patient, whether the various types must devote full or only half time to the patient, and the length of time required by each type.
7. Survival probability functions:
   a. Form of $F_0(t)$ and the correct constants.
   b. Form of $F_1(t; t_1)$ and the correct constants.
8. Disposition of surviving patients at the T&C station:
   a. Return to duty.
   b. Evacuation to a higher echelon

---

a/ There is one of these data sets for each patient class considered in the simulated action. This type of patient-class data set is used only in Submodel I.

Aid Team Data Set[a]

(Identified by fixed address of first word in set)

1. Medical unit to which team belongs permanently.
2. Medical unit to which team is attached operationally.
3. Coordinates of trip origin if travelling; of team location is not travelling.
4. Coordinates of trip destination if travelling; of team location if not travelling.
5. Location or destination code: Patient (0), forward aid post (1), rear aid post (2), T&C station (3), aid team (4), other (5).
6. Travel speed code: Along the FEBA (0), between aid posts and the FEBA (1), between T&C stations and aid posts (2).
7. Time of arrival if moving; time at which treatment will be completed if treating; time at which vehicle repairs will be completed if broken down; zero if none of these.
8. Does aid team have 3 (as opposed to 2) aid men normally assigned? yes, no.
9. Is the aid team at full strength? yes, no.
10. Expected time at which replacement aid man will reach the unit to which the team is permanently attached; zero when not used.
11. Is the team transport vehicle broken down? yes, no.
12. If vehicle is broken down, does aid team require relief? yes, no.
13. If vehicle is broken down, the address of assigned relief aid team; if team is relieving the address of the aid team it is relieving.
14. Time at which communications will be completed in reporting a vehicle breakdown; time at which the final search for a casualty begins;[b] XXX if not used.
15. y - coordinate limits, y_n and y_E, of the aid team's unscheduled casualty pickup area along the FEBA.

---

a/ There is one of these data sets for each aid team involved in the simulated action.

b/ The final search time for a patient includes both the delay involved if the aid team must leave its vehicle to reach the vicinity of the patient, and the actual time required in searching for the patient once his vicinity has been reached. The aid team vehicle is not subject to breakdown during this period.

16. If the team is not receiving communications, the last time at which communications could be received; if the team is receiving communications, zero. (Referred to in flow diagram as "last communication time".)
17. Number of units of aid team transport space which remain unoccupied by patients.
18. Patient markers of all patients in the care of the aid team. (Patient Marker I in some instances, Patient Marker II in others).

Patient Data Set [a/]

1. Patient identification number.

2. Aid post that is responsible for the area in which the patient is located initially.

3. Address of the data set representing the patient class.

4. Coordinates of the initial location of the patient.

5. Times.

   a. Wounding (accident, sickness).
   b. Aid man treatment begun.
   c. Arrival at aid post
   d. Departure from aid post.
   e. Arrival at T&C station.
   f. Treatment begun at T&C station.
   g. Ready for evacuation from T&C station, or for return to duty (XXX if dead).

6. Location coordinates of T&C station from which patient is evacuated (XXX if patient returned to duty).

7. Is the patient an aid man? yes, no.

---

a/ There is one of these data sets for each patient that is generated during the simulated action.

Forward-Company Aid Post Data Set[a]

(Identified by fixed address of first word in set)

1. Coordinates of the first section of the post, (x_{A1}, y_A).
2. Coordinates of the second section of the post, (x_{A2}, y_A)
3. Fraction of all forward casualties that are expected to occur in the area served by this aid post (or fraction of all forward-company personnel served by this aid post).
4. y - coordinate of southern end of company front, y_O.
5. Length of company front, Δy.
6. Number of T&C-station aid teams at or headed toward this aid post.[b]
7. Waiting time counter.
8. List of aid teams physically located at aid post by:
    a. Address of aid team data set.
    b. Whether at first or second section of post.
9. Patient markers of all patients at the aid post (Patient Marker II is used).

---

[a] There is one of these data sets for each aid post involved in the simulated action. If desired, the aid post may serve an area smaller or larger than that of a company. It may also serve <u>only</u> as a point where walking wounded are collected and have no aid teams actually attached to it. The term "company aid post" is used here merely for convenience.

[b] T&C station aid teams that are sent out to relieve company aid teams are not included in this number.

Rear-Company Aid Post Data Set [a]

(Identified by fixed address of first word in set)

1. Coordinates of the first section of the post, (x_{A1}, y_A).
2. Coordinates of the second section of the post, (x_{A2}, y_A).
3. Desired maximum distance of the aid post from the FEBA.
4. Desired minimum distance of the aid post from the FEBA.
5. Fraction of all rear casualties that are expected to occur in the area served by this aid post (or fraction of all rear-company personnel served by this aid post).
6. Radius of company, R.
7. Does the aid post need a T&C.
8. List of aid teams physically located at aid post by:
   a. Address of aid team data set.
   b. Whether at first or second section of post.
9. Patient markers of all patients at the aid post (Patient Marker II is used).

---

a/ There is one of these data sets for each aid post involved in the simulated action. The term "rear company" is used merely for convenience, since this type of data set may represent many different kinds of rear area units (e.g., an artillery battery).

Treatment and Collection Station Data Set [a]

(Identified by fixed address of first word in set)

1. Coordinates of the first section of the station, (x_{T1}, y_T)
2. Coordinates of the second section of the station (x_{T2}, y_T).
3. Desired maximum distance of the station from the FEBA.
4. Desired minimum distance of the station from the FEBA.
5. Numbers of different types of medical personnel available for immediate treatment of patients:

   I. First Section

      a. Officers (no. available fulltime; halftime).

      b. Enlisted Type A (full, half)

      c. Enlisted Type B (full, half)

   II. Second Section

      a. Officers (full, half)

      b. Enlisted Type A (full, half)

      c. Enlisted Type B (full, half)

6. Is an officer present at the first section?
7. Counters for keeping track of relocation time:

   a. First section

   b. Second section

8. Does the station serve forward companies? yes, no.
9. List of aid teams physically located at station by:

   a. Address of aid team data set.

   b. Whether at first or second section of station.

10. Patient markers of all patients at the station (Patient Marker II used).

---

[a] There is one of these data sets for each T&C station involved in the simulated action.

Walking Wounded Data Set I

1. Patient Markers I of ambulatory patients that are walking toward, but have not reached first sections of aid posts.

Walking Wounded Data Set II

1. Patient Markers I of ambulatory patients that are walking toward, but have not reached second sections of aid posts.

Waiting Wounded Data Set

1. Patient Markers I of non-ambulatory patients that have not been reached by an aid team.[a]

Immobile Data Set

1. Aid Team Markers of aid teams that have broken down, and which require but have not been assigned relief.

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[a] Patients in this set may already have been treated by platoon aid men if such exist.

Station-Movement Data Set
(for input to Submodel II)

1. Each time a section of a T&C station reaches a new location, add the following information to the set:[a]

a. Address of the T&C Station.

b. Whether it is a first or second section that moves.

c. Clock time.

d. Coordinates of the new location.

---

[a] At the beginning of each simulated action, initial values are read into the data set for each T&C Station.

Input Values that Define the Tactical Situation and Medical Support System Being Simulated

A. Tactical Factors

1. T = time at which some change in battle conditions is to be made. The nature of the changes to be made is governed by the action-modification word.

2. "Action-modification word" — A computer word which contains the current value of T, and which is used either to terminate the action or to indicate that changes are required during the battle in any or all of the following values:

    a. Expected casualty rates.
    b. Relative distribution of casualties by type.
    c. Rate at which the FEBA moves (forward or backward).
    d. Probability that a casualty occurring near the FEBA will be accessible to the transport vehicle of an aid team.
    e. The additional time required for an aid team to reach a casualty that is not accessible to the team's transport.

3. T_L = number of time units between moves of the FEBA.

4. Δx_{Ld}, Δx_{Ln} = day and night values of the distance that the FEBA is displaced each time it moves.

5. Forward-company aid post data sets: 3,4,5.

6. Rear-company aid post data sets: 5.

B. Environmental Factors

1. Number of time units of daylight in a day.

2. Number of time units of darkness in a day.

C. Casualty Generation

1. P_{F1} = probability that one casualty will occur in the forward area (at or near the FEBA) during a given unit of time: (a) day, (b) night.

2. P_{F2} = probability that one or two casualties will occur in the forward area (at or near the FEBA) during a given unit of time: (a) day, (b) night.

3. P_{F3} = probability that one, two, or three casualties will occur in the forward area (at or near the FEBA) during a given unit of time: (a) day, (b) night.

4. P_A = probability that a particular aid man located forward of a forward-company aid post will become a casualty during a given unit of time: (a) day, (b) night.

5. P_{R1} = probability that one casualty will occur in the rear area during a given unit of time: (a) day, (b) night.

6. P_{R2} = probability that one or two casualties will occur in the rear area during a given unit of time: (a) day, (b) night.

7. P_{R3} = probability that one, two, or three casualties will occur in the rear area during a given unit of time: (a) day, (b) night.

8. $G(\lambda)$ = probability that a casualty in a rear company will occur at a distance λR from the company aid post. (R = radius of the company, $0 \leq \lambda \leq 1$).

9. Patient-class data sets: 1.

10. Forward-company aid post data sets: 3.

11. Rear-company aid post data sets: 5.

Medical Factors

1. Patient-class data set: 3,4,5,6,7,8.

D. Doctrine and Organization

1. Desired minimum distance of forward-company aid posts from the FEBA.

2. Desired maximum distance of forward-company aid posts from the FEBA.

3. Is the forward-company aid post omitted as a unit? yes, no.

4. Are there platoon aid men? yes, no.

5. In assigning casualties for pickup by an aid team located at or near and aid post, is the priority criterion:

   a. the casualty reported at the earliest time?

   b. the casualty with the earliest time of wounding?

6. May a T&C station aid team relieve a forward-company aid team that has broken down? yes, no.

7. May a T&C station aid team relieve a rear-company aid team that has broken down? yes, no.

8. May an aid team of a rear-company aid post transport casualties directly to a T&C station if there is another active aid team attached to the post? yes, no.

9. Δ_2 = Maximum distance that a forward-company aid team will move along the FEBA from its last stop in order to pick up a reported casualty or relieve another aid team.

10. Numbers of different types of medical personnel belonging to a T&C station:[a]

   I. First Section
      a. Officers
      b. Enlisted Type A
      c. Enlisted Type B

   II. Second Section
      a. Officers
      b. Enlisted Type A
      c. Enlisted Type B

11. Patient-class data sets: 1.

12. Aid-team data sets: 1, 8.

13. Forward-company aid post data sets: 3, 4, 5.

14. Rear-company aid post data sets: 3, 4.

15. Treatment and collection station data sets: 3, 4, 8.

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[a] Personnel are listed in decreasing order of competence. It is assumed that more skilled personnel can do the jobs of less skilled personnel (if necessary).

E. Factors Affecting Delay in Reaching Patients.

1. φ = probability that a patient in a forward company will be accessible to the aid team's vehicle.

2. T_D = expected additional time delay in reaching a forward-company patient (or group of patients) if the patient is not accessible to the aid team's vehicle.

3. $\Phi_{sd}(t)$, $\Phi_{sn}(t)$ = day and night forms of the probability that t or fewer time units will be required to search for a patient (or group of patients) once an aid team reaches its reported location.

4. Δ_1 = Maximum distance at which a forward-company aid team can detect a casualty for the purpose of making a chance pickup.[a]

F. Communications

1. $\Phi_p(t)$ = probability that a message concerning the existence of a patient will reach the aid post in t or fewer time units.

2. Forward-company communications code:

(0) Aid teams do not receive messages from the company tactical net.

(1) Aid teams receive messages from the company tactical net, but there is no medical communications net for aid teams.

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[a] It is assumed that an aid team will make such detections only when stopped on or near the FEBA, since it is likely that a team moving parallel to the FEBA will keep a safe distance back from it, and will therefore be unlikely to make chance pickups.

(2) Aid teams receive messages from the company tactical net, and there is a medical communications net, but no dispatcher at aid post level.

(3) Aid teams receive messages from the company tactical net, and there is a medical communications net with a dispatcher at aid post level.

3. Rear-company communications code:

(0), (1), (2), (3) have the same meanings as they do in the forward-company code.

4. T&C station communications code:

(0) No radio communications between T&C stations and aid teams.

(1) One-way communications only, T&C station to aid teams.

(2) Two-way communications between T&C stations and aid teams.

5. T_B = expected delay in reporting aid team breakdown to the unit to which it is attached when there is no radio net available for the purpose.

G. Factors Affecting Movement Within the Medical System

1. C_T = number of time units required, over and above travel time, for the first section of a T&C station to relocate.

2. v_{1d}, v_{1n} = day and night travel speeds of aid teams along the FEBA.

3. v_{2d}, v_{2n} = day and night travel speeds of aid teams between forward-company aid posts and the FEBA.

4. v_{3d}, v_{3n} = day and night travel speeds of aid teams operating to the rear of forward-company aid posts.

5. v_w = average walking speed of an ambulatory patient.

6. T_R = expected time required for a replacement aid man to reach an aid post, once the need for a replacement is reported by an aid team.

H. Transport Load Capacity [a]

1. M_{FA} = number of units of transport space associated with an aid team attached to a forward-company aid post.

2. M_{RA} = number of units of transport space associated with an aid team attached to a rear-company aid post.

3. M_T = number of units of transport space associated with an aid team attached to a T&C station.

I. Breakdown & Repair of Aid Team Vehicles

1. ϕ_{FA} = probability that the vehicle of a forward-company aid team will break down during a given unit of time.

2. ϕ_{RA} = probability that the vehicle of a rear-company aid team will break down during a given unit of time.

3. ϕ_T = probability that the vehicle of a T&C station aid team will break down during a given unit of time.

4. $\Psi_{FA}(t)$ = probability that repairs on a broken-down vehicle of a forward-company aid team will require less than t time units.

5. $\Psi_{RA}(t)$ = probability that repairs on a broken-down vehicle of a rear-company aid team will require less than t time units.

6. $\Psi_T(t)$ = probability that repairs on a broken-down vehicle of a T&C station aid team will require less than t time units.

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[a] In an emergency, the simulation model allows a vehicle to carry slightly more than its capacity, but patient assignments are never made in excess of this capacity.

Functions Used in the Model to Express Patient Survival Probabilities

The following set of functions must be provided for each patient class considered in a simulated action:

$F_0(t)$	=	probability that a patient will be alive at time t if given no care.
$F_1(t; t_1)$	=	probability that a patient, having survived to receive aid-man care at time t_1, will be alive at time t with no higher-level treatment $(t \geq t_1)$.
$F_2(t; t_1, t_2)$	=	probability that a patient, having survived to receive aid-man care at time t_1 and treatment by a medical officer at t_2, will be alive at time t with no higher-level treatment $(t \geq t_2 \geq t_1)$.
$F_3(t_1, t_2, t_3)$	=	probability that a patient, having survived to receive aid-man care at t_1, treatment by a medical officer at t_2, and definitive treatment at t_3, will ultimately recover.

All times are measured from the onset of the ailment. Only two of these functions, $F_0(t)$ and $F(t; t_1)$, are required in Submodel I.

A preliminary examination into the nature of these functions indicates that nearly all conceivable patient classes can be represented by a relatively small number of function types (e.g., negative exponential function, linear step function). This means that a number of different patient classes will be represented by the same function, with only a change in function constants occurring from one patient class to the next. In programming the model for a computer, evaluation subroutines will be written only for the basic set of function types needed; then designations of the appropriate function types, together with the proper function constants, will be stored in each patient-class data set.

The above procedure will greatly reduce the amount of computer memory space required for the model, and will make it much easier to add or redefine patient classes. For example, suppose that $F_0(t)$ takes the form

$$A_1 e^{-A_2 t}$$

for patient class A, and the form

$$B_1 e^{-B_2 t}$$

for patient class B. Instead of writing a separate subroutine for the evaluation of each of these functions, only a subroutine for the negative exponential function is required. (A_1, A_2) is then stored in the data set of patient class A, along with a code number indicating that the negative exponential is the appropriate function type to be used, and similar information is stored for patient class B. The addition of other patient classes in which $F_0(t)$ takes the negative exponential form requires no additional computer programming.

Output of Submodel I

1. All patient data sets generated during a simulated action.[a]

2. The station-movement data set.[b]

3. The following values which are accumulated during a simulated action:

X_1 = total distance travelled by forward-company aid teams.

X_2 = total distance travelled by rear-company aid teams.

X_3 = total distance travelled by T&C-station aid teams.

Y_1 = total idle time of forward-company aid teams.

Y_2 = total idle time of rear-company aid teams.

Y_3 = total idle time of T&C-station aid teams.

Z_1 = total time that forward-company aid teams are broken down.

Z_2 = total time that rear-company aid teams are broken down.

Z_3 = total time that T&C-station aid teams are broken down.

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a/ Information from these data sets will be used to determine various waiting-time distributions. The data sets will also serve as part of the input to Submodel II.

b/ This data set will serve as part of the input to Submodel II.

Markers

Patient Marker I[a] (Used before a patient reaches an aid post).

1. Address of the patient data set.
2. Address of the data set of the aid post responsible for the area in which the patient is located initially.
3. If patient is ambulatory, the time at which he will arrive at the aid post; if patient is non-ambulatory, the time at which he will be reported to the aid post.
4. Units of transport space required by the patient.
5. (a) If the patient is waiting to be picked up, is he accessible to the aid team vehicle? yes, no. (b) If patient is ambulatory, is he walking to a first section of an aid post? yes, no.
6. Is the patient assigned for pickup by an aid team? yes, no.

Patient Marker II[a] (Used after a patient reaches an aid post).

1. Address of the patient data set.
2. Indicator as to whether the patient's next step will be:
   a. Treatment at a first section.
   b. Evacuation from a first section.
   c. Treatment at a second section.
   d. Evacuation from a second section.
3. Treatment priority.
4. Evacuation priority.
5. Time at which patient becomes ready for his next step.
6. Units of transport space required by the patient.

Aid Team Marker[b]

1. Address of the data set of the aid team that requires relief.
2. Address of the data set of the medical unit to which the aid team is attached.

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[a] There is a separate Patient Marker I or II constructed for each patient that is generated during the simulated action. Each marker consists of only one computer word.

[b] There is a separate Aid Team Marker constructed for each aid team that breaks down and requires relief. Each marker consists of only one computer word.

Counters, Registers, and Values Used in Performing the Simulation

Counters

1. Clock (gives the elapsed time from the start of the simulated action).
2. Line Movement Ctr (gives the number of time units left till the FEBA is to be moved).
3. Aid Team Ctr I, II.
4. Aid Post Ctr.
5. T&C Station Ctr.
6. Casualty Ctr.
7. Daylight Ctr.
8. Darkness Ctr.

Registers

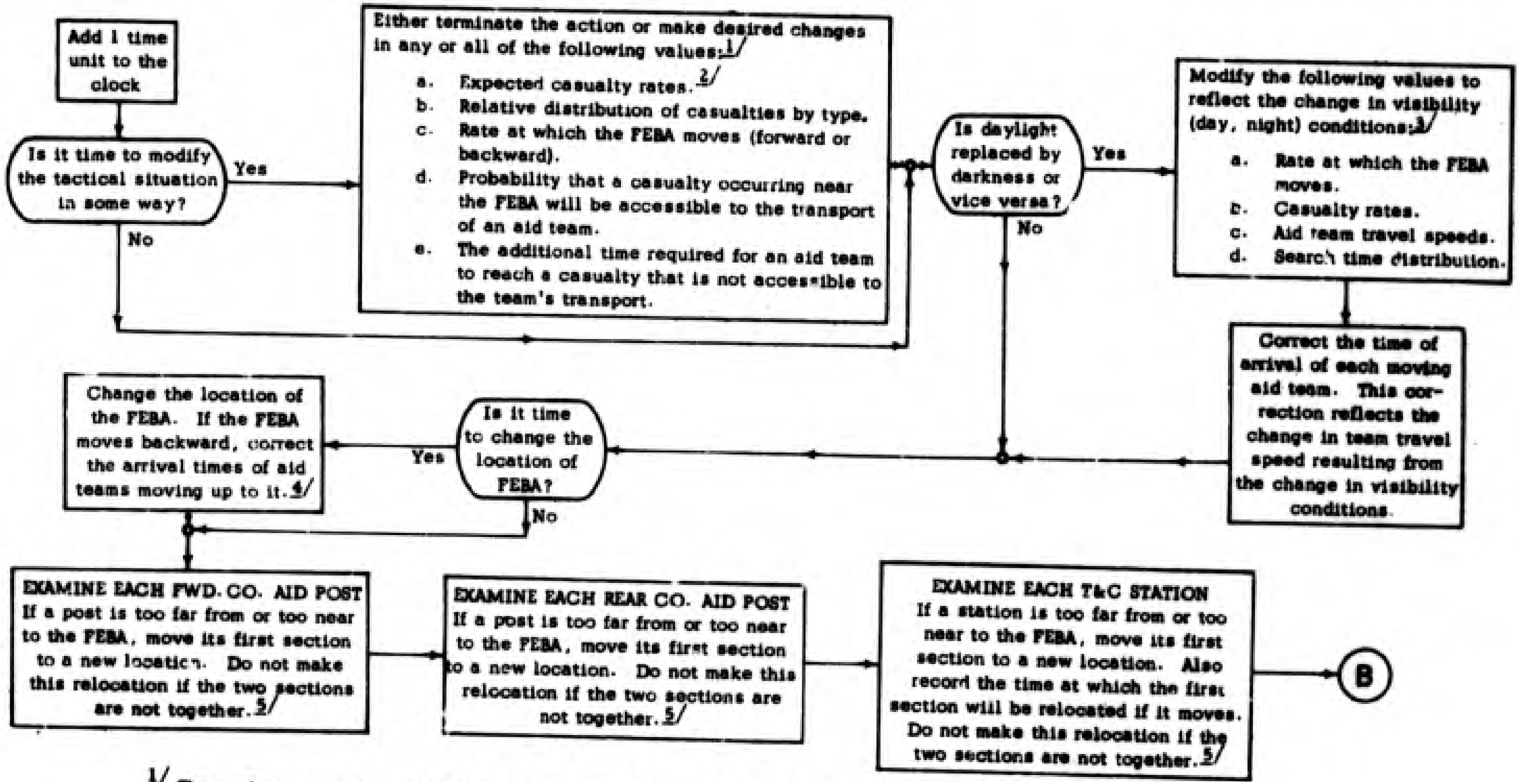
1. Station Movement Register (next available address in the station-movement data set).
2. Patient Data-Set Register (address to be used for the next new patient data set).
3. Patient Identification Register (identification number to be used for the next new patient).
4. Walking Wounded I Register (next available address in the walking wounded I data set).
5. Walking Wounded II Register (next available address in the walking wounded II data set).
6. Waiting Wounded Register (next available address in the waiting wounded data set).

Input Constants

1. N_A = number of aid team data sets.
2. N_{FP} = number of forward-company aid post data sets.
3. N_{RP} = number of rear-company aid post data sets.
4. N_T = number of T&C station data sets.
5. A_1 = address of the first-listed forward-company aid post.
6. A_2 = address of the first-listed rear-company aid post.
7. A_3 = address of the first-listed T&C station. $(A_1 < A_2 < A_3)$
8. Lowest address of a patient data set.
9. Highest address allowed for a patient data set.

Other Values

1. XXX = largest possible value that can be contained in a word or part of a word.
2. x_L = x-coordinate of the FEBA.



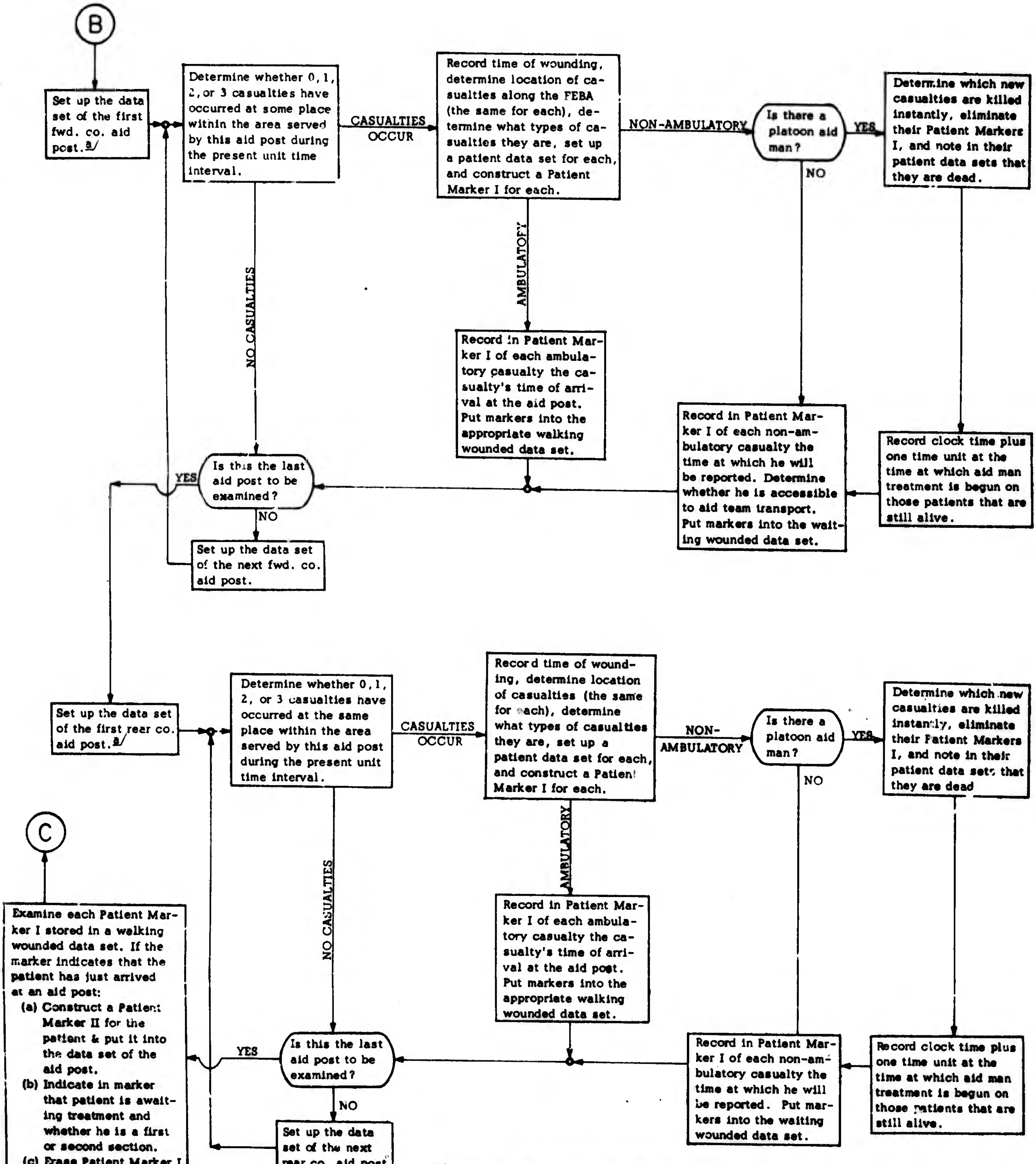
1/ These changes may be made at any desired time during the situation, and are read into the computer automatically.

2/ Here the term casualty refers not only to wounding, but also to injury and disease.

3/ The number of hours of daylight in a day may be any desired value.

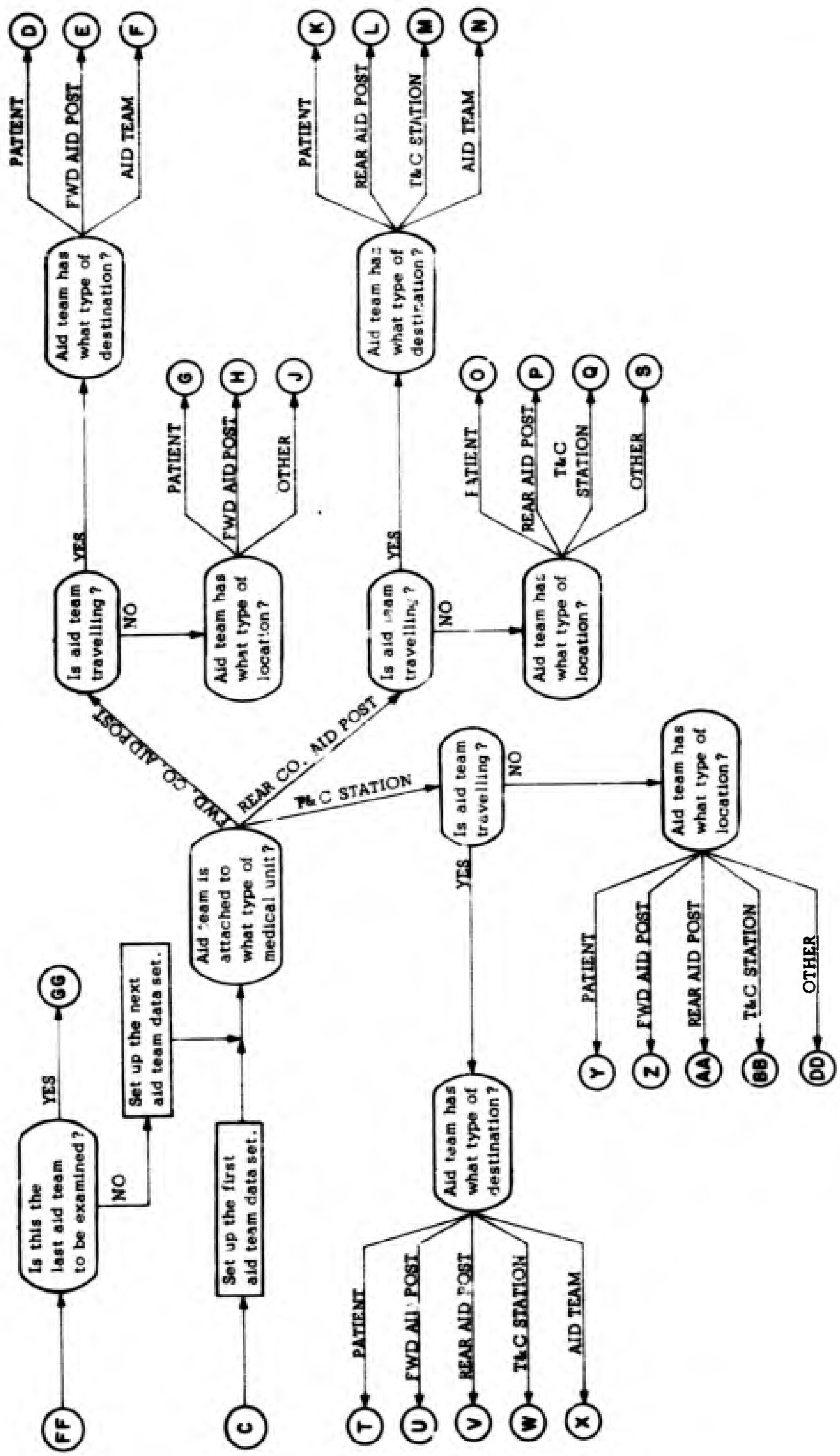
4/ If the FEBA moves backward, it is assumed that casualties are moved back with it until an aid team reaches them.

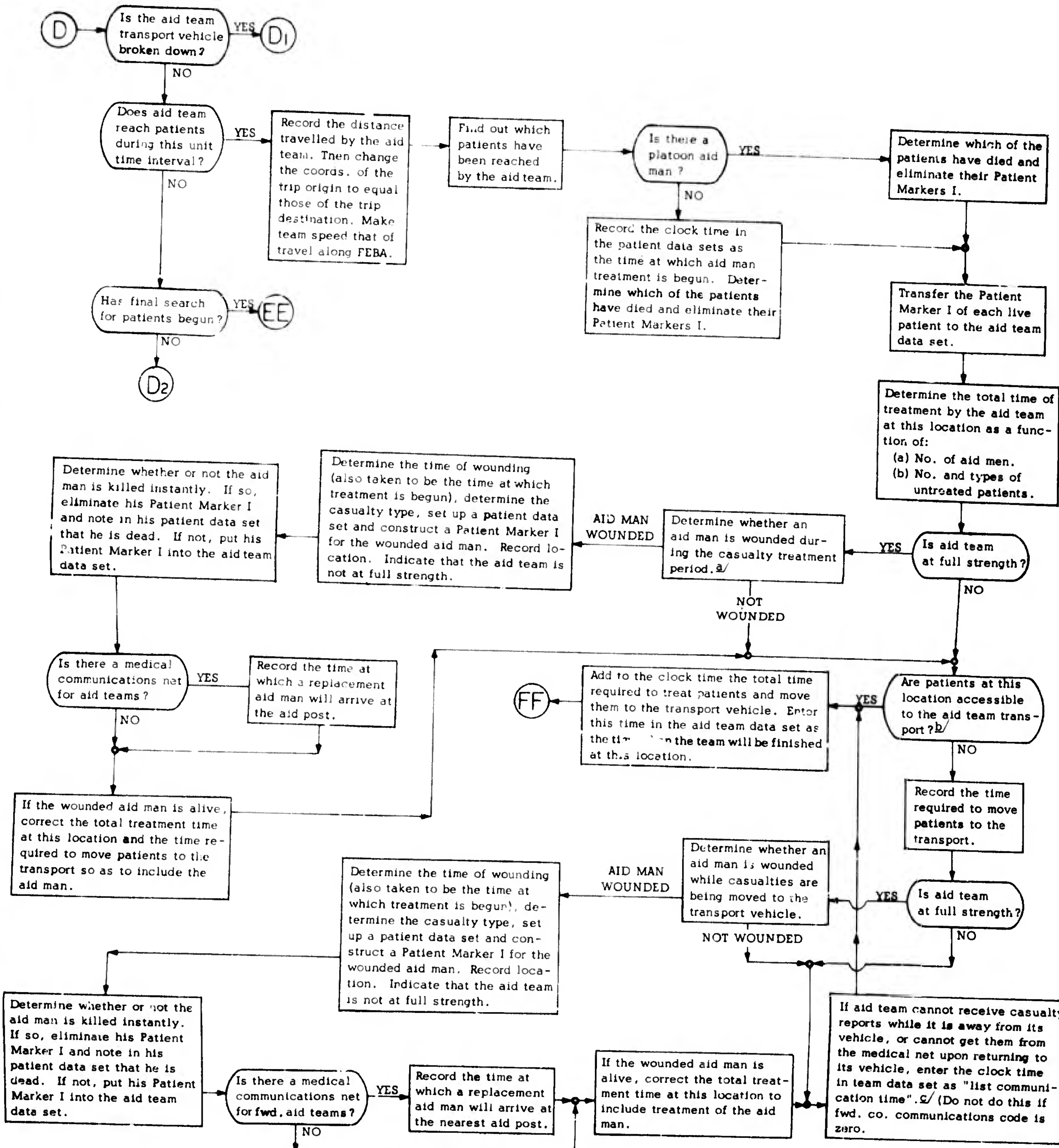
5/ If a unit is too far from the FEBA, its first section is moved to the minimum desirable distance; if too near the FEBA, its first section is moved to the maximum desirable distance. These distances may have any desired values. However, the same values must be selected for all forward company aid posts.



a/ If desired, the aid post may serve an area smaller or larger than that of a company. The term "company aid post" is used merely for convenience.

3

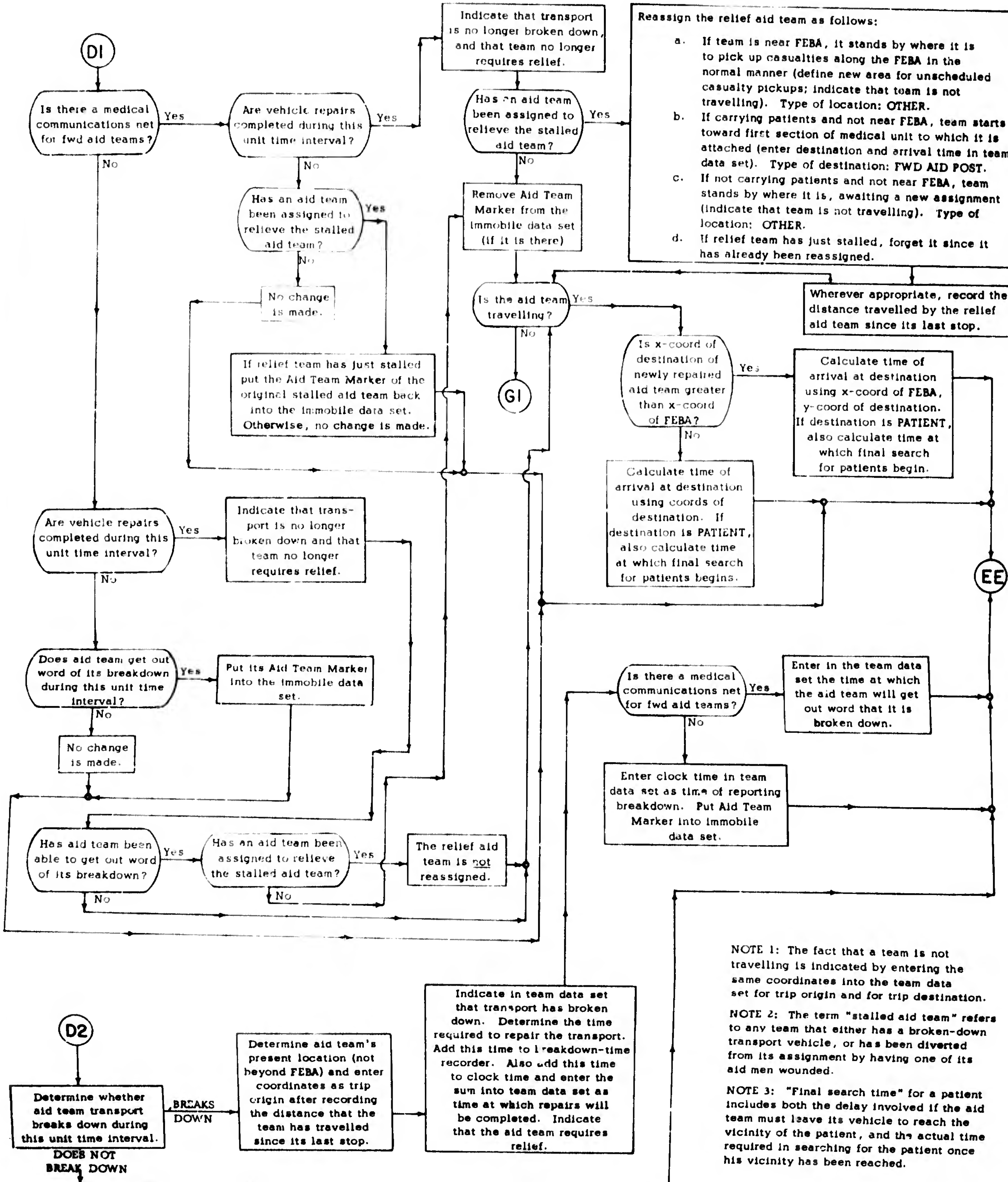

FF
Is this the last aid team to be examined?
YES
GG
NO
Set up the next aid team data set.
C
Set up the first aid team data set.
Aid team is attached to what type of medical unit?
FWD. CO. AID POST
REAR CO. AID POST
T&C STATION
Is aid team travelling?
YES
NO
Aid team has what type of destination?
PATIENT
FWD AID POST
AID TEAM
D
E
F
Aid team has what type of location?
PATIENT
FWD AID POST
OTHER
G
H
J
Is aid team travelling?
YES
NO
Aid team has what type of destination?
PATIENT
REAR AID POST
T&C STATION
AID TEAM
K
L
M
N
Aid team has what type of location?
PATIENT
REAR AID POST
T&C STATION
OTHER
O
P
Q
S
Is aid team travelling?
YES
NO
Aid team has what type of destination?
PATIENT
FWD AID POST
REAR AID POST
T&C STATION
AID TEAM
T
U
V
W
X
Aid team has what type of location?
PATIENT
FWD AID POST
REAR AID POST
T&C STATION
OTHER
Y
Z
AA
BB
DD



a/ Aid teams consisting of either 2 or 3 men may be considered. The probability that an aid man of a team will be wounded during a given time interval is proportional to the number of men on the team.

b/ It may be necessary for two aid men to leave the team transport vehicle and walk some distance to reach the casualties.

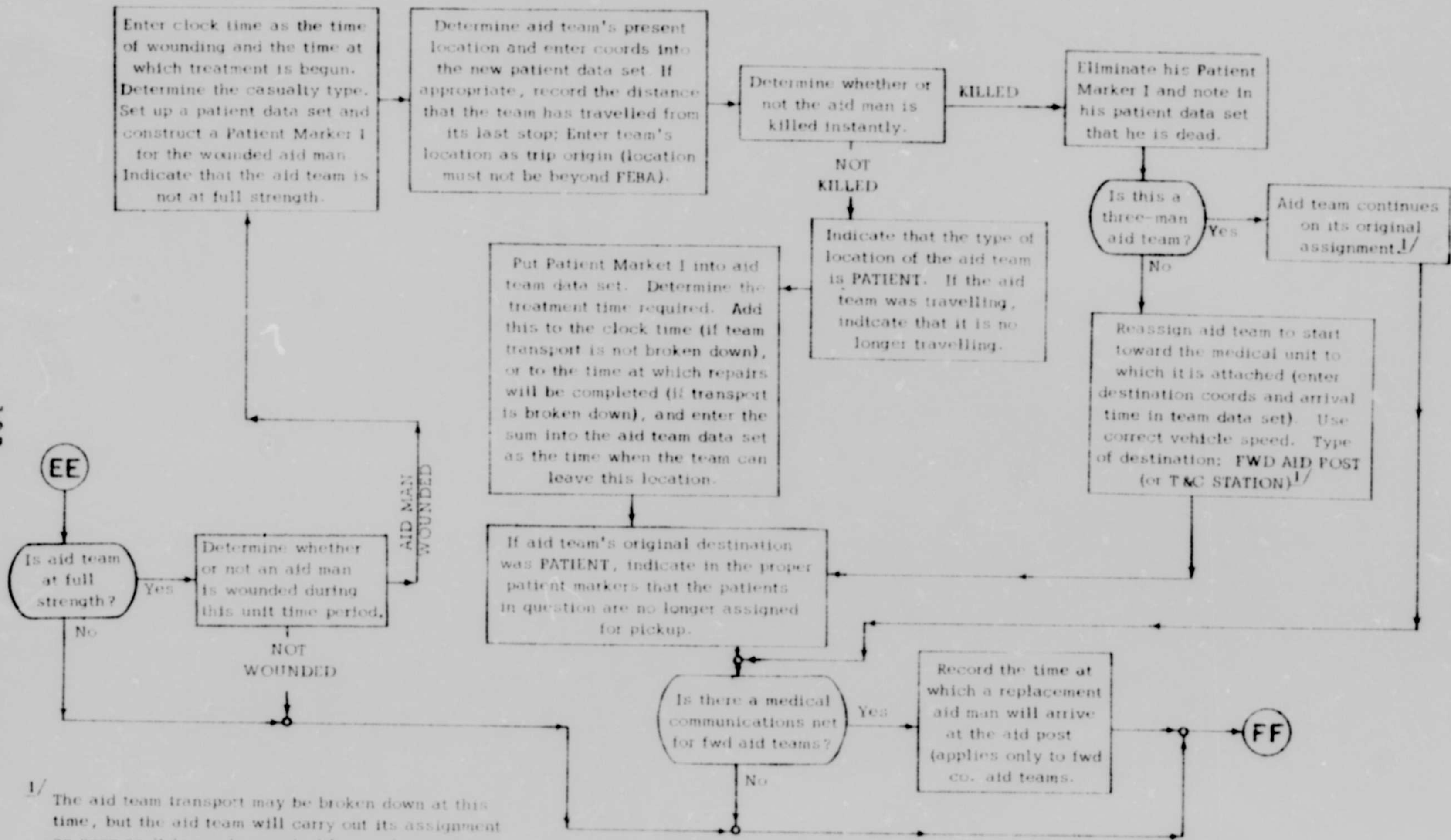
c/ This case should be distinguished from another possible case in which forward company aid teams never receive radio communications at any time and must always return to the aid post to learn of new casualty reports.



NOTE 1: The fact that a team is not travelling is indicated by entering the same coordinates into the team data set for trip origin and for trip destination.

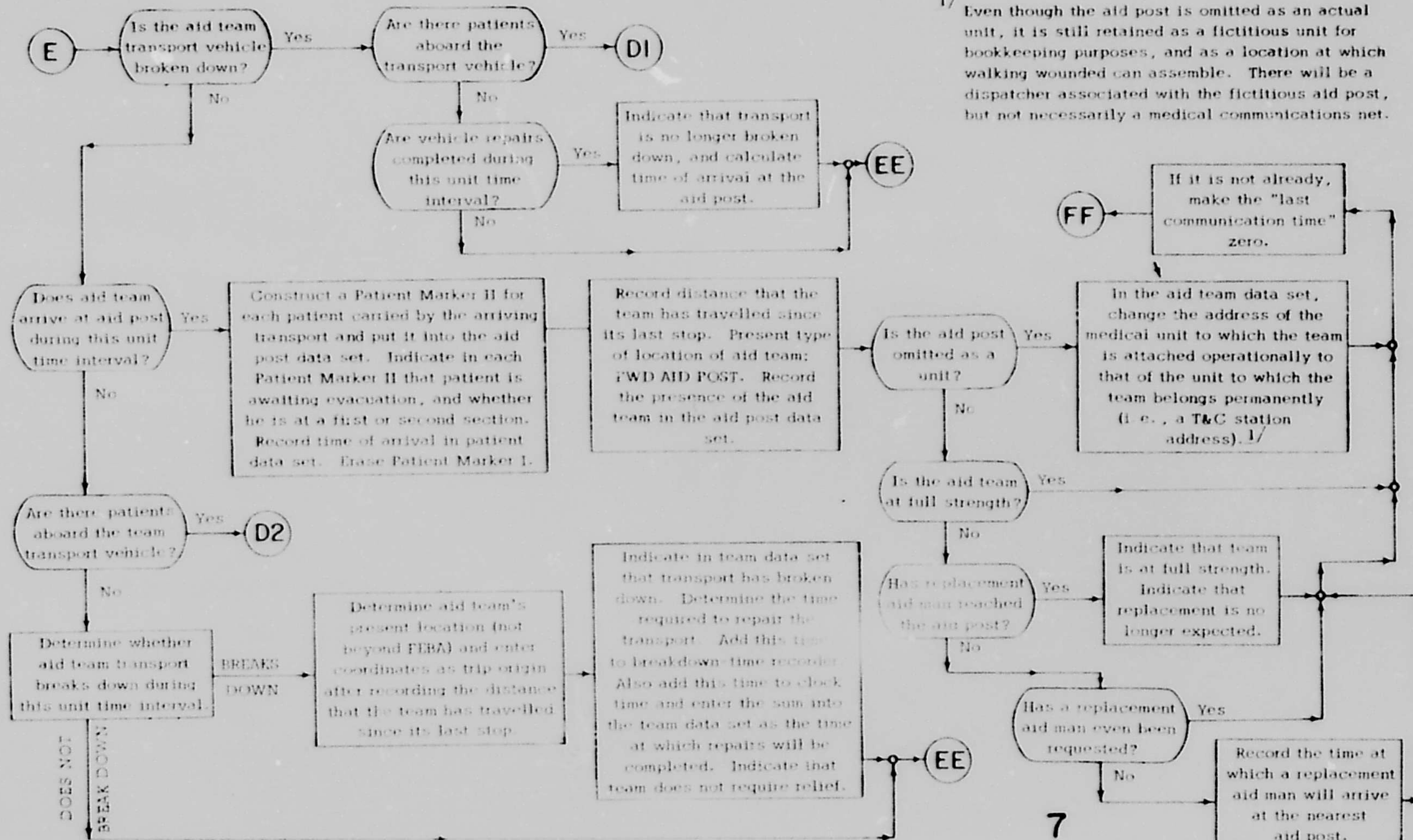
NOTE 2: The term "stalled aid team" refers to any team that either has a broken-down transport vehicle, or has been diverted from its assignment by having one of its aid men wounded.

NOTE 3: "Final search time" for a patient includes both the delay involved if the aid team must leave its vehicle to reach the vicinity of the patient, and the actual time required in searching for the patient once his vicinity has been reached.

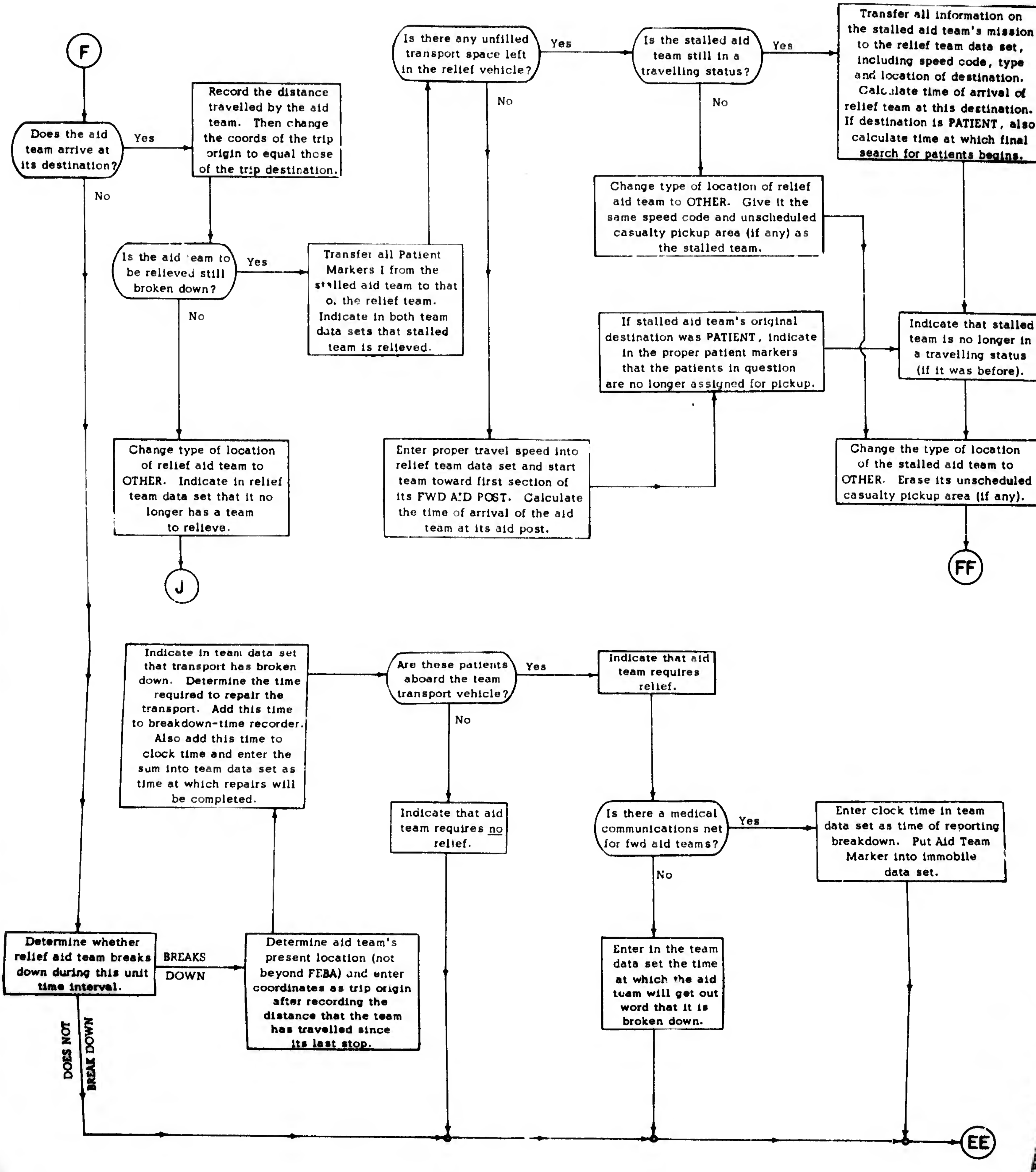


1/ The aid team transport may be broken down at this time, but the aid team will carry out its assignment as soon as it is moving again (if not relieved in the meantime).

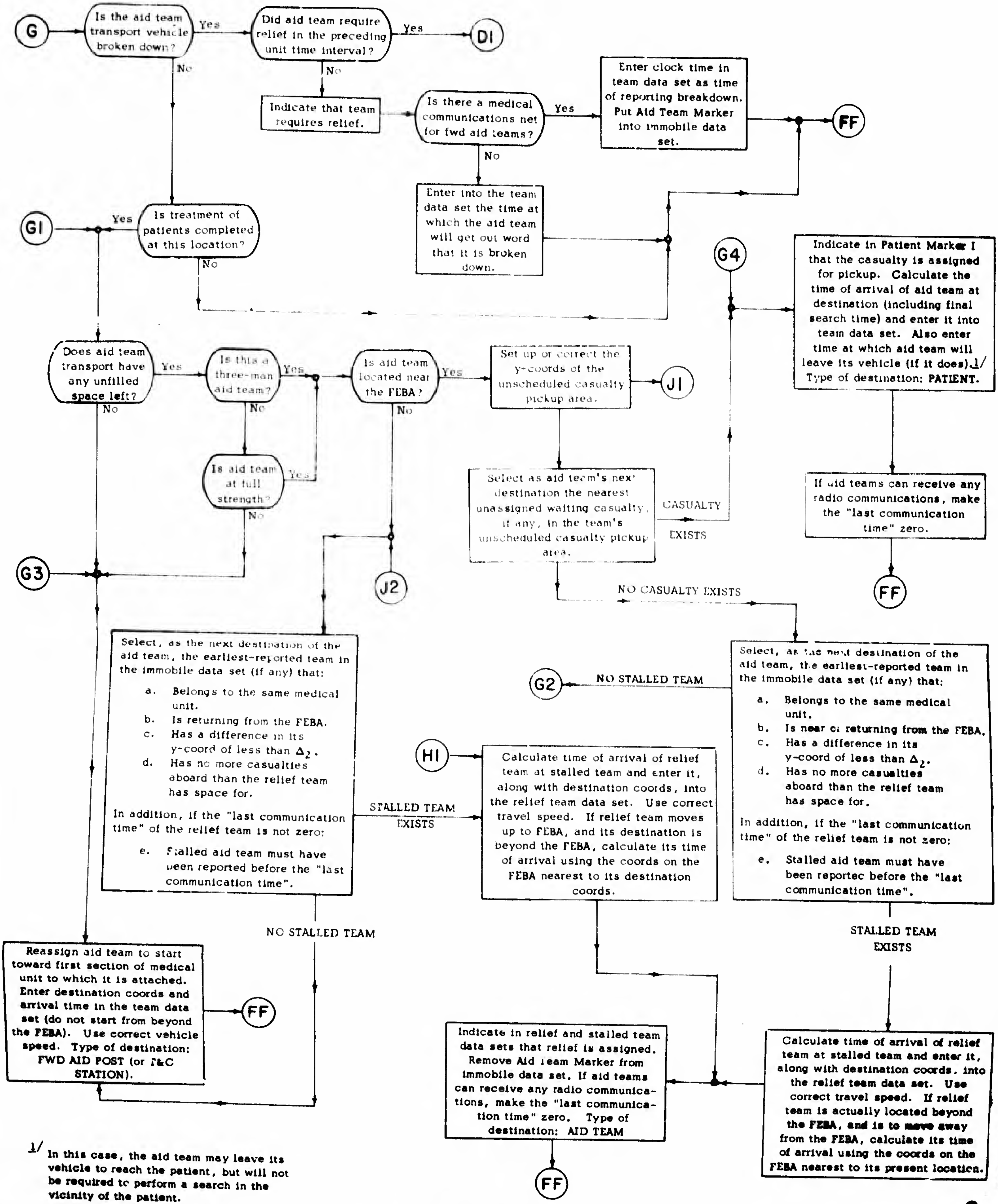
6



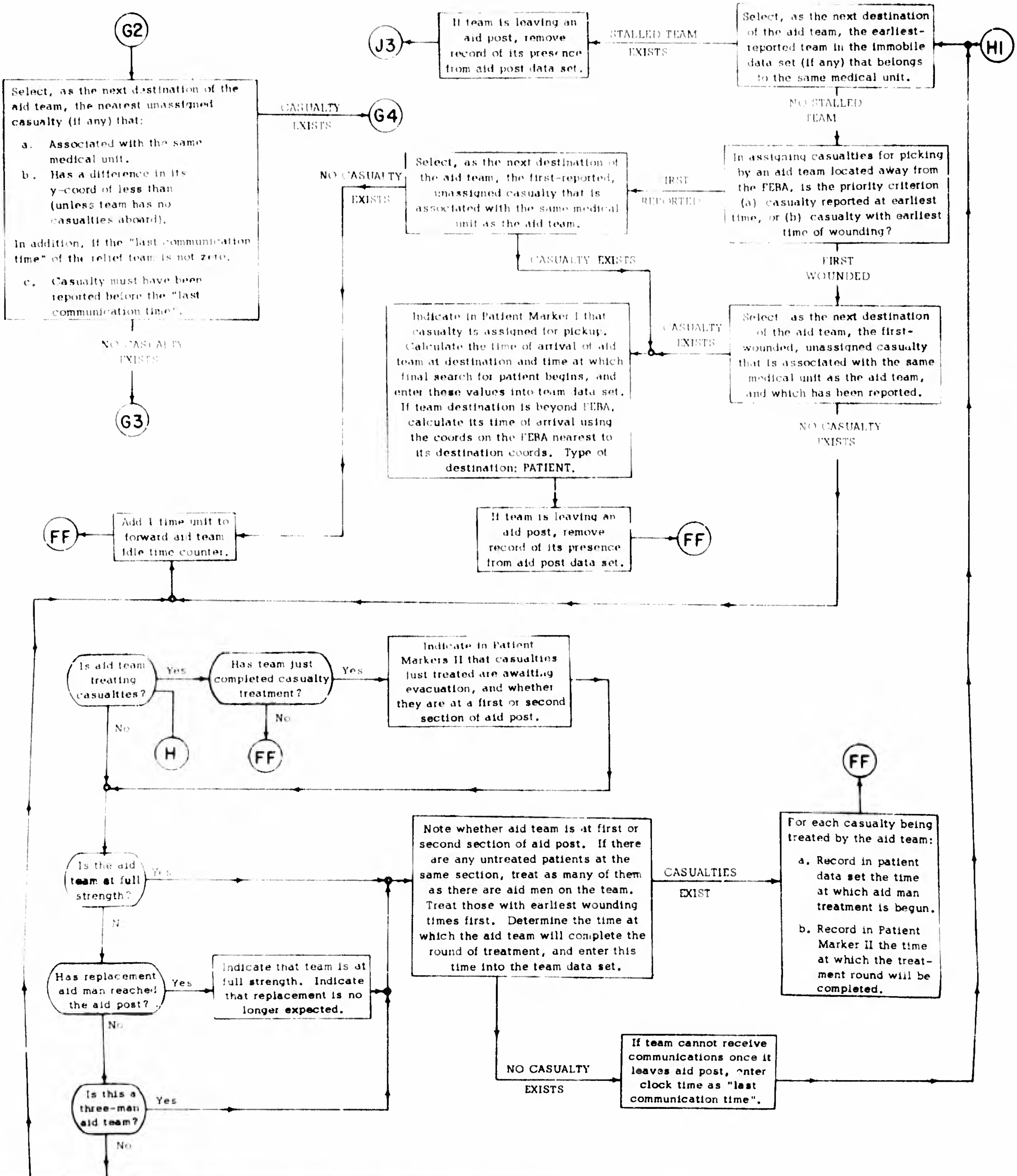
1/ Even though the aid post is omitted as an actual unit, it is still retained as a fictitious unit for bookkeeping purposes, and as a location at which walking wounded can assemble. There will be a dispatcher associated with the fictitious aid post, but not necessarily a medical communications net.

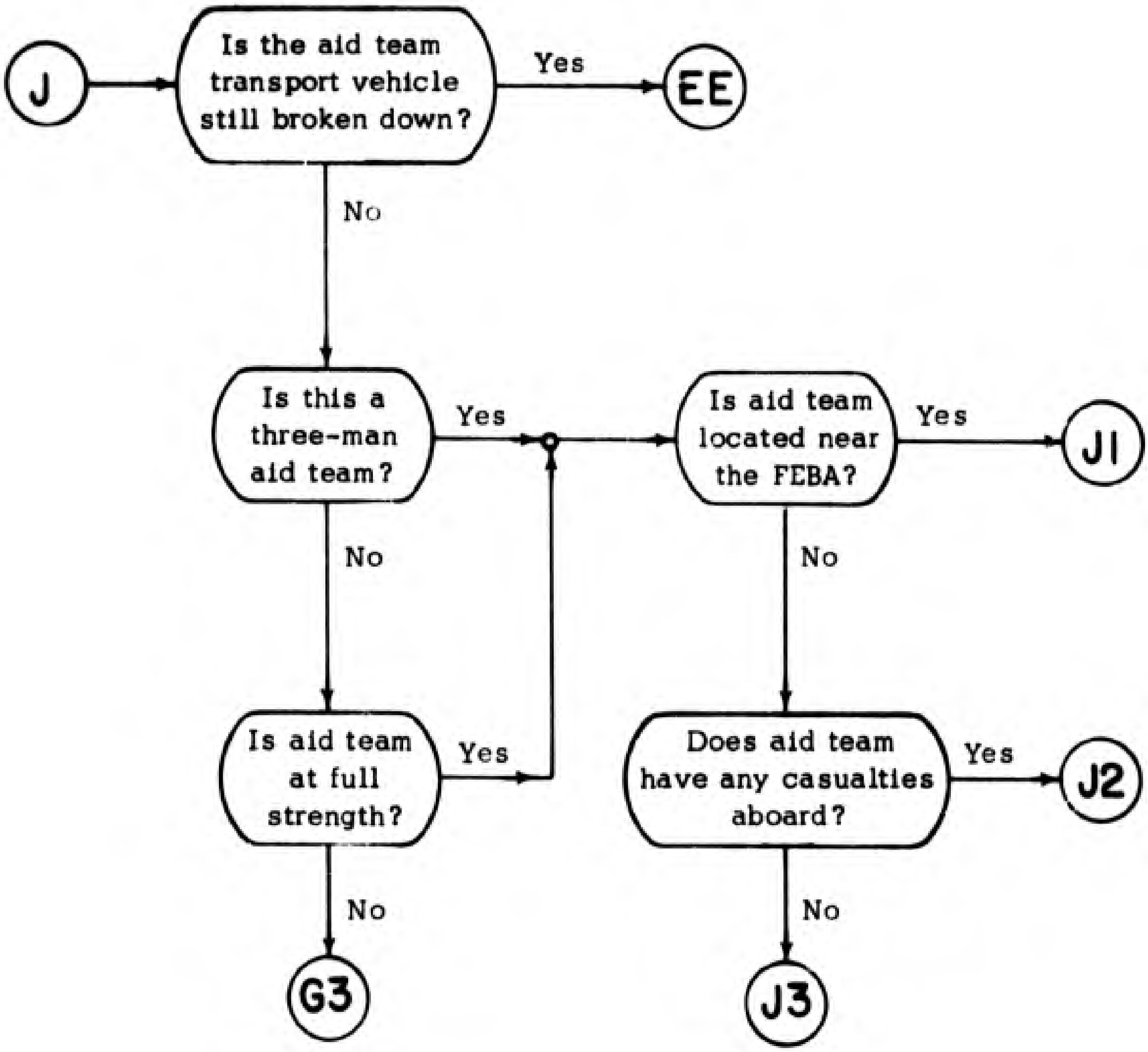


F
Does the aid team arrive at its destination?
Yes
No
Record the distance travelled by the aid team. Then change the coords of the trip origin to equal those of the trip destination.
Is the aid team to be relieved still broken down?
Yes
No
Transfer all Patient Markers I from the stalled aid team to that of the relief team. Indicate in both team data sets that stalled team is relieved.
Change type of location of relief aid team to OTHER. Indicate in relief team data set that it no longer has a team to relieve.
J
Is there any unfilled transport space left in the relief vehicle?
Yes
No
Enter proper travel speed into relief team data set and start team toward first section of its FWD AID POST. Calculate the time of arrival of the aid team at its aid post.
Is the stalled aid team still in a travelling status?
Yes
No
Change type of location of relief aid team to OTHER. Give it the same speed code and unscheduled casualty pickup area (if any) as the stalled team.
If stalled aid team's original destination was PATIENT, indicate in the proper patient markers that the patients in question are no longer assigned for pickup.
Transfer all information on the stalled aid team's mission to the relief team data set, including speed code, type and location of destination. Calculate time of arrival of relief team at this destination. If destination is PATIENT, also calculate time at which final search for patients begins.
Indicate that stalled team is no longer in a travelling status (if it was before).
Change the type of location of the stalled aid team to OTHER. Erase its unscheduled casualty pickup area (if any).
FF
Determine whether relief aid team breaks down during this unit time interval.
BREAKS DOWN
DOES NOT BREAK DOWN
Determine aid team's present location (not beyond FEBA) and enter coordinates as trip origin after recording the distance that the team has travelled since its last stop.
Indicate in team data set that transport has broken down. Determine the time required to repair the transport. Add this time to breakdown-time recorder. Also add this time to clock time and enter the sum into team data set as time at which repairs will be completed.
Are these patients aboard the team transport vehicle?
Yes
No
Indicate that aid team requires no relief.
Indicate that aid team requires relief.
Is there a medical communications net for fwd aid teams?
Yes
No
Enter in the team data set the time at which the aid team will get out word that it is broken down.
Enter clock time in team data set as time of reporting breakdown. Put Aid Team Marker into immobile data set.
EE



1/ In this case, the aid team may leave its vehicle to reach the patient, but will not be required to perform a search in the vicinity of the patient.


G2
Select, as the next destination of the aid team, the nearest unassigned casualty (if any) that:
a. Associated with the same medical unit.
b. Has a difference in its y-coord of less than (unless team has no casualties aboard).
In addition, if the "last communication time" of the relief team is not zero,
c. Casualty must have been reported before the "last communication time".
CASUALTY EXISTS
G4
NO CASUALTY EXISTS
G3
J3
If team is leaving an aid post, remove record of its presence from aid post data set.
STALLED TEAM EXISTS
Select, as the next destination of the aid team, the earliest-reported team in the immobile data set (if any) that belongs to the same medical unit.
H1
NO STALLED TEAM
In assigning casualties for picking by an aid team located away from the FEBA, is the priority criterion (a) casualty reported at earliest time, or (b) casualty with earliest time of wounding?
FIRST REPORTED
Select, as the next destination of the aid team, the first-reported, unassigned casualty that is associated with the same medical unit as the aid team.
NO CASUALTY EXISTS
CASUALTY EXISTS
FIRST WOUNDED
Select, as the next destination of the aid team, the first-wounded, unassigned casualty that is associated with the same medical unit as the aid team, and which has been reported.
CASUALTY EXISTS
NO CASUALTY EXISTS
Indicate in Patient Marker I that casualty is assigned for pickup. Calculate the time of arrival of aid team at destination and time at which final search for patient begins, and enter those values into team data set. If team destination is beyond FEBA, calculate its time of arrival using the coords on the FEBA nearest to its destination coords. Type of destination: PATIENT.
If team is leaving an aid post, remove record of its presence from aid post data set.
FF
Add 1 time unit to forward aid team idle time counter.
FF
Is aid team treating casualties?
Yes
No
H
Has team just completed casualty treatment?
Yes
No
FF
Indicate in Patient Markers II that casualties just treated are awaiting evacuation, and whether they are at a first or second section of aid post.
Is the aid team at full strength?
Yes
N
Has replacement aid man reached the aid post?
Yes
No
Indicate that team is at full strength. Indicate that replacement is no longer expected.
Is this a three-man aid team?
Yes
No
Note whether aid team is at first or second section of aid post. If there are any untreated patients at the same section, treat as many of them as there are aid men on the team. Treat those with earliest wounding times first. Determine the time at which the aid team will complete the round of treatment, and enter this time into the team data set.
CASUALTIES EXIST
NO CASUALTY EXISTS
If team cannot receive communications once it leaves aid post, enter clock time as "last communication time".
FF
For each casualty being treated by the aid team:
a. Record in patient data set the time at which aid man treatment is begun.
b. Record in Patient Marker II the time at which the treatment round will be completed.


J
Is the aid team transport vehicle still broken down?
Yes
EE
No
Is this a three-man aid team?
Yes
Is aid team located near the FEBA?
Yes
J1
No
No
Is aid team at full strength?
Yes
Does aid team have any casualties aboard?
Yes
J2
No
G3
No
J3

APPENDIX B

MEDICAL TASKS

INTRODUCTION

B.1 The current phase of the study is directed toward developing theory relating the effectiveness of the medical support system for a field army to organization and staffing. Methods by which medical objectives are accomplished are preventive in nature, in that every medical measure is designed to prevent some type of undesirable outcome. Examples include prevention of: disease; accidental injury; certain types of battle injury through specification of human requirements for body armor, protective clothing and other protective equipment; deaths avoidable by early and/or improved medical care; clinical complications and, inefficient use of hospital facilities. The present study is concerned with those measures which are pertinent to support of a field army. Inherent in the problem, however, are consideration of research and development potential for medicine and surgery, and for improved methods and field equipment for support of medical units for care and movement of patients in future combat situations.

B.2 In determining support requirements for a field army, it is essential to consider the general medical care including preventive measures, disease and injury such as is required for any population, as well as the special requirements determined by the constraints imposed in a military situation. In addition to the workload imposed by the general medical care, a supplementary burden is imposed by the influence of combat on hospitalization requirements for psychiatric cases and disease, and for continuation of care of the patient throughout convalescence until he is completely fit for duty. Further, medical management involves work unique to a combat situation such as: location and transport of the wounded patients; movement and supply of medical units; treatment with limited medical equipment at forward echelons and successive levels of treatment at the higher echelons; performance of administrative duties under field conditions; sanitation; maintenance and improvisation. This situation has always existed in the past; some aspects may well be even more serious in future conflicts. The military organization and policies also impose special duties upon professional, ancillary, and the administrative and support personnel which have no counterpart in civilian medical care systems.

Measures of Effectiveness

B.3 The mission of the Army Medical Service has traditionally been that of conserving troop strength. The degree of conservation can be conveniently measured by: (1) the recovery rates of casualties, (2) the proportion of patients returning to duty, and (3) the degree of promptness in returning the sick and wounded to duty. For any given level of effectiveness, there exists a certain theoretical optimum level of staffing and equipping of medical units. These factors then become a function of the patient workload, in relation to the medical manpower capability in handling this workload.

B.4 Effects of Delays in Treatment

For battlefield injuries, the success with which modern medical measures can be applied effectively depends upon the time after injury when treatment is instituted, and the times subsequent to this when treatment measures of increasing complexity are continued. Delays in reaching any of the various levels of medical care carry with them certain predictable hazards. Specifically, these hazards can be represented as the probabilities of casualties sustaining additional, preventable, complications. Each preventable complication, when it occurs, becomes equivalent to the addition of a new casualty to the total patient workload.

B.5 For each of the various possible types of casualties, there exist certain predictable degrees of delay beyond which the hazard of developing complications increase with time, and certain predictable types of complications exist which are likely to be superimposed if excessive delay occurs. In general, the level of medical treatment feasible for forward, non-hospital, medical units is the sort which, when successful, prevents the development of complications. This level will be subsequently referred to as "resuscitative care." For the more serious types of casualties, another level of care which is feasible only in hospital units is needed to restore the patients to good health. This level will be referred to as "definitive care."

B.6 The mechanisms which determine the level of effectiveness of a medical support system are, therefore, the physiological and pathological responses of the body to injury. These progress for certain periods of time, but may be controlled or reversed by means of proper application of medical knowledge; delays in doing so risk the hazard of added clinical complications. These complications impose the burden of both added medical workload and excessive loss of troop strength. Preventable complications, resulting from delay in treatment, result in increased mortality, increased disability, and increased periods of hospitalization.

B.7 The effectiveness of the medical support system in minimizing the undesirable effects of delay on outcome will be determined by the adequacy of staffing, distribution, and equipment of the medical units in the combat zone. Conversely, optimum medical TOE's can be determined by making estimates of the probable patient workload, the medical man-hours required to handle the workload, and the various types of delay times attendant upon the recovery and evacuation of patients.

Method of Study

B.8 Patient Workload

A way of arriving at reliable estimates of the medical workload in future military operations is needed; for the purposes of the study, tentative estimates are made on the basis of past military experience. More sophisticated methods appear to be feasible, based on a knowledge of the physical properties of weapon effects on the one hand, and the available knowledge of the body's response to injury on the other. A method of classifying all possible patients according to criteria from which medical task requirements can be derived is proposed. Due regard must be given to the occurrence of non-battle casualties which represent the continuing but varying baseline workload of the medical service both in and out of combat.

B.9 Medical Management

The capacity of the medical service to handle its patient workload will be a function of three factors: (a) the number of available man-hours, (b) the level of skill of various personnel, and (c) the system of echeloning used in the deployment of personnel in respect to the location of casualties. Times required for performing the various component medical tasks are estimated and the tasks defined. These tasks are related to the possible casualty types.

B.10 Measurement of Outcome

Essential to an understanding of the ways in which medical support systems influence the ultimate outcome of casualties is a knowledge of the processes of injury and disease in relation to the reparative mechanisms of the human body. These mechanisms are outlined, and from this kind of knowledge estimates are made of the probable outcomes of the various types of casualties according to their probabilities of pursuing complicated or uncomplicated clinical courses. Estimates are presented to indicate the percentages of each class of casualty which, when subjected to different degrees of delay in treatment, are likely to follow various courses in respect to death, disability, and period of hospitalization.

Recapitulation

B.11 The current phase of the study is directed to developing the theory relating the medical support system for a field army to organization and staffing. Emphasis is placed upon criteria and methods of development. Achievement of this objective within the time available involves assumptions concerning doctrine, casualty distribution, management times upon entering medical channels, and clinical complications. The quantitative values, while plausible and derived from factual bases and experienced judgement, do not represent a particular occurrence in the past. It has been determined that means for refinement of quantitative data and pertinent concepts exist. These means can be utilized in development of inputs in the subsequent phases of the study more reliably to predict effectiveness of alternative medical support systems under conditions of future combat.

PATIENT WORKLOAD

Classification System

B.12 The patient workload is determined by the medical attention required for patients suffering from disease, including neuropsychiatric conditions, and trauma from wounding or non-battle injury. Each of the two major catagories is made up of many subclasses, which in turn include numerous specific medical conditions. A medical management requirement is associated with each condition. This requirement can be described in terms of the times and the medical capabilities needed for the handling and treatment of the patient at successive echelons of the medical support system.

B.13 The number and composition of the medical units in the support system will be based upon knowledge of the capability of alternative organization in handling estimated patient workloads. It is necessary, then, to adopt a system of classification of patients which adequately reflects medical management requirements and is suitable for use in the model for evaluation of alternative TOE.

B.14 Criteria for Selection of a Classification System. The system proposed envisages the problem of classification in functional, operational terms consisting of various steps in a multi-stage screening process of increasing degrees of specificity. Such a system of classification must meet the following criteria:

a. Convey the information required to make decisions for treatment and disposition at each stage in the sequence of medical management.

b. Reflect clinical realities with due regard to the dynamic equilibrium between the biological processes which determine deterioration and recovery of the patient.

c. Enable definition of medical management requirements in terms of tasks, disposition and time for every type of condition.

d. Be sufficiently general to be adaptable to different types of casualty spectra.

B.15 Steps in the Classification System. A classification system is presented which will convey the information needed to make decisions for each step in the medical management chain. The steps are:

a. First will be the simple screening of patients into two groups: those to receive medical care from those which do not receive care. The latter will be made up of minor casualties not needing medical care, postponable casualties, and the KIA. Only the former group will enter medical channels.

b. The second stage divides patients into groups according to their degree of ambulation (litter cases, semi-ambulatory and ambulatory). At this stage of classification the priorities and mode of evacuation to the next higher echelon of medical care will be determined.

c. The third stage divides patients into medical and surgical categories and according to the degree of severity of the clinical condition.

d. The fourth stage divides casualties in respect to the likelihood of their developing specific complications, which then determines the nature and amount of treatment required to prevent or correct these complications.

e. Ultimately, at the time of final disposition of casualties, the standard medical diagnostic classification system would apply.

B.16 The steps and classes of conditions associated with each step are summarized in the following table.

B.17 Definitions are given to serve as rules in classifying patients.

DEFINITIONS

A. Battle Wounds and Non-Battle Injuries

a. Minor: A degree of injury which is sufficiently great to justify brief medical attention (although in many cases no specific treatment is indicated) but not sufficient to cause more than minor degree of incapacitation. These patients may not go beyond the aid man. Capacity to perform duty would not be impaired by more than 20% for the first day. In general, minor injuries can be sent back to duty within a few hours. A small percentage of minor injuries can be expected to develop subsequent complications, the commonest example being that of infection superimposed on a minor wound, and would be treated as a new casualty.

Examples: Contusions, small lacerations of non-essential (from point-of-view of military duty) parts of body, most sprains (back and ankle sprain often would fall under the moderate category), foreign body in eye.

b. Moderate: A degree of injury which requires the attention of a medical officer and is sufficiently incapacitating to require brief periods of hospitalization (less than 30 days), except for a small percentage which would respond to relatively unspecialized treatment at the dispensary or aid station level. This entire group will show a high probability of complete restoration of health following definitive treatment.

Examples: Simple fractures, severe sprains (especially back and ankle), lacerations and perforating wounds of head (not brain) and extremities, moderate but superficial wounds of chest and abdomen, concussion with unconsciousness, loss of blood sufficient to require replacement but without obvious signs of shock, wounds requiring small amount of debridement. In general, wounds requiring surgical treatment of an unspecialized type.

TABLE B. 1

Patient Classification		
Step	Classification, general	Specific
1.	Need for medical care	a. Yes b. No
2.	Ambulation	a. Litter b. Semi-ambulatory c. Ambulatory
3.	Treatment and Source	a. Surgical: (1) Battle Injuries (2) Non-Battle b. Medical: (1) Disease (2) Psychiatric
4.	Severity	a. Minor b. Moderate c. Severe
5.	Complications - prevention and/or treatment	a. Hemorrhage - shock b. Infection c. Dest. vital tissue
6.	Hospital Requirement	a. General b. Special
7.	Disposition	a. Return to combat duty b. Return to non-combat duty c. Permanent disability d. Death
8.	Final Records	a. Standard diagnostic nomenclature

c. Severe: Injuries which are completely incapacitating, requiring specialized surgical and hospital facilities for adequate treatment. They would include all those injuries which are more serious than the types mentioned above. Fairly long periods of hospitalization are usually required (more than 30 days).

Examples: Compound fractures, perforating wounds of abdomen, chest and skull; wounds requiring extensive debridement; shock; grossly contaminated wounds; strangulated hernias, perforated ulcers.

B. Disease

a. Minor: Medical conditions sufficiently severe to require medical attention, but capable of return to duty after examination or treatment. Trained aid men might handle some of these cases.

Examples: Minor upper respiratory infections (temperatures under 100°), uncomplicated urethritis, localized infections, gastro-intestinal disturbances of minor nature, hay fever, mild sinusitis.

b. Moderate: Medical conditions requiring the services of a medical officer, incapacitating for short periods of time with high probability of restoration to good health. Usually they would require hospitalization, although some might be capable of return to light duty, to be followed up at aid station for subsequent treatment.

Examples: Upper respiratory infections with fever over 100°, malaria, dengue fever, contagious diseases, moderate dysentery.

c. Severe: Incapacitating medical conditions usually requiring hospitalization for more than 30 days.

Examples: Coronary attacks, pneumonia, rheumatic fever, hepatitis.

C. Psychiatric Casualties

a. Minor: Mild anxiety or depressive reactions which can be alleviated by brief rest and reassurance, and can be returned to duty within a few hours.

b. Moderate: Definite signs of "combat fatigue" which have been in evidence for several days. These would be sufficiently disabling to require temporary relief from duty, or reassignment, but not sufficiently severe to require prolonged hospitalization.

c. Severe: Serious "combat fatigue", or reactivation of previous serious psychiatric problems, requiring hospitalization and subsequent noncombat assignment. Recognizable by virtue of serious deterioration of performance of duties.

D. Summary

a. Minor Casualties: Require brief, unspecialized medical attention, return to duty within a few hours, capable of performing 80-90% of usual duties.

b. Moderate Casualties: Usually require hospitalization of 1-30 days but not of highly specialized nature, back to regular duty at end of this time. Exceptions would be those cases which could be sent back to light duty when this is either feasible or expedient from the tactical viewpoint, with follow-up OPD treatment.

c. Severe Casualties: Totally incapacitating for more than 30 days, requiring specialized surgery or medical management. Unlikely to return to combat duty.

B.18 Further examples of classification of specific clinical conditions in relation to severity classification of clinical complications are shown in the following tables.

Generalizations Applicable to All Feasible Systems

B.19 In the screening process, three distinct stages will apply to any system of medical support. They are (1) the initial discovery and identification of casualties (which could take place on the battlefield by an aid man, at one extreme, or at the admission service of a hospital at the other extreme), (2) preparation of casualties for definitive treatment (resuscitative care, first aid, admission examination or prophylactic treatment), (3) administration of definitive treatment (operations, specialized medical treatment).

B.20 In respect to medical personnel required for any feasible system, three levels of competence will be applicable, corresponding to the three levels of screening. They are: (1) sub-professional personnel with basic medical training, at one or several levels of competence, (2) professional

TABLE B.2

CLASSIFICATION OF CASUALTIES ACCORDING TO THREE-LEVELS OF SEVERITY: EXAMPLES OF SPECIFIC APPLICATION

CLINICAL CONDITION	MILD	MODERATE	SEVERE
Blood loss	Less than 5% of total	5-25% of total	More than 25% of total
Shock	Blood pressure over 100	BP 80-100	BP less than 80
Type of bleeding	Capillary	Venous	Arterial
Fractures	Chip fractures	Simple fractures	Compound fractures, Comminuted fractures, Multiple fractures
Perforating wounds	Skin only	Skin and muscle	Bones, viscus, organs
Skull	No damage to bone or brain	Damage to bone, not brain	Damage to brain
Sprains	Single, small joint	Large joints, torn ligaments	Multiple, torn ligaments, and tendons
Burns	1^{o}, less than 10% of body area	2^{o}, more than 5%	3^{o}, more than 10%
Infection, sepsis	Local abscess	Cellulitis, adenitis	Peritonitis, pleuritis, meningeal involvement, blood sepsis
Chronic illnesses	Sinusitis; Hay fever; Simple asthma; Hypertension, uncomp.	Rheumatoid arthritis; Perforated ulcer; Kidney stone	Coronary occlusion; Rheumatic heart disease; Cerebral vas. accident
Virus infection	Temperature under 100	Temperature 100-104	Temperature over 104
Infectious disease	Upper respiratory	Pneumonia	Meningitis
Toxic agents	Lacrymal, coughing; sneezing agents; Minor GI disturb.; Transient alteration of consciousness	GI disturb. with dehydration; Deep unconsciousness, Transient anemia	Paralysis; Prolonged coma; Intractable anemia; Liver, kidney necrosis
Radiation effects	Transient GI disturb.	Severe GI disturb.	Profound anemia

TABLE B.3

CLASSIFICATION ACCORDING TO COMPLICATIONS

A. Hemorrhage
1. Cardiac (Tamponade): Laceration of Heart, bleeding into pericardium.
2. Major Vessels: Severance, perforation of major vessels (aorta, innominates, common carotid, subclavian, abdominal aorta, hepatic, pulmonary, renal, iliac, mesenteric, superior and inferior vena cava).
3. Medium Arteries: Major branches of above vessels plus liver and spleen.
B. Shock
1. Complicated: Severe Tissue destruction, infection, crushing.
2. Relatively uncomplicated: Small artery, venous and capillary bleeding, moderate trauma and destruction of tissue.
C. Destruction of Vital Tissue
1. Lower brain centers: Medulla, Midbrain.
2. Higher brain, high cord: Upper cervical cord, cortex, cerebellum.
3. Pulmonary: Bronchial or tracheal obstruction, sucking wounds of chest.
4. Renal: Serious interruption of urinary system: Kidneys, ureters, bladder.
D. Infection
1. Intra-abdominal: Peritonitis, abscess.
2. Intracranial: Meningeal infection, brain abscess.
3. Intrathoracic: Pleural infection, pericardial infection, lung abscess.
4. Extremities: Compound fracture, gangrene, septicemia.

but unspecialized medical officers, and (3) medical specialists. Three levels of medical care will be accomplished by the three categories of personnel.

B.21 Any group of casualties can be theoretically subdivided again into three levels of severity (mild, moderate, severe). The implication of this three-level process will be the identification of those casualties which, on the one hand have urgent need for medical care, and on the other hand, are most likely to benefit from the care rendered. For the most part, the latter would be the middle or moderate group. In contrast, the less serious group would be those for whom medical care can be either safety postponed or eliminated entirely, while the most serious group would be made up of those with the least favorable outcome in spite of adequate medical care.

Incidence of Medical Conditions

B.22 The times for medical management must be related to each of the various conditions represented in the patient workload. In consequence the probable incidence of disease, non-battle injury and type of wounds must be estimated for specific doctrine, weapons, tactical situation, theatre of operation and the immediate past history of the troops which may be pertinent for medical evaluation. Such estimates can be based on the statistical data on admissions during past wars, principally World War II and Korea, and analysis of weaponry, doctrine and probable tactical usage for each weapon type and for combinations of weapons types anticipated for use in future conflicts.

B.23 Historical Approach. The acutal casualty spectrum characteristic of military experience in the past, and civilian accident and injury experience generally, constitute one basis for making predictions for the immediate future. For the most part the military data currently available present average totals or rates for theaters of operations or other large samples for total duration or an extended period of a war or specific ground campaigns and operations. These provide general guidance rather than information concerning variability in number and types or the probabilities of various casualty spectra constituting the workload for a medical unit. The principal source of casualties, including deaths, have come from non-battle sources. The percentage of admissions for the total army for January 1942 to August 1945 were 85 per cent for disease, 12 per cent for injury and three per cent for wounds.[1/]

B.24 Battle Wounds. Statistical description of past experience utilizes various systems in listing, including frequency distributions of hits and

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1/ Statistical Health Report, WD, AGO Form 8-122 cited by Beebe and DeBakey Battle Casualties, Chas. Thomas, Springfield, Illinois, 1952.

wounds, and of admissions, fatalities, clinical complications and primary and secondary causes of death by body region, structure, tissue, surgical specialty, nature of traumatism and by causative agent. An example of one such listing is presented in Table B.4.

B.25 These descriptions have important implications for certain medical and other technical services requirements. These include medical requirements for:

a. Training in resuscitative treatment procedures.

b. Determination of types of general and specialized professional capabilities.

c. Special medical equipment.

d. Body armor.

e. Research requirements (for improved medical techniques and medical equipment).

B.26 They may also have implications for ordnance and weapons development, classification of KIA, in cases where a principal wound is evident, and for combat intelligence.

B.27 Currently available historical statistical descriptions have a certain, though somewhat limited value for:

a. Quantitative estimates of medical management workloads.

b. Triage at successive echelons in the medical support system.

c. Evacuation policy, procedures and equipment.

B.28 The limitations in providing directly useful information on proportions of various types of conditions are imposed primarily by the heterogeneity of the categories of patients. A great deal of variability in the condition of patients within a group or class can exist in historical descriptions of the wounded. For example, data on a class of wound based upon primary diagnosis may include cases with secondary diagnoses, and complications such as infection, shock, or hemorrhage. Further, regions or parts have critical areas, as well as areas where fatal injury from a missile is unlikely, as is the case of head or abdomen. Considerable variation in weapons effects, where the extent of tissue damage is related to the energy of the missile and the type of tissue involved, adds to variability. Further, one class or group for which time lag to a specific level of treatment is given may include individuals who have received prior medical treatment influencing the effect of subsequent delay. These all introduce variability in workload including variability in response to treatment.

TABLE B.4

MORTALITY RATES FOR VARIOUS TYPES OF INJURY FROM VARIOUS WWII REPORTS

(Mortality Shown as % of Cases in Each Category)

Anatomical Site of Wound	5th Army 1944-45	2nd Aux. Gp.	SWP-MTO-POA Jan-June '44	5th Aux. Gp.	SWP 1942-43
Head:					
Intracranial	26		12		47
Eye-ear	0		0.3		
Scalp	0		0		
Cranial bones			34		
Face bones	1.5		5		23
Head, general			8		
Mouth			1		
Superficial	0.24				
Neck:					
Organs			31		
Muscles			0		
Vessels			50		
General	0.9		6		6.8
Chest:					
Lungs			11		
Heart			33		
Other organs			12		
Bones			2		
Joints, muscles			0		
Vessels			75		
General	7.8		9		22
Superficial	0.2				1.4
Abdomen:					
Intraabdom. general	20				21
Thoraco-abdominal	23				50
Liver		27		27	
Spleen		25		29	
Stomach		41		44	
Large Intestine		37		50	
Small Intestine		30		47	
Kidney		35			
Rectum		30			
Bladder		30			
Duodenum		56			
Gall Bladder		30			
Ureter		41			
Pancreas		58			

B.29 Disease. Admissions from disease have constituted a major portion of the patients in war as well as peace. The estimated average admission for the total Army, January 1942 to August 1945, based upon Statistical Health Report, WD, AGO, Form 8-122, is 666 per 1000 men per year. Wide variations exist which are primarily related to time and place; they are not particularly related to the tactical situation. In the past, military service appeared to carry with it an extra risk of incurring illnesses, above the expected rates among civilians. As a result, the illness and deaths came principally from non-battle sources. This was a result of the unusual sanitary problems encountered by field armies, for which there did not exist adequate preventive measures. Beginning with World War I, however, the incidence of disease among troops became more nearly comparable to that in the civilian population for young men. Collins, in his Public Health Report article on "Trends in Sickness and Mortality with Special Reference to War and its Aftermath," shows that death rates from non-battle medical conditions in both civilian and military United States populations have closely comparable trends since the time of the Spanish-American War.

B.30 Non-Battle Injury. Non-battle injuries have tended to show a fairly constant incidence, with some increase under combat conditions because of the increase in exposure to many types of hazards in addition to gun fire. Major injuries are likely to result from motor vehicle accidents and burns while many minor ones arise from ordinary cuts, bruises and sprains. Because non-battle injuries do not involve penetrating wounds, they tend to have a clinical character which distinguishes them from battle wounds. Shock and infection are not so likely to complicate non-battle injuries, a higher per cent will be restored to duty, and they will generally be less emergent.

B.31 Psychiatric Casualties. The incidence of psychiatric problems tends to be a function of time, as in the case of disease, except that it is more directly related to combat conditions. The correlation between wounding and psychiatric casualties has been shown to be high for the greater part of the combat in World War II. It was demonstrated in the 8th Army in Italy that the number of days spent by a unit in combat was closely proportional to the number of psychiatric casualties. A certain number of these were the consequence of pre-combat psychiatric problems. With the level of psychiatric supervision now available, any unit trained for combat should be relatively free of the type of men who are likely to become psychiatric casualties during the first couple of days in battle. Subsequently, however, a predictable small percentage can be expected to turn up, increasing with periods of low morale and with number of days in combat. The reported incidence of psychiatric casualties in the past is only very roughly related to the actual incidence. Many of the reported casualties might have been handled on duty status without hospitalization, but the physician's lack of familiarity with this class of casualty often resulted in unnecessary evacuation. An important issue to be decided for the future is whether or not to consider all disciplinary problems as psychiatric casualties. As it is, some clear-cut psychiatric problems and some disciplinary problems are treated as psychiatric casualties.

B.32 Current Studies of the Medical Statistical Division - OSTG. Much of the statistical data which have been available up to this time represent material which was published prior to obtaining final data on Individual Medical Records and completion of final reports on World War II and the Korean War. Meetings with the Medical Statistical Division revealed that the data analysis for the Korean War is nearing completion. A list of the various tables and sample tables was obtained. The Statistical Division also reported that progress has been made in further analysis and compilation of World War II data. When the report on Korea and, subsequently the report on World War II, become available they will be of very real assistance in review of experience on patient workloads with conventional weapons under the doctrine and tactical conditions employed at the time. The tables which will be presented in the report on Korea will provide more detailed data, and more homogeneous data samples than have been available heretofore.

B.33 Further, it was determined that with the information available it will be possible to assemble a statistical sample of patients who can be identified and their medical records obtained for a pilot study. This detailed study of complete medical histories, together with the data available on the IBM cards, will contribute accurate and comprehensive information on medical management of a sample population which will be of significant value in refinement of input data for application in the model.

B.34 Predictive Studies of Patient Workload. The spectrum of patient workload anticipated for the future must be estimated and appraised in terms of both previous experience and in the content of future concepts of warfare. This will involve a detailed, comprehensive review and analysis of the reports of the Technical Services on weapons effects, tactics and the results from war games and field exercises. Such an analysis must be medically oriented considering specific weapons effects, compatible mixes of weapons, and their implications for the nature, proportions and rates of casualty production.

OUTCOME

B.35 The outcome for any particular casualty or class of casualty will be determined by nature and extent of the pathological and physiological processes going on in the body, and the influence of treatment on these processes. For purposes of the present problem, two levels of treatment are considered: resusciative and definitive. The former is directed toward correcting immediate critical conditions and preventing the development of additional complications. Definitive care is directed toward eradication of pathological conditions, repair and restoration to achieve the best possible outcome. For some conditions only simple remedial measures are required; for others definitive care requires complex procedures and elaborately equipped medical and surgical facilities. In general only the resuscitative measures will be instituted by the forward medical units. The effectiveness of a forward unit is determined by the degree of success achieved in:

a. Saving lives of battle casualties who would die without early or immediate resuscitative measures.

b. Treating and returning to duty all those capable of performing assigned functions.

c. Maintaining a satisfactory clinical condition of patients requiring more complex, definitive treatment until such time as it can be administered.

Reference Level for Medical Care.

B.36 The method for measurement of effectiveness requires that a reference level of medical care be established as the basis of comparison for levels of care which would be provided by various alternative support systems. The concept which is chosen is that of optimum achievable level for a field army, with due regard to constraints imposed by field and combat conditions. Essentially it represents the highest degree of care possible with the current state of the medical arts and sciences, with most of the initial or emergency treatment being given by non-physicians with excellent training, and with equipment and facilities which are fully adequate but which, at forward echelons, do not match fully equipped hospitals.

B.37 The clinical course and outcome with optional achievable care can be expressed in terms of probability for each class or condition of patient. In developing the present methodology reasonable values for times to return to duty have been assumed. There are considerable amounts of data on the time course of various conditions which will enable satisfactorily precise estimates of probabilities when time permits. An example of the approach is shown by graphs of the percentages of patients with minor, moderate and severe battle and non-battle injuries returning to duty during a 90-day period following injury (Figure B.1, 2).

B.38 For many classes of casualties, particularly the most serious ones, the success of medical treatment in effecting a desirable outcome is dependent upon the timeliness and the quality of treatment. Essentially this involves the reversal of pathological mechanisms of clinical complications and deaths, i.e., hemorrhage, shock, destruction of vital tissues and infection.

B.39 In a report on a study of the Metabolism of Trauma, Dr. Francis Moore states:

> "Immediately after trauma occurs, the body begins to mobilize its healing resources. The adrenal glands, particularly, respond with great rapidity. For example, the blood level of 17-hydroxy corticoids rises 4-5 times within minutes after injury. The damaging effects of trauma, on the other hand, are mediated through:
>
> a. Interference with pulmonary oxygen exchange because of mechanical injury to the breathing apparatus or disturbance of neural control.
>
> b. Deficiency of blood flow to vital organs.
>
> c. Metabolic changes leading to necrosis of tissues.
>
> e. Contamination by micro-organisms and introduction of infection.
>
> The progression of these damaging mechanisms can often be arrested by adequate medical and surgical treatment. If this is not accomplished, however, the progressive tissue anoxia and piling up of metabolic products leads to further tissue injury throughout the body. The tissues which are most vulnerable to the effects of anoxia are the brain and heart, and danger to life during the first 12 hours is chiefly represented as cardiac or brain failure, the immediate mechanism being the circulatory failure known as shock. A patient who is in shock for 12 hours is very likely to die, and if he survives will almost inevitably have a

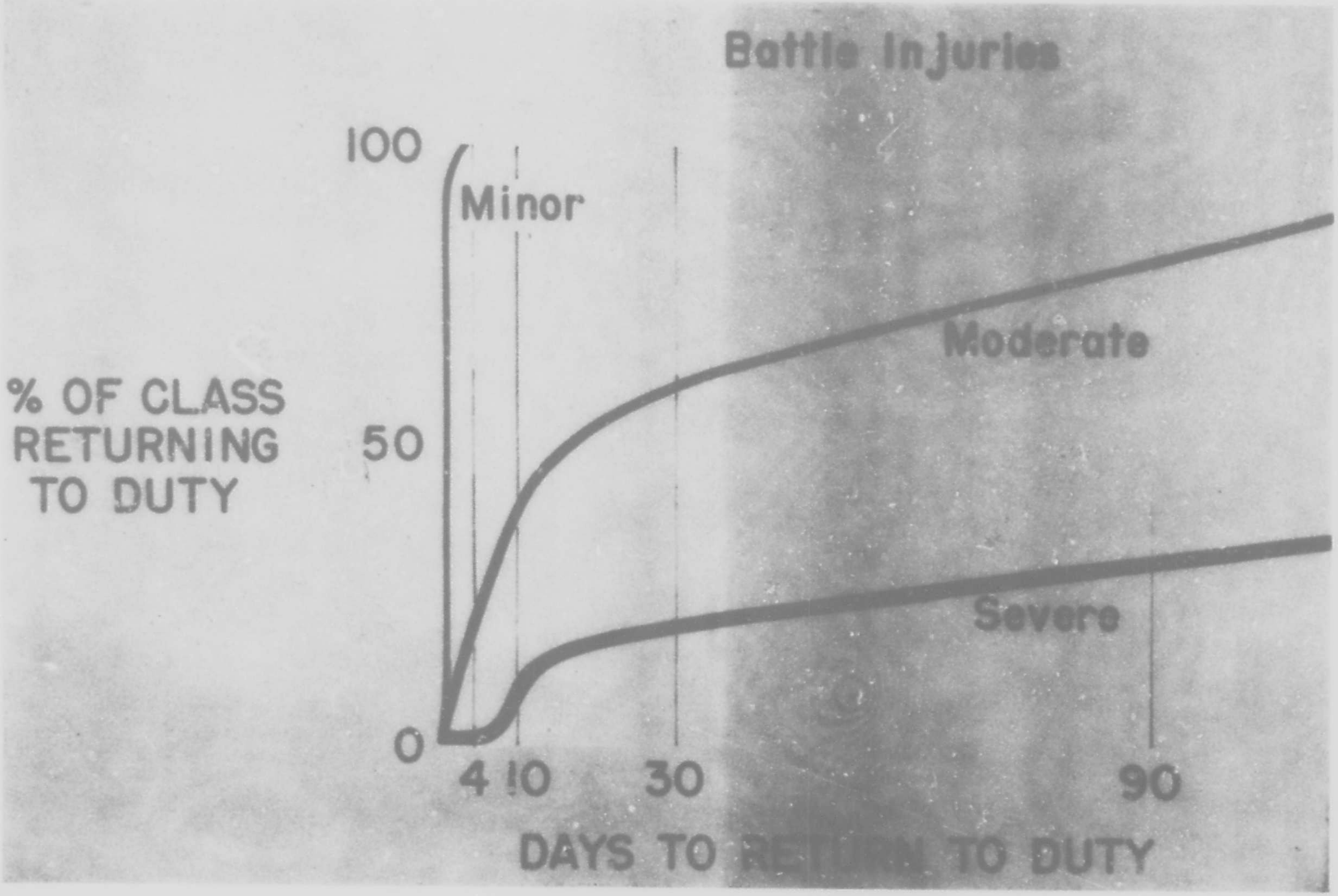
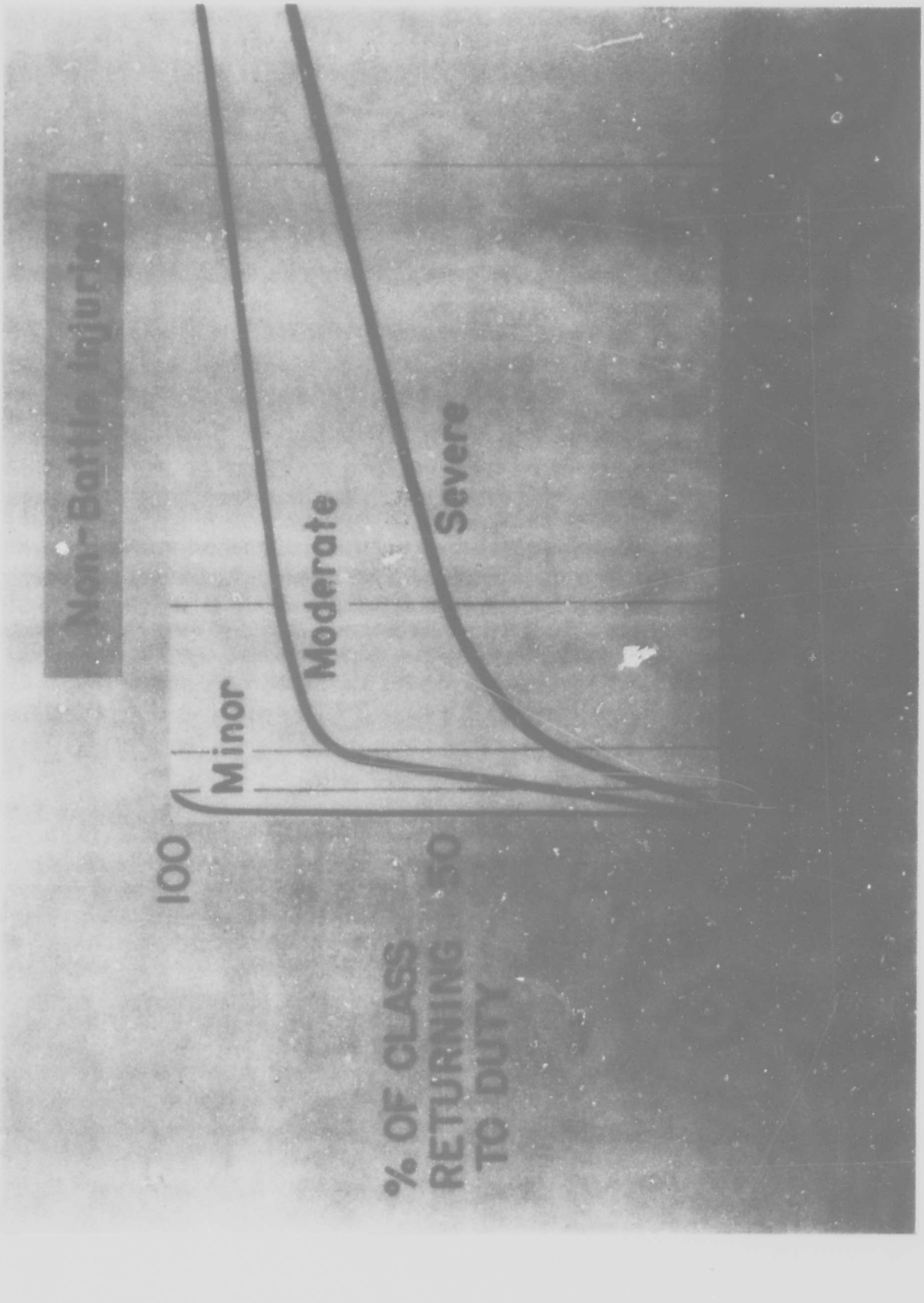

Battle Injuries
100
50
0
% OF CLASS RETURNING TO DUTY
Minor
Moderate
Severe
4
10
30
90
DAYS TO RETURN TO DUTY

FIGURE B.1


Non-Battle Injuries
Minor
Moderate
Severe
100
50
% OF CLASS
RETURNING
TO DUTY

complicating infection. The amount of carbohydrate in the body available for energy production is small and is burned quickly.

Correction of the anoxic state, removal of toxic products and interruption of the infection produces a state conducive to convalescence. This state is then characterized by:

a. Restoration of normal blood volume.

b. Restoration of normal excretion.

c. Restoration of normal nitrogen balance and energy resources.

d. Healing of damaged tissues."[2]

Criteria and Method of Measurement of the Effectiveness of Medical Units

B.40 The criteria selected for determination of the medical effectiveness of a medical support unit are:

a. The number of lives saved.

b. Day to return to duty.

c. The number of permanent disabilities attributable to delay in treatment.

B.41 The method estimates the probability of delay in administering an achievably optimum level of treatment leading to rapid death or complications of the original condition. Probabilities are expressed as the per cent of a total class of casualty which will develop complications at a stated time. Two delays are considered:

a. Delay in resuscitative care.

b. Subsequent delays in receiving definitive level of care.

B.42 For the purpose of illustrating the methodology, assumed values have been assigned to the per cent total of a class of casualties developing complications with various delays. The assumed relationships are illustrated by Figures B.3-B.6, inclusive. The values for the ordinate are expressed as per cent of class developing complications and abcissae values as hours after

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[2] Francis D. Moore, "Metabolism in Trauma," Harvey Lectures, 1956-57.

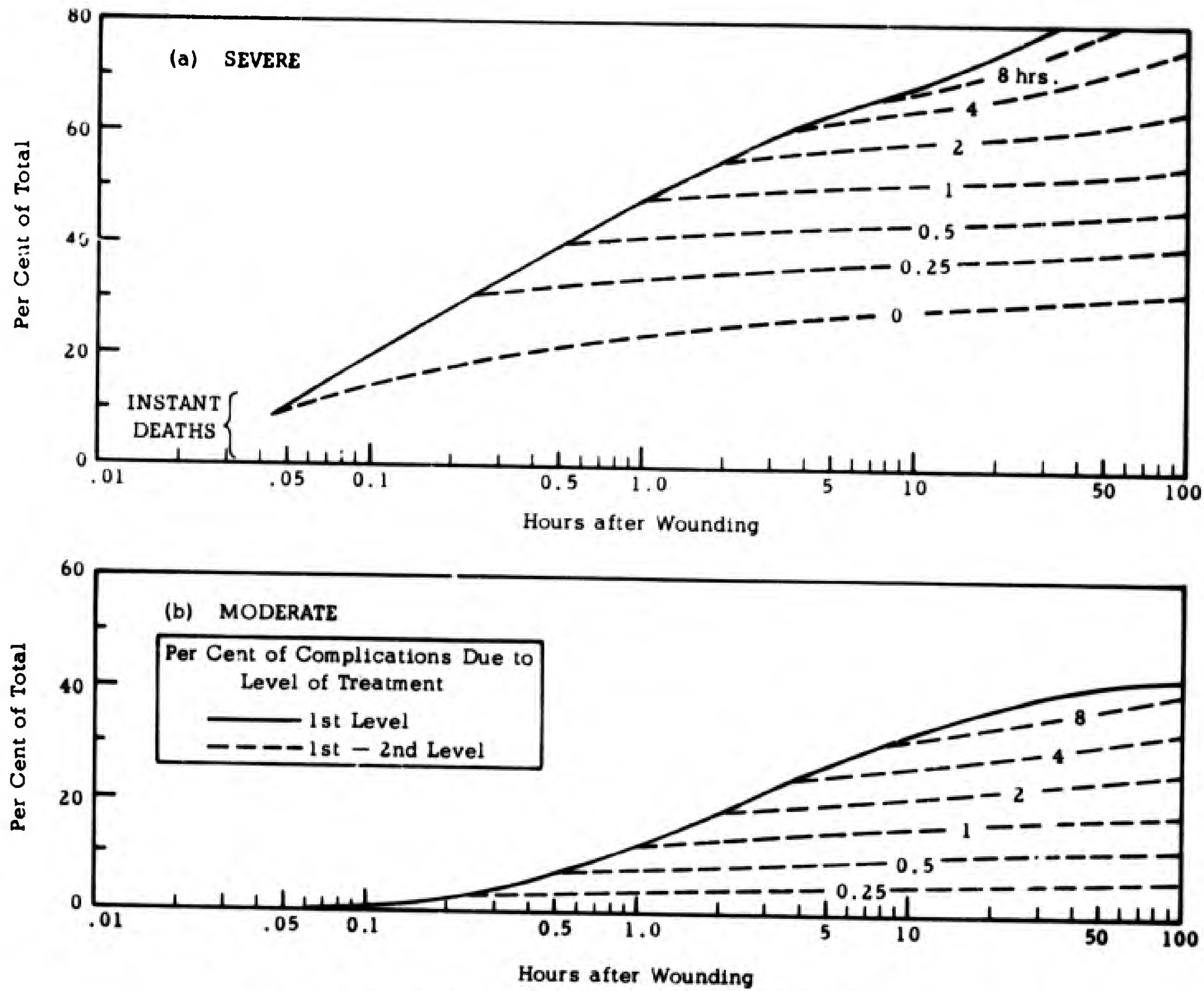


FIGURE B.3. BATTLE WOUNDS: PER CENT OF CLASS DEVELOPING COMPLICATIONS WITH VARIOUS DELAYS

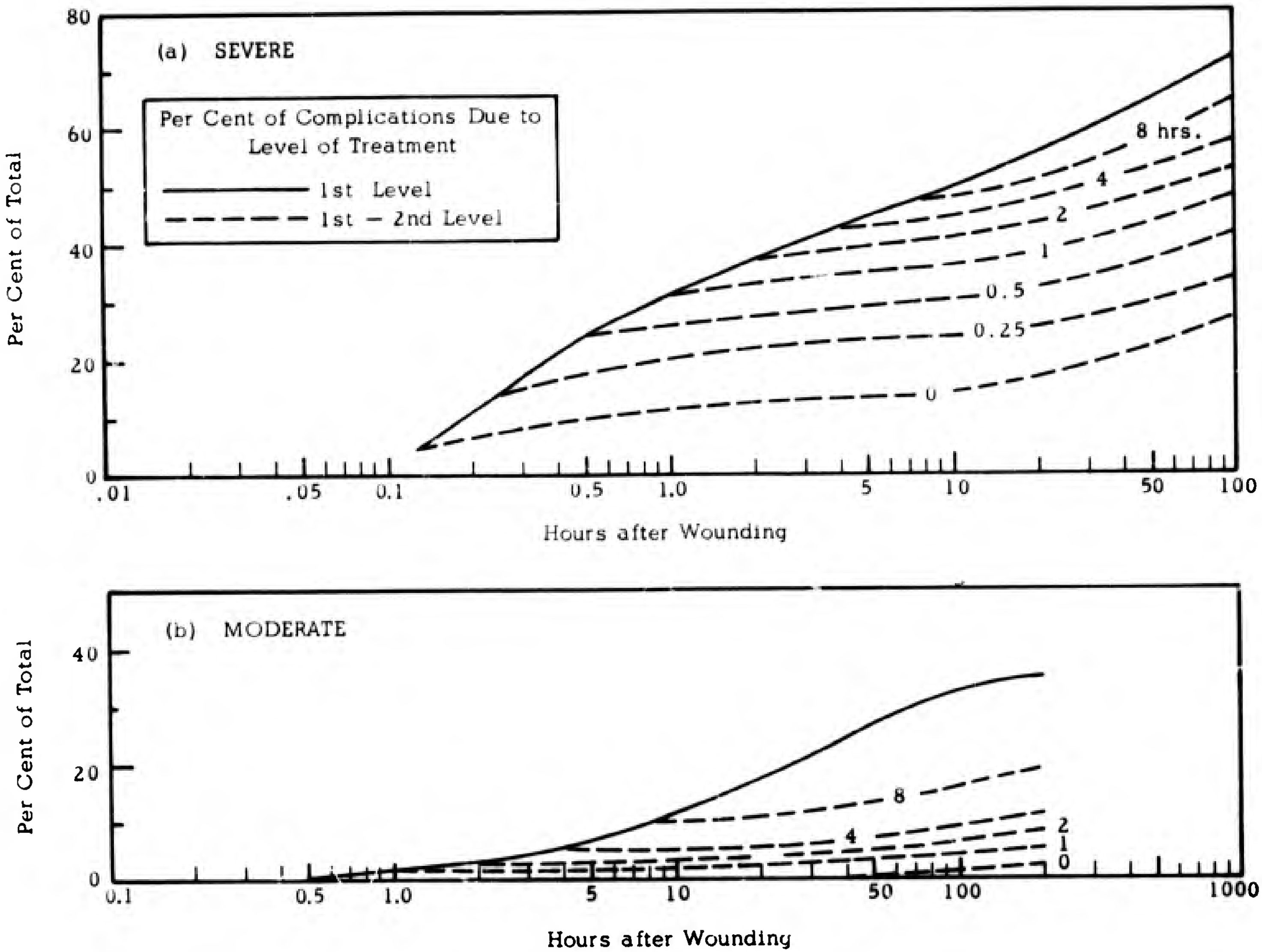


FIGURE B.4. NON-BATTLE

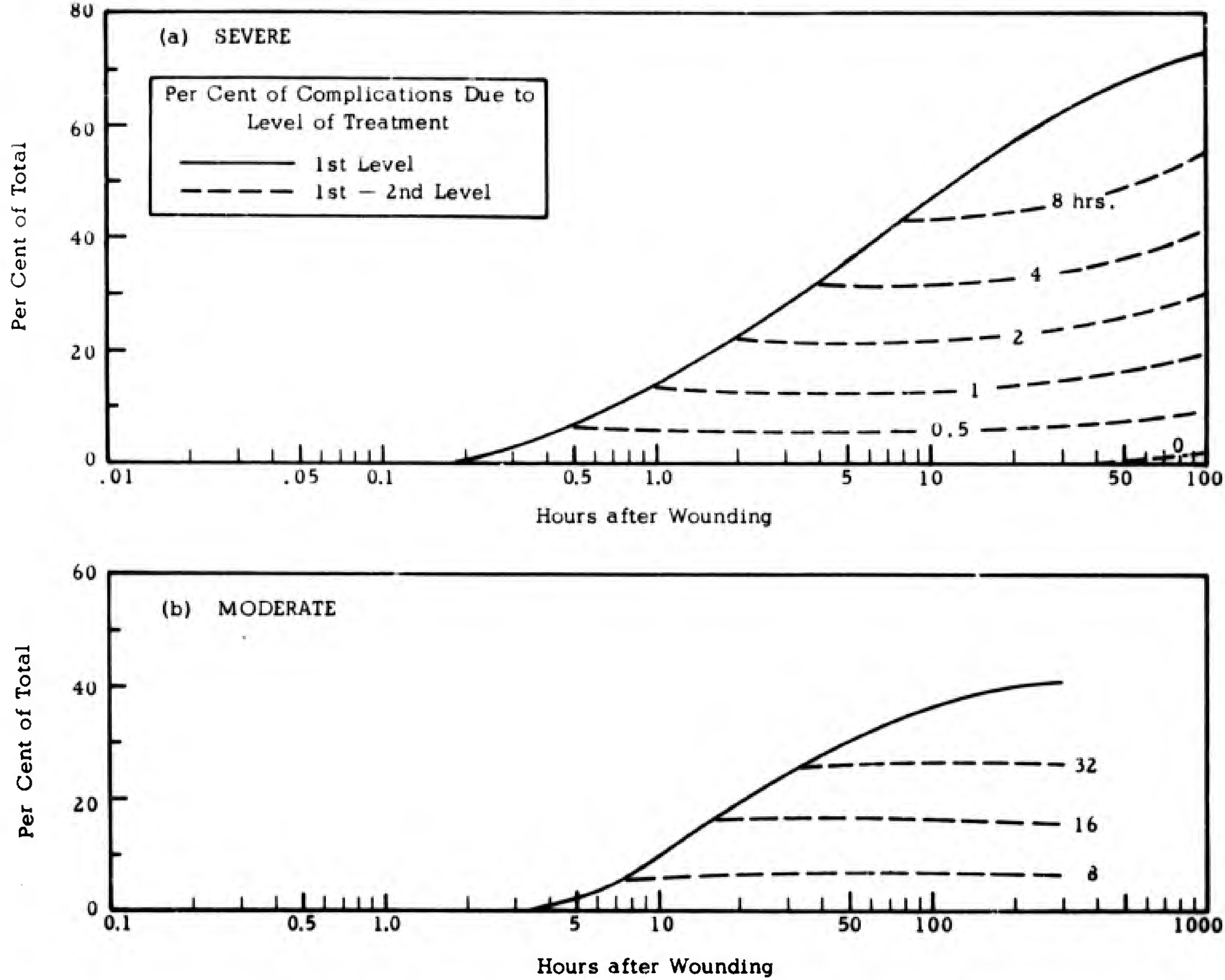


FIGURE B.5. DISEASE

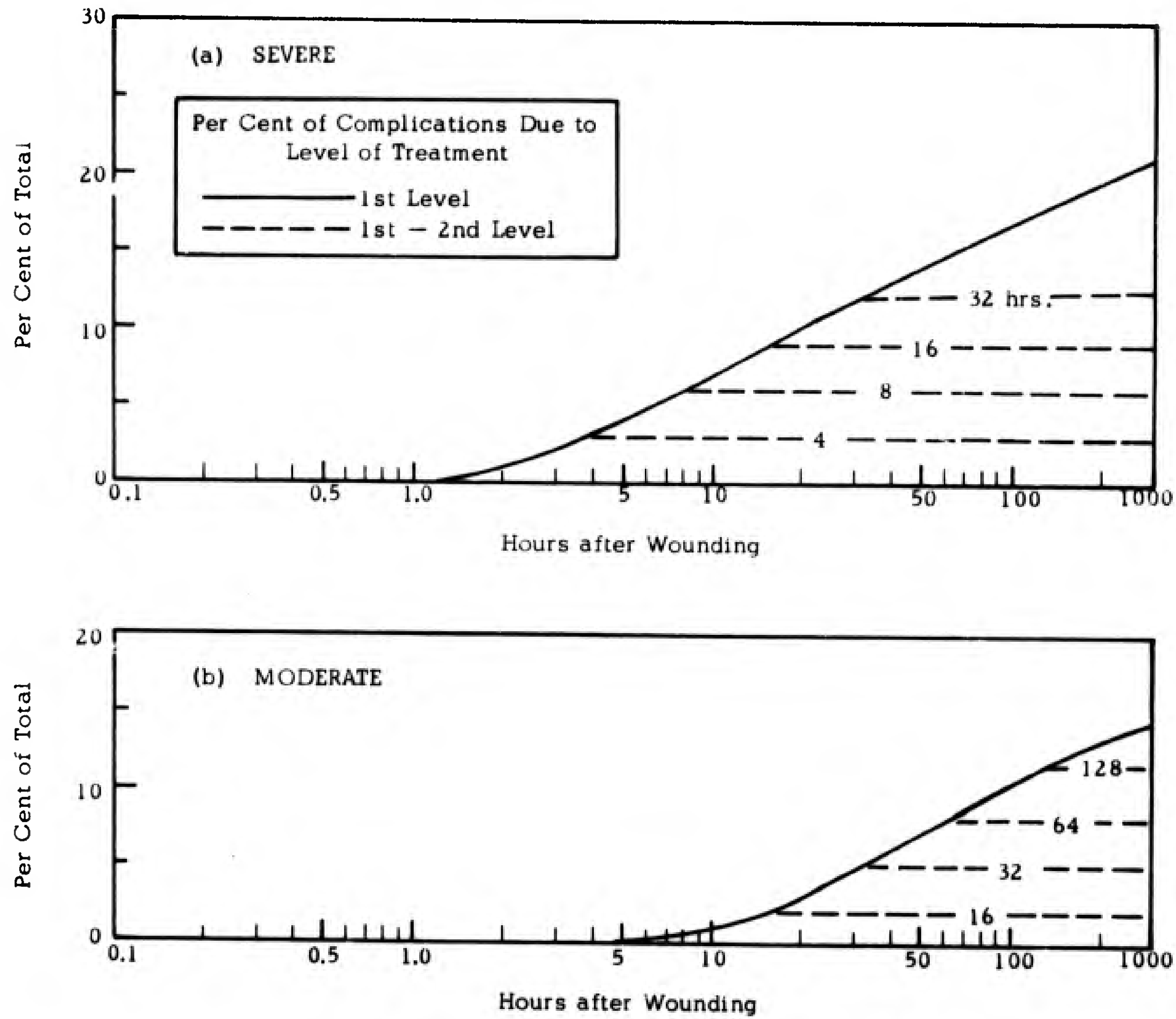


FIGURE B.6. PSYCHIATRIC

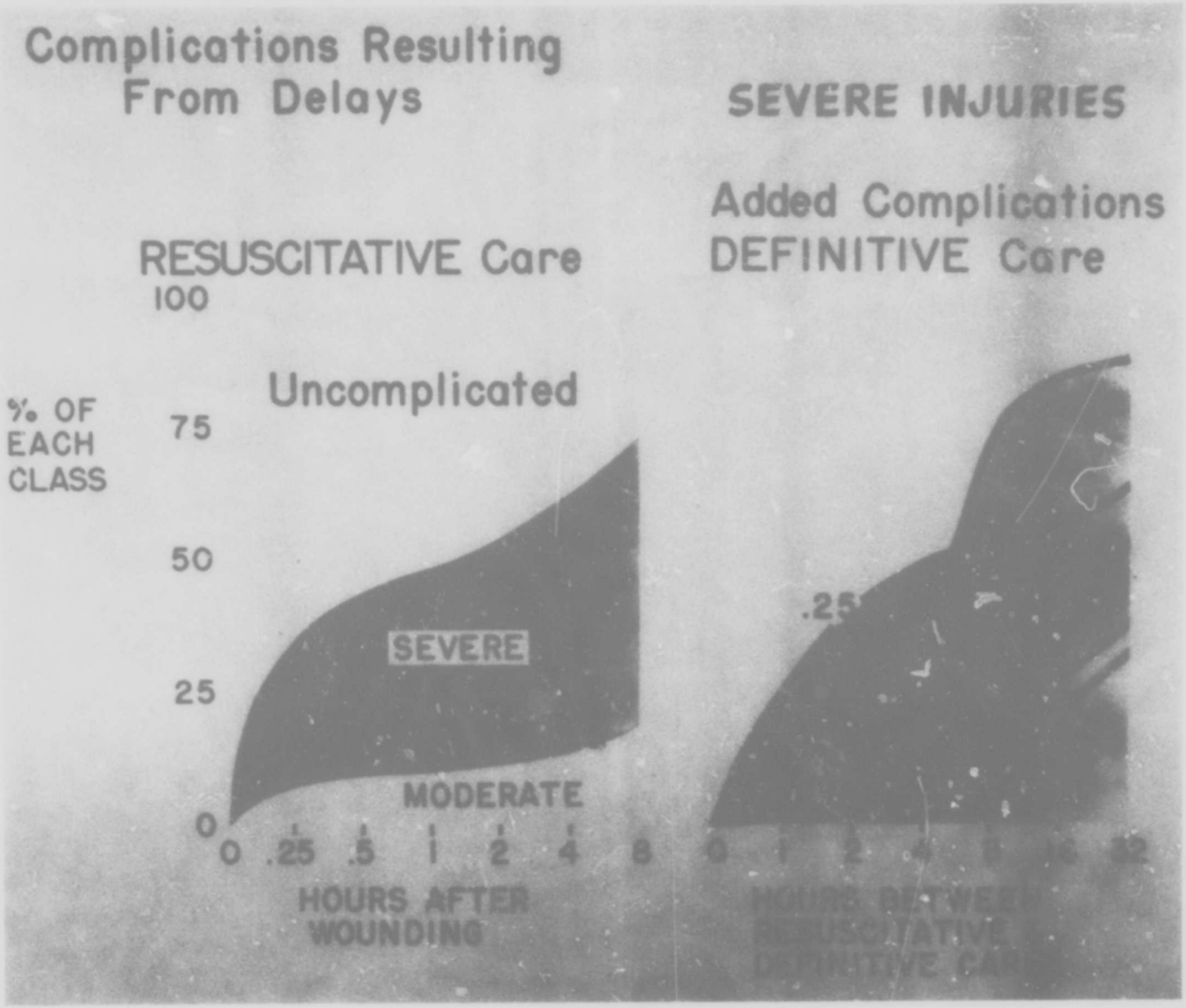
wounding. Per cent of complications due to delay in the first level of treatment at given intervals after wounding is shown by the uppermost curve of each graph. Complications for the very short intervals are shown as "instant deaths". The per cent of a class developing complications as the result of varying delays between the first and second level of treatment are shown by a family of curves, each of which joins the curve of delay of resuscitative treatment at the appropriate time. For example, in Figure B.3a, the uppermost curve illustrates that 40 per cent of a class develops complications due to a delay of one-half hour after wounding in administering the first level of treatment. The curve for 0.5 hour delay between treatments joints the uppermost curve at a point corresponding to 0.5 hours as shown on the abcissa. This shows that there was no delay between the 1st and 2nd level of treatment. It also shows that if definitive treatment is given at that time only 50 per cent of the class of injury would have developed complications 16 hours after wounding, whereas if only the 1st level of treatment had been given, 72 per cent of the class would have become involved within the 16-hour period.

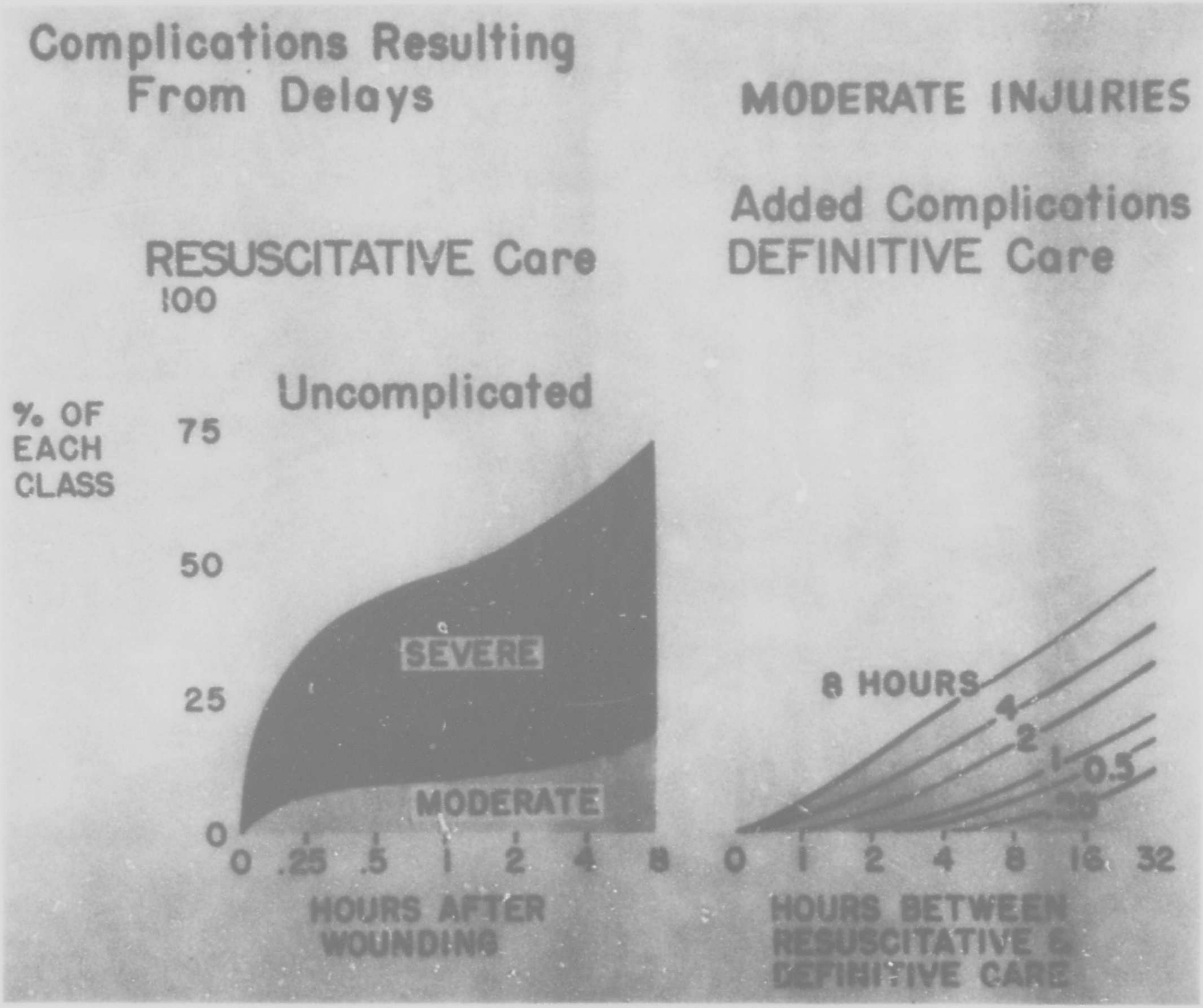
B.43 The complications resulting from delay are shown in another form to illustrate the per cent of each class developing complications from moderate and severe wounds (Figure B.7). The accompanying graph shows the effects of delay between the first and second levels of treatment for the severe injuries of the same class. Another figure (Figure B.8) illustrates the identical resuscitative care curve as in Figure B.7 and the effects of subsequent delay to the 2nd level of treatment for moderate injury.

Application of Data to Estimate Disposition of Casualties — Cumulative Per Cent Returned to Duty or Dead at Stated Times.

B.44 A sample work sheet is presented showing assumed values for cumulative per cent of class killed in action, and returning to duty following treatment, after initial and subsequent delays, by an Aid Man or Battalion Surgeon and after 4, 10, 30, 90, and over 90 days after hospitalization. The last two columns show the cumulative percentages after including those not returning to duty or those dying of wounds.

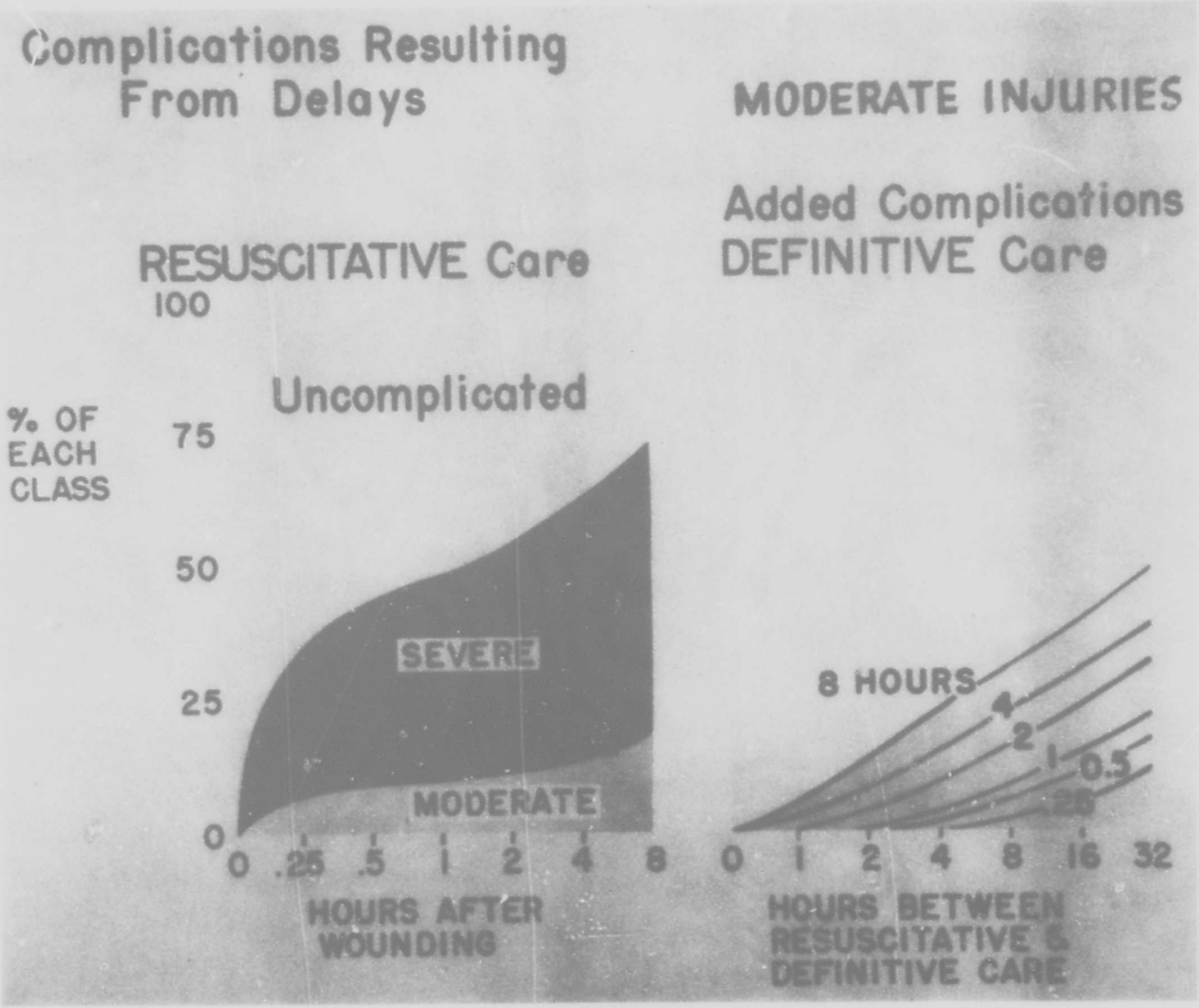
B.45 In Figure B.9 the per cent of a group of moderate battle injuries returning to duty after varying delay to treatment is presented to show that short delay, i.e. less than one-half hour, represents a very high level of effectiveness. This results in a higher per cent return to duty for any corresponding values of the abcissa than would be expected on a practically achievable, or usually optimal field medical care; this "achievable optimum" is shown by the heavy line.


Complications Resulting
From Delays
SEVERE INJURIES
RESUSCITATIVE Care
Added Complications
DEFINITIVE Care
100
Uncomplicated
% OF
EACH
CLASS
75
50
25
0
SEVERE
MODERATE
.25
0 .25 .5 1 2 4 8
0 1 2 4 8 16 32
HOURS AFTER
WOUNDING



Complications Resulting
From Delays
MODERATE INJURIES
RESUSCITATIVE Care
Added Complications
DEFINITIVE Care
% OF
EACH
CLASS
100
75
50
25
0
Uncomplicated
SEVERE
MODERATE
0
.25
.5
1
2
4
8
HOURS AFTER
WOUNDING
8 HOURS
4
2
1
0.5
.25
0
1
2
4
8
16
32
HOURS BETWEEN
RESUSCITATIVE &
DEFINITIVE CARE

FIGURE D.6


Complications Resulting
From Delays
MODERATE INJURIES
RESUSCITATIVE Care
Uncomplicated
% OF
EACH
CLASS
100
75
50
25
0
SEVERE
MODERATE
0 .25 .5 1 2 4 8
HOURS AFTER
WOUNDING
Added Complications
DEFINITIVE Care
8 HOURS
4
2
1
0.5
.25
0 1 2 4 8 16 32
HOURS BETWEEN
RESUSCITATIVE &
DEFINITIVE CARE

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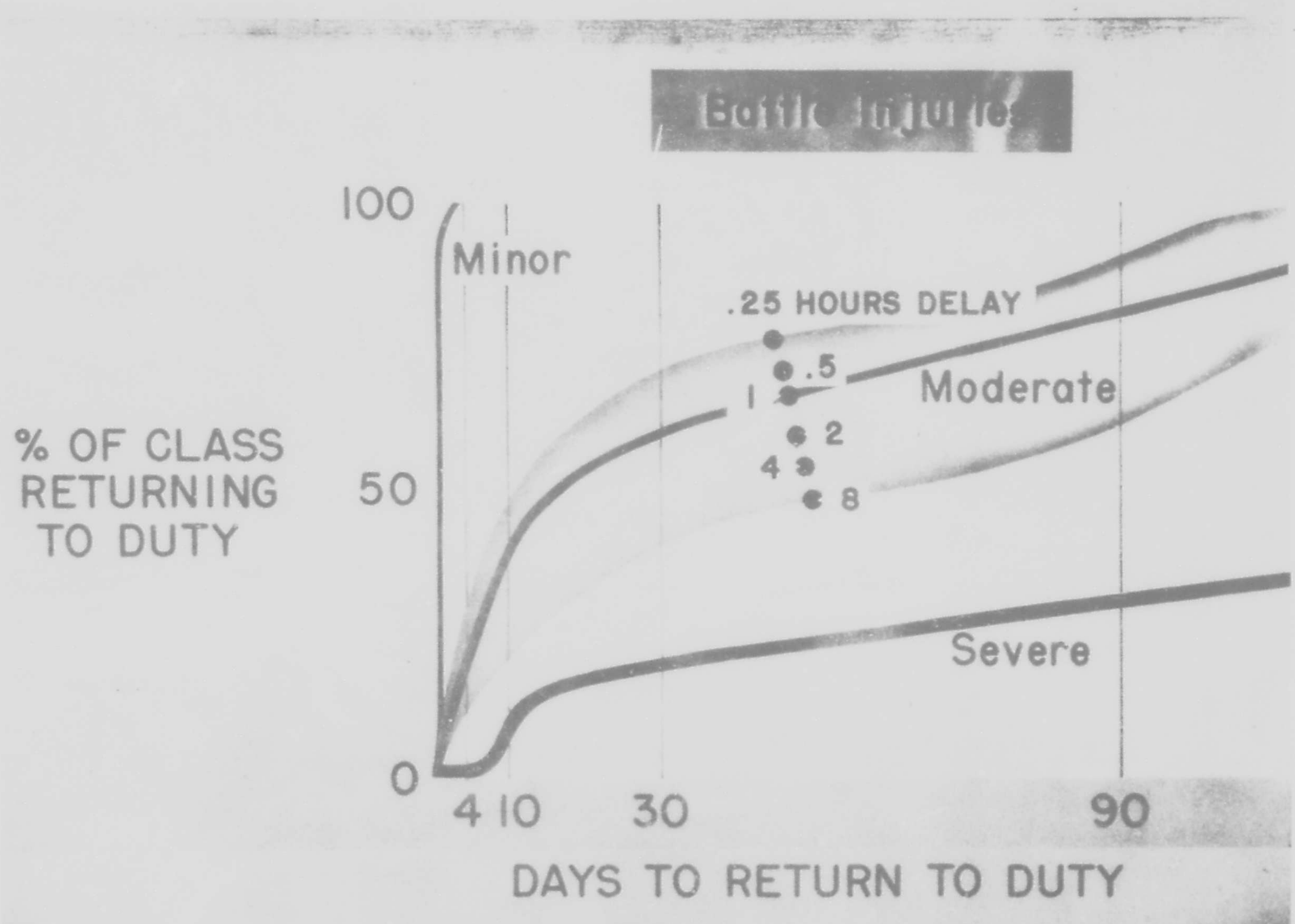

Battle Injuries
% OF CLASS RETURNING TO DUTY
100
50
0
Minor
.25 HOURS DELAY
.5
1
2
4
8
Moderate
Severe
4
10
30
90
DAYS TO RETURN TO DUTY

FIGURE B.9

TABLE B.5

DISPOSITION OF CASUALTIES

BATTLE WOUNDS, SEVERE Hours Delay in Treatment to		Accumulated Per Cent Returning or Dead at Stated Time								Added % for	
Resuscitative Care	Definitive Care	KIA	Aid Man	Bn. Surg.	Days after Hospitalization					NORDT	DOW
					4	10	30	90	< 90	(Cumulative)	
0.25	1	30			35	40	50	60	70	90	100
	2	30				35	45	55	65	91	100
	4	30					40	50	60	90	100
	8	30					35	45	55	90	100
	16	30						40	50	89	100
	32	30						40	50	88	100
0.5	1	35				40	50	60	70	92	100
	2	35					45	55	65	91	100
	4	35					40	50	60	90	100
	8	35					40	50	60	90	100
	16	35						45	55	89	100
	32	35						45	55	88	100
1.0	1	40					50	60	70	95	100
	2	40					45	55	65	94	100
	4	40					45	55	65	93	100
	8	40					45	50	55	92	100
	16	40						45	50	91	100
	32	40						45	50	90	100
2.0	1	45					50	60	70	94	100
	2	45					50	60	70	93	100
	4	45					50	55	60	92	100
	8	45						45	50	91	100
	16	45						45	50	90	100
	32	45						45	50	89	100

TABLE B.5

DISPOSITION OF CASUALTIES

(CONTINUED)

BATTLE WOUNDS, SEVERE — Hours Delay in Treatment to		Accumulated Per Cent Returning or Dead at Stated Time								Added % for	
Resuscitative Care	Definitive Care	KIA	Aid Man	Bn Surg.	Days after Hospitalization					NORDT	DOW
					4	10	30	90	< 90	(Cumulative)	
4.0	1	50					55	60	70	93	100
	2	50					55	60	65	92	100
	4	50						55	60	91	100
	8	50						55	60	90	100
	16	50						55	60	89	100
	32	50						55	60	88	100
8.0	1	55					60	65	70	92	100
	2	55						60	65	91	100
	4	55						60	65	90	100
	8	55						60	65	89	100
	16	55						60	65	88	100
	32	55						60	65	87	100

Some Comments on the Basis for Estimates of Assumed Values.

B.46 Survival Times. Comments on two sources of recently published or unpublished data which have been helpful in providing background guidance for assumptions are warranted. Of particular interest are data provided by Major J.C. Beyer, MC, AFIP. Holmes and Beyer surveyed some 2000 KIA casualties of the Korean War to obtain data useful for designing body armor. Not all cases were autopsied, but nearly all were at least photographed and x-rayed. In a series of 354 cases, estimates were made of the time of death after wounding, the type of missile and the number of fragments determined, and identification of the causative agent attempted (Figure B.10)According to Beyer (personal communication), it was rare to find a casualty in which there was not a clear-cut, easily-identifiable cause of death, except perhaps in cases of possible suffocation from caved-in bunkers. Essentially all casualties were estimated to have died within one hour, and 75% within 10 minutes. The cause of death was either massive extravasation of blood from major blood vessels and/or heart, or destruction of brain substance or suffocation from pulmonary obstruction. The few casualties (5%) which survived 30 minutes were nearly always wounds of the extremities, with arterial severance distal to elbow or knee.

B.47 Other information was obtained from Dr. Light, Biophysics Laboratory, Army Chemical Corps, on the results of experimental studies. Two series of goats subjected to both aimed and unaimed missiles were autopsied, with survivors sacrificed at the end of 48 hours. As in the case of the Holmes and Beyer estimates, the great majority of deaths occurred within a few minutes, and the cause of death was ascertained to be massive extravasation of blood from large vessels and the heart with rate of blood loss varying inversely with time of death. Among the 48-hour survivors there was found to be remarkably little evidence of the shock or infection which would be expected in humans. Distribution of survival times are shown in Figures B.11 and B.12.

Rationalization for Assumed Time Intervals for Hospitalization.

B.48 Assumptions have been made in regard to significant time intervals for hospitalization in considering accumulative percentages of patients at various stages of medical management. Comments on the intervals are shown below:

a. Four Days of Hospitalization: This would be the upper limit of time feasible for keeping a patient in a clearing station. In general, it can be predicted that if a patient is hospitalized, that his condition would be such that

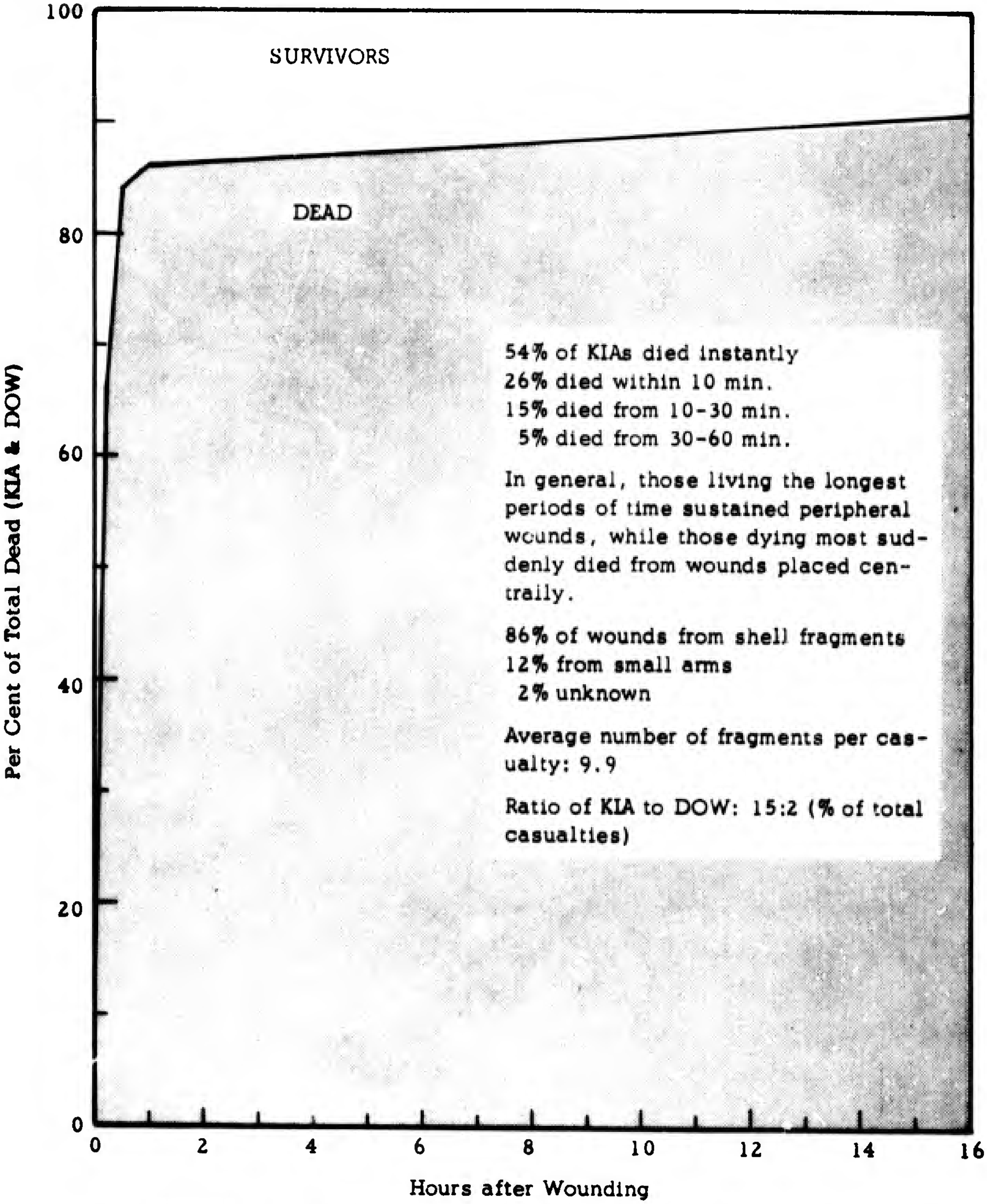

FIGURE B.10. SURVIVAL TIME OF KIA AND DOW CASUALTIES
Estimates made from autopsies made on KIAs in Korean War
(Major J.C. Beyer, M.C. AFIP)
354 cases in this series (1952-53)

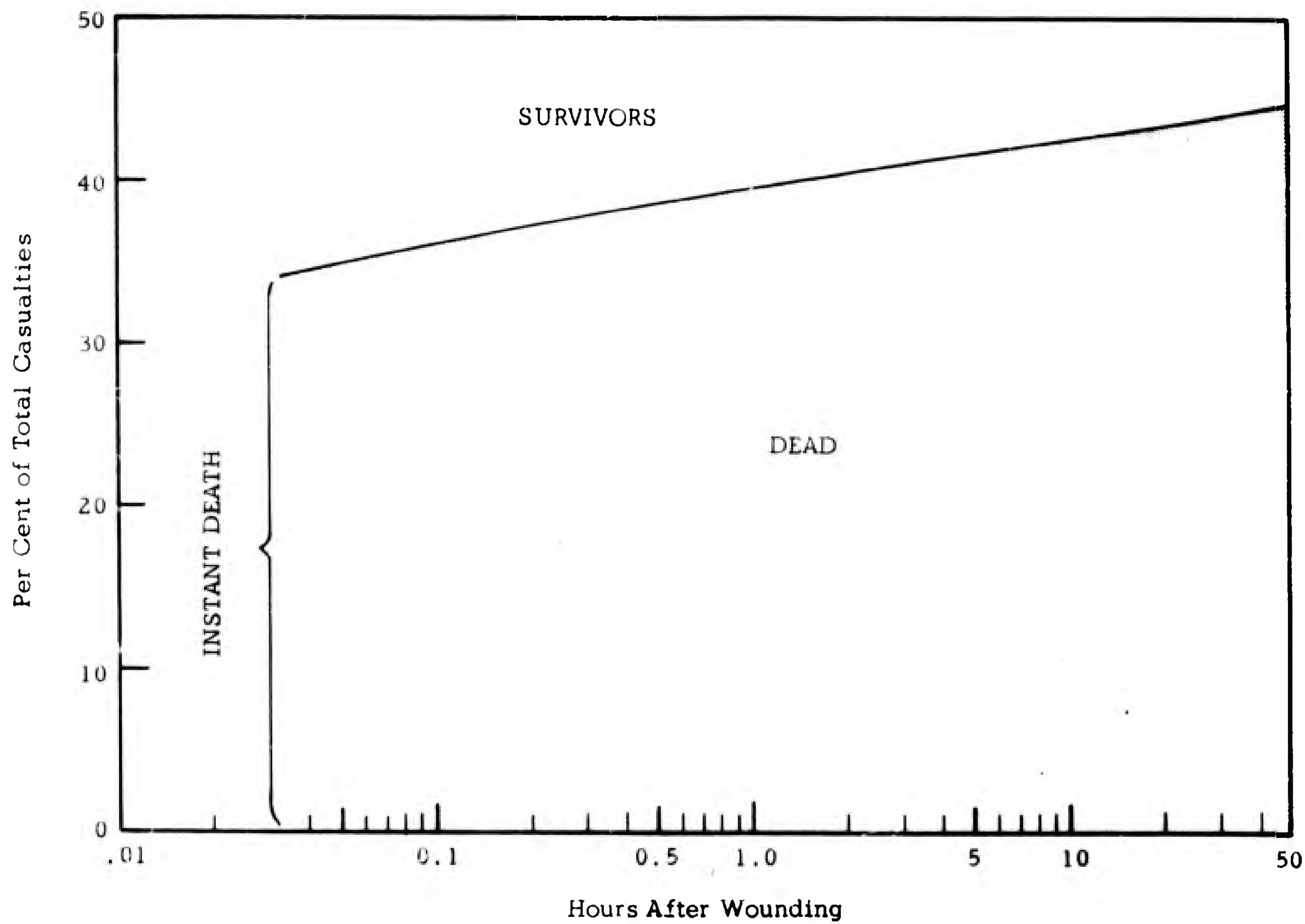

FIGURE B.11. DEATHS DUE TO AIMED MISSILES, SINGLE, IN GOATS
(Light, Biophysics Lab., Army Chem. Corps)

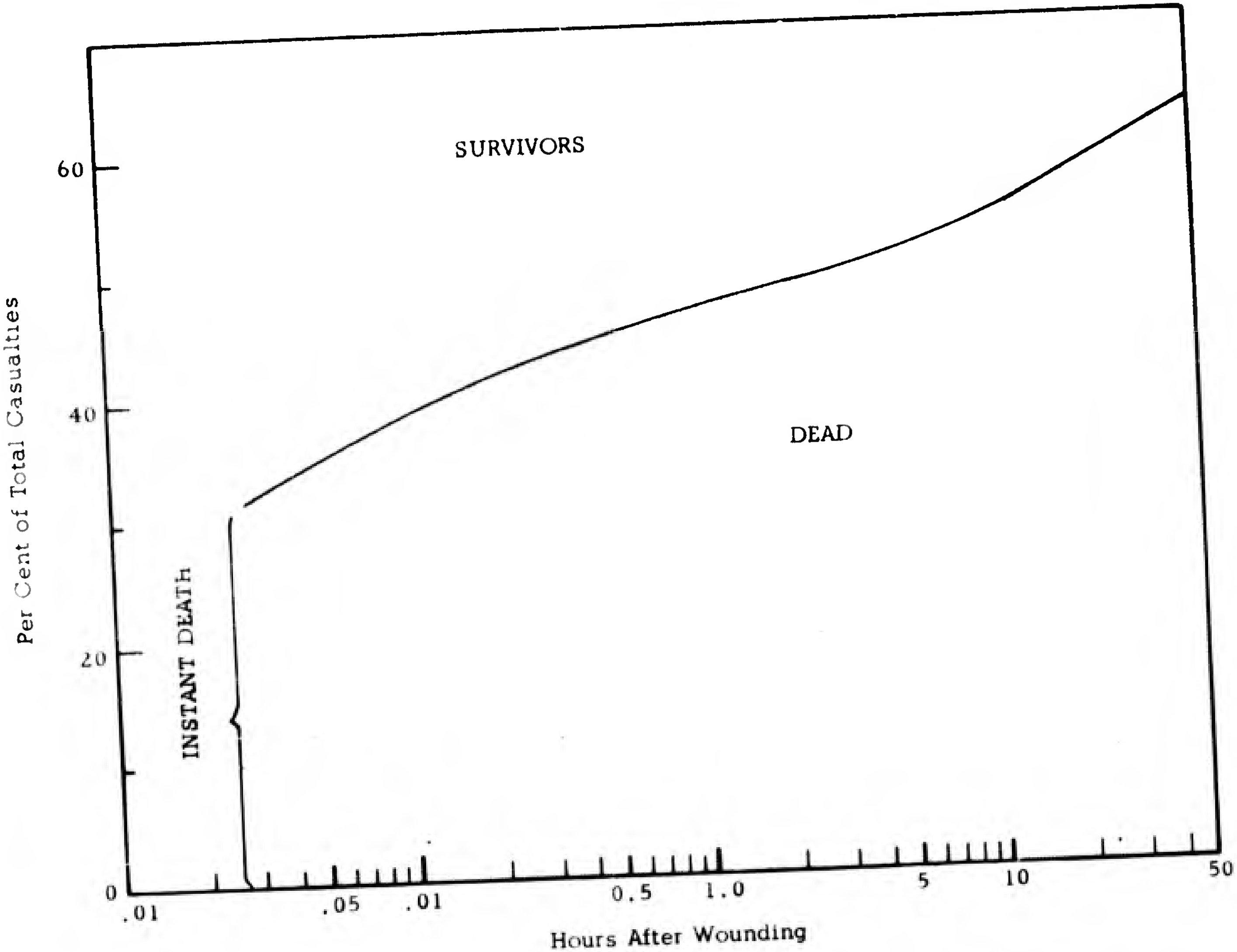

FIGURE B.12. TIME OF DEATH OF 34 GOATS SUBJECTED TO GRENADE EXPLOSIONS (Light, "Some Aspects of the Pathology of Wounding by the Mk II Grenade and by Single Fragments as Observed in Goats," Military Med., June 1958) more than one day would be required to restore him to duty. The range of time for the briefest periods of hospitalization is, therefore, likely to be from 3-5 days, averaging out to four.

b. Ten Days of Hospitalization: Although many of the minor conditions which are likely to be found in military personnel may be substantially cleared up in a week, the usual picture is that this period of illness or injury is sufficiently debilitating that a few days convalescence is needed to restore a man to full military duty. Comparable conditions in civilian life may lead to only 6-7 days of care. In general, then, any condition which requires more than 4 days of medical care is likely to need at least 10 days of hospitalization.

c. Thirty Days of Hospitalization: More serious condition, such as wounds more extensive than those found in the preceding two groups, or illnesses which are more serious, require substantially more time for convalescence. Therefore, a patient who is still disabled at the end of 10 days is likely to require 30 days hospitalization. This period of time is probably the upper limit of time feasible to keep a patient in the combat area. Actually, it will usually be the case that any patient who is still substantially disabled at the end of 20 days will be evacuated to a rear area.

d. Ninety Days of Hospitalization: This is the upper limit of time which is feasible for keeping a patient in the theater of operations. The large bone fractures, nerve injuries and infected wounds are examples of conditions which would require prolonged convalescence likely to go to 90 days.

e. Over Ninety Days of Hospitalization: These will be made up mostly of patients evacuated to the Z/I and not likely to be returned to combat duty.

f. No Return to Duty: These will be the permanently disabled who are discharged from military service. When the prognosis for these cases become obvious, they could be discharged from military service after relatively brief periods of hospitalization, although, in the past this usually took more than 90 days.

MEDICAL MANAGEMENT

B.49 Estimates of time required for the performance of various medical tasks involved in the management have been developed in the course of this study. As has been the case for quantification of other inputs in the development of methodology, reasonable values have been assumed based upon guidance provided by existing information. Treatment times for various classes of wounds were assumed on the basis of experience by investigators conducting medical studies at CDEC. In the course of their field studies, measurements have been made of times for simulated treatment. Further a series of work measurements in Army Hospitals provide additional data.[3] A considerable volume of unit management time data from civilian medical studies has been developed; sample data from two such studies are shown in Tables B.6 and B.7.

Management Tasks in Successive Levels of Patient Care.

B.50 General categories of medical management tasks at various steps in the successive levels of care include:

First Level

By Aid Man

Inspection of Casualties: Estimation of severity of wound and condition of casualty with respect to first aid needed and degree of ambulation possible.

First Aid: Administration of first aid measures, such as control of hemorrhage, bandaging, splinting, and administration of drugs according to established policy (morphine, etc.).

Evacuation: Litter carry or load on vehicle for evacuation patient care.

Second Level

By Medical Officer

Examination: Physical examination of casualties as necessary to make estimates of priority of care, treatment needed, evacuation plan.

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[3] Work measurement in Army Hospitals, Hospital Management Research Unit, Brooke Army Medical Center 1956, (Nursing Service Study General Medical Service; Nursing Service Study General Surgical Service; Pharmacy Study; Registrar Division).

TABLE B.6

TIMES REQUIRED FOR SURGICAL PROCEDURES

Type of Operation	No. Cases	Anesthesia	Surgery	Total (Min.)
1. Laparotomy, Explor.	30	14	11	25
2. Lumbar Laminectomy	30	16	10	26
3. Trephine	2	10	16	26
4. Excis. pilonidal cyst	6	15	33	48
5. Nerve repair	3	10	40	50
6. Cataract	30	24	26	51
7. Amputation, digit	9	13	38	51
8. Enucleation	5	29	31	60
9. Appendectomy	42	11	55	66
10. Colostomy, close	4	10	67	77
11. Jaw, wiring	1	20	60	80
12. Hernia	30	11	80	92
13. Skin graft, debride.	27	11	81	93
14. Tendon graft	2	22	72	94
15. Reduce fracture	10	17	78	95
16. Amputate, leg	8	16	79	96
17. Cholecystectomy	28	11	90	101
18. Hip nailing	30	24	78	102
19. Gastrostomy	6	11	97	108
20. Shunt, ventricular	9	35	90	125
21. Dissection, axilla	3	15	113	128
22. Splenectomy	4	22	177	199
23. Resection, colon	21	17	186	203
24. Commissurotomy	10	37	169	206
25. Pericardectomy	1	26	190	210
26. Dissection, groin	3	10	229	239
27. Gastrectomy, subtotal	24	15	229	244
28. Dissection, neck	9	24	228	251
29. Graft, arterial	2	38	223	261
30. Pneumonectomy	4	34	268	302

Thomas Newberry, Jr., Emory University Hospital, June 1960 - personal communication

TABLE B.7

TIMES FOR TREATMENT

Type of Clinic	No. Observations	Av. Time Spent by M.D./pt.	
General Medical	231	9 Min.	
General Surgical	240	5	
Pediatric	147	16	
Dermatological	110	16	
Diabetic	171	5	
ENT	144	7	
Opthalmic	246	8	
Orthopedic	130	3	
Daily Dressing	400	5	
Obstetric	145	5	
Times Spent in Surgical Examination - Consultation			
		New Patient	Old Patient
General Surgical	287	7	4
Neurosurgical	13	9	8

<u>Studies in the Function and Design of Hospitals</u>, Nuffield Provincial Hospitals Trust, (Oxford University Press, London: 1955).

Specialist Medical Officers:

Definitive Treatment: Surgery, specific medical or psychiatric care.

By Medical Surgical Technicians

Preparation: Prepare casualties for examination and treatment, undress, clean, unbandage, blood pressure measurement.

Treatment Procedures: Carry out prescribed measures, medication, intravenous, etc.

Laboratory Procedures: X-rays, blood chemistry, blood counts, etc.

OR Management: Surgeon's assistant, sterilizing and care of instruments, preparation of OR, requisitioning supplies.

By Unspecialized EM

Moving Casualties: Loading and unloading, transfer to various hospital services.

Housekeeping: Cleaning and maintenance, care of personal effects.

Feeding: Preparation and serving of meals.

By Administrative Personnel

Medical Records: Hospital records, reports

Transportation: Receiving, collecting, evacuating casualties

Supply: Medical supplies, housekeeping and subsistance supplies, requisitioning, transferring, issuing.

(Does not include transportation personnel and personnel who handle unit administration).

B.51 The values assumed for the tasks listed above are shown in Table B.8; the estimates are considered as those for the first day of admission. Some estimates for management times for the 1st, 2nd and 3rd, and the 4th to 30th day of admission are also given (Table B.9). The number of persons collaborating in the performance of the task are shown in parentheses.

Work Measurement Criteria

B.52 The present study has provided additional insight into the problem of work measurement criteria. In certain tasks the conventional type of

TABLE B. 8

Medical Management Schedules	Time/Casualty for Medical Tasks - Day of Admission					
	SURGICAL CASES			MEDICAL CASES		
	Mild	Mod.	Severe	Mild	Mod.	Severe
	Time in Minutes					
I. FIRST LEVEL OF CARE: (Battlefield)						
1. Inspection of casualties	1	1	2	1	1	1
2. First Aid	3(2)*	9(2)	13(2)	1(2)	4(2)	4(2)
3. Evacuation: Moving, loading	0	5	5(2)	0	5	5(2)
II. SECOND LEVEL: (Aid station)						
A. Medical Officer Tasks						
1. Examination	2	3	3	2	3	3
2. Resuscitative treatment	3	7	17	3	7	7
B. Med-Surg. Technician Tasks						
1. Preparation for examination and treatment	3	5(2)	5(2)	3	5(2)	5(2)
2. Treatment procedures	5	15	20(2)	5	15	25
C. Unspecialized Tasks						
1. Moving casualties	0	10(2)	15(2)	0	10	15(2)
2. Housekeeping	5	10	15	5	10	10
3. Feeding	5	10	10	5	10	10
D. Adminstrative Tasks						
1. Medical Records	10	10	10	10	10	10
2. Transportation control	5	10	15	5	10	15
3. Supplies	5	10	15	5	10	15
III. THIRD LEVEL: (Hospital)						
A. General Medical Officer Tasks						
1. Examination	-	3	3	-	3	3
2. Preparatory treatment	-	5	5	-	3	3
B. Specialized Medical Officer Tasks						
1. Definitive treatment	-	22(1.5)	52(2)	-	14	34
C. Med-Surg. Technician Tasks						
1. Preparation of casualties for examination and treatment	-	5	5	-	5	5
2. Treatment procedures	-	10(2)	10(2)	-	10(2)	10(2)
3. Laboratory procedures	-	15(3)	15(3)	-	15	15
4. OR Management	-	15(3)	15(3)	-	-	-
D. Unspecialized Tasks						
1. Moving casualties	-	15	15(2)	-	15	15(2)
2. Housekeeping	-	30	30	-	30	30
3. Feeding	-	30	30	-	30	30
E. Administrative Tasks						
1. Medical Records	-	15	15	-	15	15
2. Transportation	-	10	15	-	10	15
3. Supplies	-	10	15	-	10	15

*No. of Persons Required for Task in Parentheses - Multiply by Number of Minutes

TABLE B.9

ESTIMATED TIMES REQUIRED FOR MEDICAL TASKS IN FIELD HOSPITAL

TASK	Day No. 1				Days Nos. 2 & 3		Days Nos. 4 to 30	
	Surgical Cases		Medical Cases					
	Mod.	Severe	Mod.	Severe	Surg.	Med.	Surg.	Med.
	MINUTES Per Patient Per Day							
A. <u>General Med. Officer</u>								
1. Examination	3	3	3	3				
2. Treatment	5	5	3	3	10	10	5	5
B. <u>Specialized Med. Off.</u>								
1. Treatment	22 (1.5)*	52(2)	14	34	15	0	0	0
C. <u>Med. Surg. Tech.</u>								
1. Preparation	5	5	5	5				
2. Treatment Proc.	10(2)	10(2)	10(2)	10(2)	60	50	40	30
3. Laboratory Proc.	15(3)	15(3)	15	15				
4. Or Mgmnt.	15(3)	15(3)	-					
D. <u>Unspec. Personnel</u>								
1. Moving Casualties	15	15(2)	15	15(2)				
2. Housekeeping	30	30	30	30	20	20	15	15
3. Feeding	30	30	30	30				
E. <u>Administrative Pers.</u>								
1. Med. Records	15	15	15	15				
2. Transportation	10	15	10	15	20	20	15	15
3. Supplies	10	15	10	15				

* Numbers in Parentheses Indicate Number of Persons Performing Task — Multiply by Number Minutes

Resuscitative Treatment: Directs or carries out resuscitative care including: fluid replacement, minor debridement, control of hemorrhage, adjustment of splints and bandages, prophylactic antibiotics.

By Med-Surg Technicians

Preparation for Examination and Treatment: Undresses, cleans, removes bandages and splints as necessary. Takes BP, temperature.

Treatment Procedures: Carries out procedures prescribed by medical officer. (For many standard types of casualties, a standard operating procedure will apply which will need little or no supervision from the medical officer.) Administers medications, intravenous fluids and splints.

By Unspecialized Personnel, EM

Moving Casualties: Loading, unloading, litter carry of casualties to designated site.

Housekeeping: Care of personal equipment, disposition of weapons, issue of blankets, cleaning, labor.

Feeding: Preparation and feeding of simple food and beverage.

By Administrative Personnel

Medical Records: Emergency medical tags, statistical reports, etc.

Transportation: Traffic control, location of casualties, communication.

Supplies: Exchange of litters, blankets, medical supplies forward and back.

Third Level

By Medical Officers

General Medical Officers:

Examination: Appraisal, diagnostic examination, determination of priorities and treatment plan.

Resuscitative Treatment: Preparation of casualties for surgery and other definitive treatment, treatment for sick, post operative care.

time and motion data will be relevant, and can be used directly or after application of a field difficulty factor to correct for performance in a field or combat situation. A different approach will be necessary for development of other, and the more frequent combination of tasks. Medical management involves varied rather than repetitive tasks. These are commonly discontinuous, overlapping and are performed by groups or teams rather than a single individual. Measurement criteria must be based upon probabilities of performance of specific tasks in varying proportion and sequence, and for the most part must be considered as combinations of dutues performed by minimal functional units. Essential combinations must be defined and criteria reflecting the minimal functional unit capacities carried out singly or in combination for performance professional, medical ancillary and support tasks for a given level of medical care within the reference frame of duties which are probable for the future AMEDS support systems.