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AN ANALYSIS OF SYSTEMS FOR FEEDING HOT MEALS TO THE ARMY IN THE FIELD DURING 1975-1990 TIME FRAME

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AN ANALYSIS OF SYSTEMS FOR FEEDING HOT MEALS TO THE ARMY IN THE FIELD DURING 1975-1990 TIME FRAME

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FOREWORD

An operations research/systems analysis study was conducted of potential feeding systems and to provide a basis for planning the RDT&E program for development of a suitable system for feeding the Army in the field in the 1975-1990 time frame. The study was conducted by the U.S. Army Natick Laboratories at the direction of Headquarters, U.S. Army Materiel Command.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

An analysis was conducted of a large number of potential systems for feeding hot meals to the Army in the field during the 1975-1990 time frame. Systems selected for detailed study were essentially synthesized from the major elements of both on-going developmental projects and other proposed systems. Major objective was resource expenditure reduction through food service personnel reduction and general system simplification. The study gives a cross sectional view of the effects of adoption of systems employing advanced food preservation and preparation techniques in comparison to the present doctrinal system of company level feeding. An analysis of alternative mixed systems (company level and higher) is also made indicating greater potential for food service personnel reduction and system simplification than in any of the solely company size systems evaluated. Conclusions suggest need for extension of the study to determine more clearly the direction of required reorientation of RDT&E effort.

I. INTRODUCTION

A. Introduction to Problem

In the last few years, there has been a developing interest in updating Army feeding equipment and rations in keeping with apparently radical changes taking place in the commercial food world. Such changes are characterized by the increasing availability of factory prepared foods preserved by a number of different methods such as freezing or freeze dehydration. Also, some equipment available today embodies techniques of cooking and heating by microwave and infrared emissions which, if not scientifically "new", are at least new in the sense of some of their relatively recent applications within the food field. The availability of new techniques and equipment and the rising costs of labor, capital investment and the continuing difficulties of obtaining food service personnel, has led to very active experimentation among many diverse elements found in the American food industry. A number of systems, new in terms of application, has been developed as a result of this active experimentation, drawing attention to their possible use for feeding the uniformed services.

A number of different kitchens are under development by the Army Materiel Command on the basis of stated requirements by users. A family of combat rations is also under development. An example of an integrated approach (food and equipment) is the SPEED system (in exploratory development) which proposes the use of special purpose convenience food and microwave heating (77).

In general, the study of alternative approaches is a healthy situation and much valuable knowledge is being gained. However, it is obvious that if the DoD objective of maximum commonality of systems is to be achieved a selection process will have to take place. A prime requisite for the selection of a new system would be the determination that the cost effectiveness of that system is favorable in relationship to the cost effectiveness of competing items on a DoD wide basis. The proposed system or combination of systems must be compared with other choices available throughout DoD to include new, existing, or modified systems for meeting operational requirements (92). Thus, this study is in effect a part of the concept formulation phase for development of a new feeding system.

This study was initiated by the U. S. Army Natick Laboratories by direction of HQ Army Materiel Command. The basic purpose was to conduct a systems analysis of potential feeding systems and to provide a basis for planning the RDT&E program aimed at developing a suitable feeding system for the Army in the field in the 1975 to 1990 time frame.

The magnitude of this task was recognized early in the planning of the study. Only by making certain broad assumptions and scope limitations could the study group hope to accomplish a useful effort. It was recognized also that this effort would probably serve to uncover and identify a multitude of problem areas that would be the basis for follow-on studies. This has occurred and many areas have been indicated as potentially profitable targets for follow-on studies.

B. Purpose and Scope

This study was initiated to evaluate candidate feeding systems for the Army in the field for the 1975-1990 time frame. The primary purpose was to select the best system capitalizing on advances in food technology, food service technology and transportation which would provide troops in the field highly nutritious, palatable and well accepted meals, accompanied by a savings of manpower (reduction of support troops) both in quantitative needs and skilled personnel.

The field feeding system today is deceptively simple in appearance yet is enormous in size and complexity upon detailed analysis (Appendix B). Certain limitations were agreed upon in order to make the study manageable and still produce guidance for planning the RDT&E program for developing a suitable feeding system for the time frame specified.

General limitations to the study were:

a. Feeding systems would provide at least an equal level of system performance or effectiveness under the same tactical situations.

b. Consider only systems or subsystems whose hardware can be type classified by 1975; whose general mobilization production base for all components can be assured by 1977; and whose food requirements can be expressed in specifications for large scale competitive procurement by 1977.

c. Consider only systems employing an organic 200-man company level kitchen.

d. Exclude separate small group feeding, i.e., squads, patrols, tank crews, etc.

e. Select criteria in terms of cost for each system, based on at least equal performance or effectiveness for all systems.

f. The present doctrinal system of M-1937 kitchen and B-Ration be used as the base system for comparative purposes.

Limitation b eliminated systems designed to exploit the full capability of freeze dried and radiation processed foods and should have eliminated systems designed to exploit the full capability of special purpose convenience foods (see definitions in Appendix C and availability of special purpose convenience foods, pg 38). Strict adherence to limitation b would have reduced the study to consideration of not much more than product improvements of the current system. In recognition of the current interest in use of special purpose convenience foods, systems based upon this type food were included. The inclusion was made possible by the availability of sufficient data on existing special purpose convenience foods to permit reasonably accurate predictions of procurement cost, weights, cubes and other factors.

During Phase I of the study it was discovered that no proposed company level system provided an operating cost decrease under that of the base system. This led to an expansion in scope to include alternative systems employing combinations of kitchens of varying capacity (Phase II). The same limitations listed above were in effect during Phase II of the study except for c.

II. ANALYSIS OF SELECTED SYSTEMS UTILIZING COMPANY LEVEL KITCHENS (PHASE I)

A. Assumptions

The following assumptions were made:

a. That all food be shipped in modules of 25 meals containing all major components to prepare and provide a specific menu and that at least a 28-day cyclic menu be followed (28 breakfasts, 28 dinners and 28 suppers).

b. That all kitchens will be designed to have the capability to prepare fresh foods (as opposed to prepared food input) in the event of either breakdown of the supply line or command desire to supplement with local or CONUS procured fresh foods.

c. That all systems would be based on the shipment of food modules in standard 8' x 8' x 20' containers.

d. That all alternatives are in the system long enough that the initial investment cost could be treated as a sunk cost (complete equipping of the field Army with the proposed system).

e. That meal quality and acceptability for all systems are designed to at least equal the base system, the M-1937 kitchen with B-Ration.

f. That standard personnel costs will be based on DoD guidance and annual rates.

g. That interactions between field and garrison feeding will be resolved in favor of optimization of the field feeding system at the expense of the garrison system.

h. That under any frequently occurring tactical situation, the design of all kitchens will be such that, given the required food inputs, the probability of being able to serve a hot meal is about the same for all.

i. That all feeding systems can, if necessary, extend the range of support capability by use of insulated containers for delivery of food when troops cannot return to the kitchen.

j. That the management structure for all systems remains essentially the same and therefore is a constant cost for all systems.

B. Discussion of Assumptions

The costing of the present system of bulk issue of subsistence could not be accomplished within the resources of the study group. The effect of assumption of a 25-man module is to put all systems on a common base so that differences in pipeline cost are due solely to differences in weight, bulk, and associated handling cost. The CDC DPQMDO for a Food Service System for the Army in the Field (90) calls for a modularized system. The technical feasibility of a modularized B-Ration has been established and can be adopted at any time (94). An assumption of a modularized A-Ration is impossible since the A-Ration is composed of non-perishable, chill and freeze items which cannot be successfully shipped in the same module. Another effect of this assumption is to limit the items that could be put into the modules, i.e., perishable items could not be handled in a non-perishable pipeline and non-perishable items handled in frozen modules have to be limited to those items which are not affected by freezing.

The assumption of fresh food capability follows from the long established Army policy of serving it to the maximum extent feasible as was recently reemphasized in the DPQMDO for a Food Service System for the Army in the Field.

Assumption of shipment of food in standard containers is in keeping with the current trends in transportation and CDC guidance documents (39). This assumption provides a high degree of supply control and elimination of damage and pilferage. It presents the same problems as the modularized ration concept in that items shipped in the same container must be compatible in terms of the transportation method used, i.e., refrigerated or dry cargo.

The assumption that the cost of initially equiping the Army with a system as a sunk cost (already paid for out of prior year funds) is a frequently used simplification when initial investment cost is a small fraction of the total life cycle cost of owning and operating the system. The assumption is justified on the basis that the annual operating cost, including replacement cost, of systems included exceeds the initial investment cost and the expected service life of the system is, on the average, roughly ten years.

In addition to nutritional content, variety and component acceptability as determined by established techniques, meal quality has other parameters which have been too little investigated to permit definition in a form compatible with objective analysis. The consumer evaluation of meal quality is believed to include environmental, psychological, cultural, social, symbolic and perhaps other factors present at the time the meal is served and consumed. It is not beyond possibility that the factors that can only be vaguely suggested at present may be more important in formulating the consumers' concept of meal quality than the three contained in the assumption concerning meal quality parameters. The assumption was adopted as the only one available that would not require that the study be suspended indefinitely until the question of meal quality could be resolved by proper investigation.

The effect of assumption h is several fold. It recognizes the prime importance of food supply to serving meals. It takes the comparison of kitchens out of the "worst case" category and places the comparison on the basis of the most good for the most men.

The purpose of the systems under study is to provide hot meals to company groups (200-man). Feeding smaller groups hot meals is an entirely separate system for which a large number of alternatives is available. Among the alternatives are systems based upon transporting hot food from any available source in some means that provides for hot delivery. The link or interaction between these small group alternatives and the large group alternatives is the hot food. The assumption recognizes that, for the purpose of delivery at a remote point, given that hot food from one source is indistinguishable from the same hot food from another source, the interaction is weak enough to be neglected in considering the large group system.

The strong interactions between garrison and field feeding have not been apparent because the Army has used essentially equivalent systems for both for years. The garrison is in effect a "live storage" facility in which designated units of the Army in the field are kept in readiness for deployment. If, while in garrison, these designated units do not use essentially the same feeding system they do in the field, they will not be ready for deployment. A current day example is the Army bread bakeries. Most Army posts contract for bread deliveries. There are only a few military operated post bakeries. This makes good economic sense and stabilizes personnel turnovers. It does present problems, however, when the Army moves to the field and needs trained military bakers to serve in a combat zone. The effect of the assumption is to place a dominant priority on combat readiness over economy in garrison feeding.

The management structure affecting Army field feeding is large and complex (Appendix B). To completely cost out this structure is beyond the capability of the present study group. There is little reason to believe that the structure above the theater Army would undergo drastic changes as a result of a change to any of the new field feeding systems studied. By a commonly accepted technique in systems study, the cost of this large unknown is assumed to remain constant for comparative purposes. It must be left to follow-on studies to analyze this large and complex structure.

C. <u>Subsystem Elements Studied</u>

The following are the subsystem elements studied:

a. Food

(1) Frozen special purpose convenience food, preportioned.

(2) Frozen special purpose convenience food, bulk packaged.

(3) Non-perishable special purpose convenience food, preportioned.

(4) Non-perishable special purpose convenience food, bulk packaged.

(5) Non-perishable conventional food, bulk packaged (B-Ration).

b. Kitchens

(1) Appropriate kitchens for preparation of food types (1) through (4).

(2) Three kitchen types for food type (5): powered (electrical); non-electrical; M-1937 kitchen.

c. Transportation

(1) Dry (non-perishable)

(2) Frozen (conventional refrigeration)

(3) Frozen (liquid nitrogen refrigeration)

The subsystem elements are discussed in Appendix A.

D. <u>Methodology</u>

The various subsystems listed in C above were costed, based on information obtained from the most recent technical references available (see Bibliography) and input data from the General Equipment and Packaging Laboratory and the Food Laboratory, U. S. Army Natick Laboratories. This information, as developed, is contained in Appendix A.

A large number of alternative systems is produced by taking all possible combinations of subsystem alternatives. A computer program was developed and written to calculate and rank the alternatives by totals of costs. The summation process is described in Appendix A, along with the actual elements included (transportation, personnel, fuel, etc.).

E. Discussion of Results

Appendix A describes the major subsystems of food, pipeline and kitchen. Table A6 gives the most economical element of each subsystem as determined by a computer program based on five different food types. These costs are shown as incremental costs in excess of the lowest cost food, pipeline, kitchen system. The lowest cost system is the B-Ration, non-perishable (dry) pipeline and M-1937 kitchen. Therefore, despite the application of a variety of advanced food preparation and preservation techniques to the systems, the total quantitative requirements (in dollars) in all cases are greater than the present B-Ration and M-1937 company kitchen system.

F. Kitchen Police Requirements

The cost of KPs was not included in the systems cost developed since it is not known to what extent the introduction of special purpose convenience foods and expendable eating utensils would affect the workload of the KP. The costs of assigning from one to five KPs per kitchen is shown in Table A6 based on the total requirements for a 500,000 man theater. Adding the cost of five KPs per kitchen to the lowest cost system (B-Ration and M-1937 kitchen) and nothing to any other system would make two systems cheaper than the dry pipeline and M-1937 kitchen system. Since these two systems, in which the M-1937 is replaced with a newer kitchen, utilize the same dry pipeline and food, it is likely that the KP requirements and ranking would be about the same.

G. Skill Requirements and Minimum Staffing

One of the major objectives of this study was to select a system which results in a reduction of support troops involved. It has been commonly assumed that the use of convenience food with the "built-in skill and labor" would require less personnel. However, there are two factors which apparently prevent a significant reduction of personnel from taking place when special purpose convenience food is used in the alternative systems. One is the retention of a fresh food preparation capability and the other is a minimum staffing level for feeding 200-man groups.

The retention of the fresh food capability affects only the skill required of the assigned food service personnel. In other words, at least one man per kitchen must have the complete knowledge and skill to prepare meals utilizing fresh food. This would have some effect on training costs since there would be fewer trained cooks to be assigned to each company. The lesser skilled personnel could be given more abbreviated training and thus lower the total training costs. Since the most important objectives is to reduce the total manpower requirements, this factor is of secondary importance.

The most important factor which determines the total food service personnel requirements appears to be a minimum staffing limitation. In actual tests in the field utilizing special purpose convenience foods, the SPEED kitchen required three persons to perform all the tasks required for the feeding of 200 persons within the prescribed meal period (unpublished data, U.S. Army Natick Laboratories). The food preparation time is shorter with special purpose convenience foods but this only affects the meal preparation starting time and not the staffing. Prepared foods must still be garnished and served, beverages must be reconstituted, field bread must be sliced, salads and desserts must be portioned and many other minor tasks performed. A recent study (106) of food service labor in nine hospitals showed that the total labor time involved in preparation and processing of food took less than 14 percent of the total labor time involved in preparing and serving meals. Two studies, one conducted by the Navy (29) and one by the Department of Agriculture (32), computed theoretical requirements for food service personnel staffing. Three types of facilities were involved: a large Navy galley ashore, a commercial single line cafeteria and a commercial double line cafeteria. When a comparison is made of the theoretical manhours required per meal served, the total work required (food preparation, serving, cleanup, etc.) to produce a meal is very close regardless of the average number of meals served.

These facilities studied were all using conventional food input. All of the facilities were judged to be overstaffed. The studies showed that actual food preparation (i.e., recipe formulation by a cook or baker) is only a small percentage of the total work to be accomplished in any food service facility. Thus, convenience foods affect only a small portion of the total work level. In the smaller messes this simply means that with special purpose foods the cook can devote more time to the other pre-meal time activities or resources remain idle. The manpower savings in small messes are measured in increments amounting to fractions of a man day which cannot be profitably used for other activities. In larger messes, however, equipment can be provided which increases the cooks' productivity. Also, the fractional savings of manpower for different functions can be profitably turned to the accomplishment of other tasks or to staff reduction since these savings then possibly amount to complete man days.

Much more work needs to be done to firmly establish the minimum food service staffing of a company in the field. On the basis of the above references and experience with SPEED in the field, there is a strong indication that a food service personnel reduction much below the current company kitchen staffing level cannot be made regardless of the type of food and kitchen used. What this means is that the doctrine policy of company size (approximately 200 man) mess units does more to establish food service manpower requirements than the type of preparation equipment used or the food issued.

H. Systems Analysis and Design Problems (Phase I)

In Phase I the study was essentially an analysis of proposed new systems for a company level feeding of effectiveness at least equal to the current doctrinal system to find a system which reduces total resources required. It was expected that this approach would provide a system which was better than the present. The fallacy of this approach (seen in the clear perspective of hindsight) was to presuppose or accept that company level feeding, an accepted tradition, is the single "best" way to feed troops in the field. A basic rule of systems analysis and design is that a total system not be designed to meet the requirements of a small portion of the total system. To do so usually results in less than optimum system performance and excessive expenditure of resources. Put in terms of a field feeding system, a kitchen designed to meet the needs of, for example, an infantry company in combat will result in a kitchen which may also be used to feed a rear area service company. The cost will, however, be excessive since the requirements of a combat unit, which are high in terms of mobility, reliability and dependability, will add to the total dollar cost of the kitchen. The rear area unit has the same basic requirements but at a reduced level which may not justify the extra expenses. The present M-1937 kitchen is austere, meeting essential requirements, but incorporating practically no "nice-to-have" features. As an "all-purpose" kitchen, however, it apparently cannot be surpassed without increasing feeding cost.

The basis of the frequently expressed dissatisfaction with this kitchen is far from clear. It seems to center around a belief that, current technology would allow a "better" kitchen but the "Army" has not provided it, rather than any serious deficiency. There is some vague connection between "better" and feeding under conditions less austere than full scale combat operations. It may well be that dissatisfaction with the kitchen can never be eliminated as long as only one kitchen is issued for all field uses. The range of conditions may be far too broad to design one kitchen that would be fully satisfactory for all.

Company level feeding undoubtedly evolved from the time when the ratio of combat troops to support troops was high and equipment was limited to simple hand weapons and cannons. Today, the equipment of a modern Army is complex and sophisticated and the ratio of combat troops to support troops has reversed itself as a result of support requirements. On this basis alone there is sufficient reason to reevaluate the company level feeding concept which has changed very little while the tactics and strategy of modern warfare have drastically changed and probably will continue to do so.

Units in the Army are broadly grouped as combat, combat support and combat service support. Each type of unit has a different mission and is found at different places in the theater of operations as a result.

The ability of these units to feed their men hot meals is dependent upon the degree of intensity of combat in which they are engaged. At any one time within a theater different units have different missions and are engaged in varying degrees of combat intensity. Under these circumstances, when the same equipment is provided to all units, the standard kitchen does not fit neatly into every situation.

A more logical approach to this study is to analyse the total theater feeding system in terms of its actual requirements considering numbers and types of units, their missions, the degree of combat intensity, environment, etc. Since future warfare may be fought under a number of different alternative situations (as different as Vietnam and World War II in Europe), the problem immediately becomes large and fairly complex. Since the actual scenario developed under various alternative situations will affect the troop list and their missions, this may mean that several field feeding subsystems are required to meet different situation requirements.

I. Conclusions

a. Of the company level alternatives studied, the M-1937 company kitchen, B-Ration and non-perishable (dry) pipeline is the most economical combination of subsystems.

b. As a result of minimum staffing requirements, the total food service manpower requirements may be more dependent upon the policy of company level feeding than on food input or equipment used.

c. Alternative methods to the doctrinal policy of company level feeding should be examined for possible economies based on total theater feeding system requirements.

III. ANALYSIS OF SOME ALTERNATIVES TO COMPANY LEVEL FEEDING (PHASE II)

A. Introduction

One of the conclusions of Phase I of this study is that alternative methods to the doctrinal policy of company feeding be examined for possible resource reduction and other gains based on the total theater feeding system requirements. Based on this conclusion two alternatives of company feeding were constructed based on the data of Phase I. A 1,200 man central kitchen and a 50 man special purpose convenience food kitchen (Chuck Wagon) were arbitrarily chosen as alternatives. The large kitchen was selected to study the effects of the concept of resource reduction through centralization. The smaller was selected as a simplified approach to hot meal feeding which could be expected to accompany combat troops into all but the most intense combat situations without the burden of a larger company size kitchen. For comparative purposes the present B-Ration and M-1937 kitchen combination represents a company size kitchen. It should be emphasized that the size selections of the new systems are arbitrary and are not necessarily the optimum-sized facilities. The purpose of this phase of the study was simply to allow preliminary evaluation of new and different concepts rather than a system based solely on company level kitchens.

B. Assumptions

All assumptions of Part I are valid for this phase except that larger than company level kitchens may be considered for feeding up to 90 percent of all troops in the combat zone and that a smaller than company level kitchen can be used for up to 10 percent of the combat and combat support troops.

C. Discussion of Assumptions and Costs

While the scope of Phase I of the study was limited to various alternatives at the company level (200-man) kitchen, it was concluded that at least a preliminary evaluation of alternatives of feeding at other levels should be conducted. It was assumed that all limitations and assumptions of Phase I are valid for this phase of the study except that considerations of the other than company size kitchens may be made.

It should be clearly understood that the total cost of the present system is not known. Costs of portions of the system such as operation of the management structure are unknown. However, the costs of portions believed to be dominant contributors to cost differences of the present system are known with a fair degree of accuracy. For the purpose of the following comparisons the unknown costs are assumed to be closely equivalent regardless of the field feeding configuration. Where it is thought that significant savings may be gained in the unknown portions as a result of the use of any particular system, it will be discussed.

Equipment Selection and Costs. The present system as used in this phase of the study refers to the M-1937 kitchen and modularized B-Ration combination.

The central facility kitchen is assumed to be an all electric kitchen utilizing an electrical power source and conventional foods and equipment. No assumption is made that the design is optimum. It has an arbitrarily selected feeding capability of 1,200 men. It is not divisible into separate functionally equivalent operating sections. It makes maximum utilization of high capacity production equipment which improves the work output per cook many times over the small batch type equipment. The size selected is not necessarily the optimum but was selected to illustrate the savings potential for a large field feeding facility. This facility utilizes the same conventional food input as the present system.

The Chuck Wagon concept is not a kitchen in the true sense. It is an extremely simple, inexpensive, food preparation device supporting approximately 50 men. It would be lightweight and possibly operated on a small trailer or quarter-ton truck. It would provide a method for heating individually preportioned, non-perishable, convenience menu items and a method for making hot beverages and soups from premixes. Possibly based on simple adaptation of the present M-2 burner, it could be operated and maintained on a duty roster basis by any member of a combat unit. A reasonable variety of hot meals could be provided in situations where combat troops might otherwise be expected to eat the Meal, Combat, Individual (MCI). It would be expected to be more effective in raising the probability that combat troops receive hot meals under situations that preclude use of kitchens preparing an A- or B-type ration. It could accompany combat troops into situations where a larger kitchen could not go.

Procurement Costs. The procurement costs of each system have not been included in this systems comparison. This comparison is based only on operating costs of systems in being. This assumption was discussed in the Phase I and the same rationale applies. For information purposes the estimated production costs and life span of each kitchen are as follows:

a. Present kitchen - $3,161   8 to 10 year life

b. Central kitchen - $100,000   10 year life

c. Chuck Wagon - $1,500   8 to 10 year life

The operating costs of kitchens significantly outweigh the procurement costs when compared over the expected life span of the equipment.

Staffing Costs. The staffing for the central kitchen and the Chuck Wagon are all based on the best informed opinions and field experience with experimental kitchens (such as MUST, BARE BASE, and SPEED) being developed by NLABS. The salaries are based on the DoD standard annual rates (on a 365 day basis). The staffing of the present system is based on the criteria of AR 310-32, Organizational Equipment Authorization Tables, Personnel (20). Kitchen Police (KPs) authorization is based on the minimum rate of two for a mess serving 50 or fewer persons per meal and one for each additional 50 persons or major fraction thereof served (15).

The assumption is made that these authorizations are correct and based on appropriate "yardstick" measurements of actual work to be done. Informal discussions with the DA agency responsible for manpower management indicate that this area probably should be reevaluated to take into account any changes which have been made over the years. For example, some of the duties ascribed to KPs in TM-405 may exist in the garrison situation but not to any extent in the field, e.g., preparation of fruits and vegetables for serving and/or washing dishes, trays and tableware.

AR 310-32 provides the basis for development of TO&E authorizations for personnel. Nonproductive time factors specified include a standard factor of 2.0% or 88 manhours for kitchen police. Informal discussions with field commanders indicate that some commanders are not aware that a factor for KP manhours expended is included in TO&E strength computation.

Despite this allowance, experienced combat commanders have indicated that during combat operations the actual number of men diverted to KP duties varies widely. Usually these men are light casualties, replacements, transients, and other personnel not otherwise suitable for use in combat. It is the rare exception during combat when four or five experienced combat soldiers capable of fighting are diverted to this duty.

In the central kitchen four mess men are added to perform the functions of KPs. These men would be OJT or junior grade cooks, progressing into higher ranking positions in the kitchen. This suggested staffing for

KP-type duty should not be considered optimum and is subject to verification.

Administrative personnel such as mess officers, mess sergeants and their assistants are not included as they do not contribute directly to the performance of the food preparation workload. It is known that some of these personnel are frequently called upon to perform as cooks when long and short term vacancies occur but the assumption of a full staff of cooks is made for each system.

Maintenance Costs. Estimated maintenance costs (obtained from USA Mobility and Equipment Command) include individual component replacement factors but do not include combat loss replacement. The combat loss figure depends upon the degree of combat intensity and would vary with the operational assignment area. The higher degree of expected combat losses in the forward area must be considered in selection of relatively costly kitchens for use in forward areas. However, this factor has not been considered in this study since the costs are small in comparison to the magnitudes of the other costs considered.

Fuel Costs. Fuel costs are included since an increased liquid fuel requirement for any system must be considered not only for increases in fuel volume and cost but also for additional POL distribution equipment. These factors are of an increasing significance as the operational level is moved toward the Forward Edge of the Battle Area (FEBA). No system is penalized in this present comparison for increased fuel distribution requirements but the fuel costs are included to emphasize that this consideration must not be overlooked in the systems selection process.

Expendable Mess Gear. Expendable eating utensils are considered to be an add-on feature which can be used when justified with any kitchen system. The central kitchen assumes the use of nonexpendable mess gear with appropriate dishwashing facilities. The Chuck Wagon food input is assumed to be in a packaged form which does not require additional mess gear. The cost of this feature is included as a part of the ration costs.

Ration Costs. The current field kitchen system is based on the use of a modularized, 25 meal, B-Ration, as in Phase I. The central kitchen is assumed to use the same ration. It should be noted that this in no way precludes the use of the central kitchen to prepare an A-Ration. The B-Ration is defined as to food items and menu in SB 10-495 (90) and is therefore computable in exact cost terms. On the other hand, an A-Ration is highly variable in composition with regard to percentages of frozen, chilled, canned, and other items and varies between CONUS and overseas commands. This requires consideration of a number of complex factors such as command refrigerated storage space, shipping and storage life of perishables and commander's desires in order to compute the exact cost. The B-Ration on the other hand represents a well defined (and therefore predictable) level of feeding readily procurable in the event of a major mobilization.

In this systems comparison the consumption rate of the Meal, Combat, Individual (MCI) has not been deducted from the total operation cost. Current consumption rate of MCIs in Vietnam amounts to about five percent of the total meals consumed. MCI consumption is not usually deleted from theater subsistence requisitions because it is very difficult to predict, six months in advance, which troops, in what area, will be consuming MCIs. This acts, in effect, as a safety level for the theater menu stocks to allow for losses or slippage in transportation.

Transportation Cost. The transportation cost is that from CONUS producer to the kitchen and is based on the same transportation costs developed in Appendix A.

D. Present Troop Feeding Practices and Alternatives

The present methods and practices for Army troop feeding in the field are products of an evolutionary process. This process, started in 1775, actually had its beginnings in European Armies. The ties between organizational structures and feeding practices have remained relatively unchanged, i.e., the company has been the basic echelon responsible for feeding troops. Prescott (67) explains this in "A Survey of Rationing and Subsistence in The United States Army, 1775 to 1940":

"The basic reason for the company being, generally, the mess unit lies in the established custom of regarding the company as the military financial unit with which the source of supply has always dealt.

Aggregations of per capita allowance unified into bulk requirements have always been figured by the company commander to present as requisitions for supplies. It has not been the platoon, the battalion or regiment that did this. Consequently, it has always followed that the company was the natural group to eat in common, as a unit. That is, the company being the basic administrative unit it has also been, naturally, the military social unit."

While administrative procurement and supply procedures for supplying food have been modified to accommodate the requirements of the various periods of quiescence to extreme activity in which the Army found itself, company feeding has remained as the basic focal point of all food procurement and supply activities. In latter years there has been some movement toward the establishment of consolidated messes in garrison but the majority of feeding units in the Army today are of company size.

Alternatives to this policy exist and are practiced not only in foreign armies but in the sister services. For example, the battalion is the basic mess unit in the Marine Corps. In this phase of the study an alternative to company feeding policy is postulated and evaluated for its effect on resource reduction.

The Army troops in a theater of operations are divided into combat, combat support, and combat service support. Each of these type units is, by definition, engaged in different activities with different missions. The ratio of combat troops to support type troops is 1:8 or 1:9, dependent upon how units such as artillery and combat engineers are classified. For purpose of this study, the ratio is assumed to be 1:9. Thus, ten percent of the troops in a theater are expected, on the average, to be engaged in active combat.

Experienced Army food service personnel agree that the tactical situation will always dictate the feeding method employed. No matter how mobile or sophisticated the company kitchen can be made, the present M-1937 field kitchen, mounted on a truck, could be expected to accomplish the same results in feeding hot meals to troops as a more sophisticated, technically advanced kitchen under identical tactical situations. A company kitchen's size and vulnerability prevent it from accompanying the troops to combat areas. The Chuck Wagon described above was based on the reasoning that there are some situations where a simple device with proper food input could accompany troops into combat to provide hot meals of a better quality than that provided by foods supplied in insulated containers or by MCIs.

For the purpose of this phase of the study, it is assumed that Chuck Wagons would be pooled at an appropriate level and issued to troops engaged in combat, when required. On the average this would amount to about ten percent of the theater troop strength. All other units, including combat units not in actual combat, would subsist at the 1,200 man mess previously described. The assignment of control of the 1,200 man messes could be accomplished in a number of ways such as to a tactical headquarters (brigade) or to the division support command. In rear areas this could also be done in a number of different ways. It is not important at this stage to answer this control question but it is simply assumed that they are in the theater and operating in conjunction with the use of the Chuck Wagon, i.e., an average of ten percent of the theater troop strength subsisting from the Chuck Wagon and the remaining 90% from the 1,200 man kitchen.

E. Discussion of Analysis

Table 1 develops the daily and yearly operating costs for the present system, the central kitchen and the Chuck Wagon. The figures are based on the costs and assumptions previously discussed.

Table 2 gives a comparison of the present system and the proposed alternative of 90% central kitchen and 10% Chuck Wagon in terms of yearly support costs for a 500,000 man theater similar to Vietnam.

The alternative to the present system provides an operating cost decrease of $31 million. Perhaps more important is that it also provides a reduction in food service personnel (trained and untrained) of 21,500 men. The salaries of these men figure in the cost reduction but the most significant factor is that these 21,500 men would not be required at all in the theater. The resultant overall decrease in training, replacement and casualty care has not been credited to the alternative system.

Another advantage for the central kitchen concept is that there is a possible cost savings through simplification of the logistical system. The future supply system relies heavily upon containerization in standard 8' x 8' x 20' containers. Due to the larger size of the

TABLE 1
COMPARATIVE SYSTEMS COSTS (per kitchen)
OPERATING COSTS OF SELECTED PORTIONS (LESS OVERHEAD AND RATION DISTRIBUTION SYSTEM)

	Food Service Staff	Personnel Daily Costs	Maintenance Daily Cost	Fuel Daily Cost	Ration Daily Cost	Transportation Costs	Operating Costs Daily	Operating Costs Yearly	Operating Costs /Man/Day
Current Company Kitchen 200 Men	2 E5 First Cook	$ 34.40		30 Gal./Day					
	4 E4 Cook	53.60							
	1 E3 Cooks' Helper	8.90	371/yr / 365	@ .12/Gal.					
	5 E3 KP	44.50							
TOTALS	12	$141.40	= $1.01	$3.60	$240.24 a/	$36.96 c/	$423.21	$154471.65	$2.12
Central Kitchen 1200 Men	2 E5 First Cook	34.40		300 Gal./Day					
	8 E4 Cook	107.20	8500/yr / 365	@ .12/Gal.					
	6 E3 Asst. Cook	53.40							
	4 E3 Mess Atndt.	35.60							
TOTALS	20	230.60	= $23.29	$36.00	$1441.44 a/	$221.76 c/	$1953.09	$712877.85	$1.63
Chuck Wagon 50 Men	1 E3 Food Preparer/ KP	8.90							
TOTALS		$ 8.90	$0.50	$ 1.00	$222.06 b/	$9.24 d/	$241.70	$88220.50	$4.83

a. Modularized B-Ration = $10.01/25 Man Meal Module
b. Preportioned Non-Perishable Convenience Food = $37.01/25 Man Meal Module
c. Transportation Costs = $1.54/25 Man Meal Module
d. Non-Perishable Convenience Food Transportation Costs are same as B-Ration/25 Man Meal Module

TABLE 2
COMPARISON OF ALTERNATIVE FEEDING SYSTEMS
500,000 MAN THEATER (SIMILAR TO VIETNAM)

Type Kitchens(s) & Employment	Feeding Strength	No. Kitchens Required	Personnel Required per Kitchen	Yearly Operating Costs/Kitchen	Theater Yearly Operating Costs (Millions)	Personnel Total	Total System Cost (Millions)	Total Personnel Trained	Total Personnel Untrained
Current Company Kitchen 100%	500,000	2,500	Trained 7, KP 5 } 12	$154,471.65	$386	30,000	$386	17,500	12,500
Chuck Wagon 10%	50,000	1,000	Trained 0, KP 1 } 1	$ 88,220.50	$ 88	1,000			
							$355	7,500	1,000
Central Kitchen 90%	450,000	375	Trained 20, KP 0 } 20	$712,877.85	$267	7,500			
						DIFFERENCE	$ 31	10,000	11,500

central kitchen, the unit of issue could be standard containers holding a certain number of days (or meals) of supply. These containers could be shipped without intermediate breakdown from the processor to the consumer. The company size (200 man) kitchen precludes efficient utilization of this principle and will always require some breakdown facilities as in the current practice. Follow-on studies should carefully consider this factor since the overhead costs of the present cumbersome line item breakdown system, while not known, are probably large since this is essentially a heavily manpower oriented operation with relatively little automation possible.

The above considerations are admittedly oversimplified for study purposes, but the implications are clear. The results of this phase of the study indicate that the key to reduction of manpower and skill requirements do not lie only in the purchase of convenience foods and more modern equipment. Alternate solutions must be pursued considering relatively radical changes in the management and organization structure of the field feeding system if it is expected to gain profitable advances over the present system.

A final caution is in order. The terms or limits to the present study were to stay within the field feeding area. Changes in the field feeding procedures must be carefully weighed against changes which might be necessitated in the garrison feeding area. The present systems of field and garrison feeding present no significant interface problems since the field and garrison situations, with respect to size and staffing, are very close. There is a trend in military construction toward building larger messes but the vast majority of the Army garrison mess facilities are still quite small. Adoption of the central kitchen concept might well necessitate an acceleration of this construction since the manpower requirements of the field and garrison might be significantly different. Follow-on studies are definitely indicated and conversion to any new system must be carefully planned and coordinated to prevent advancement into a costly situation from which there is no retreat.

F. Systems Design Problems

The results of this phase show that a new approach to field feeding is more likely to result in overall decrease of expenditure of resources than the use of new foods and equipment alone. Exactly how this new approach should take shape may be difficult to determine. Consensus of opinion will be difficult to obtain. A recent survey of infantry officers (NLABS, unpublished data) shows divergent opinions as to the best field feeding methods. A disinterested approach should be taken viewing the problem from the highest Army decision making level.

Increase in Size of Mess and Meal Scheduling Problems. It can be shown that as the capacity of a kitchen increases, the efficiency of personnel utilization increases. The staffing of a kitchen designed to feed 1,000 men is considerably less than five times the staffing of a kitchen designed to feed 200 men. This increase in efficiency occurs only if the larger units are designed as an indivisible unit. Operating a 1,000 man kitchen composed of five units of equipment, each designed for 200 men, will not provide nearly as high personnel efficiency as operating a kitchen designed as a single unit of equipment.

If the five units are required to be capable of independent operation, i.e., each separately serving 200 men, there will be almost no gain in personnel efficiency. The larger the kitchen used, and the greater the portion of the population fed from the larger kitchens, the fewer the personnel that will be required to feed hot meals.

The size and personnel efficiency of a given kitchen, e.g., one intended to feed 1,000 men, will depend upon how a given meal is to be served. Smaller equipment and fewer personnel will be required if the feeding can be done over a two-hour meal period rather than if the whole 1,000 customers must be fed at one time. The increase in personnel efficiency from extending the meal period should increase as the number of customers the kitchen is intended to serve increases. There is some minimum size kitchen below which no reduction in staffing can be accomplished by extending the meal period. Best personnel efficiency will occur when customers arrive at a uniform rate during the meal period. Units utilizing a feeding facility could employ the extended meal period to maintain continuity of operation and hence increase their effectiveness.

Meal Scheduling. The concept of proper meal time is a very important consideration in feeding systems when other than company level messes are involved. If 10,000 men are to eat lunch at 50 company messes, having them all eat in a given 45-minute period has little effect on the design or staffing of the kitchens. But, if the whole 10,000 are to eat lunch at one mess hall, the way in which they are scheduled to eat has a very significant effect on the design and staffing of the kitchen. Large messes can provide personnel economy, but if the economy is to be maximized, it could involve scheduling of meal periods. This is a new dimension in Army field feeding systems. (Resolution belongs in follow-on studies that may be conducted.)

Future Organization for Feeding in the Field. Any number of organizational and operational structures are possible for integrating new feeding systems into the Army in the field. Selection of the best is in itself a major task. No pretense is made that these trade-offs have even been superficially evaluated in the current study. It is believed sufficient information has been presented to justify initiation of a major study effort to exploit fully the potential provided by abandoning the policy of accomplishing all hot meal feeding in the field through company level kitchens.

6. Conclusions

a. The use of centralized messes for a large part of the troop population can result in significant economies in resources.

b. The operating costs are more dependent upon the management structure (see Definition, Appendix C) and organization of the theater feeding system than the type of food and equipment used (within certain limits which should be defined in follow-on studies.)

c. Future studies should concentrate on the feeding system organization, considering (1) the mission and location of the unit(s) to be supported and (2) the adoption of a policy that one standard kitchen for all situations is uneconomical.

IV. SYSTEM DESIGN PROBLEMS AND METHODOLOGY CRITIQUE

A. Guidance for Follow-on Studies

In conducting this study many problems were encountered that required resolution before the study could proceed. The general approach was taken that the entire study effort was a first iteration of a series of studies and that follow-on effort would be required to more clearly define objectives and limitations. Problems that were outside the scope and/or limitations of resources of this study group will have to be resolved. Some of these problems and the methodology used are discussed in this section for the guidance of future system analysts.

B. What is the Present System?

To be meaningful the study had to include the present system. This caused serious study problems as the Army does not, in practice, have a well defined system. It has a collection of equipment, foods and methods that are used in whatever way may be expedient at a given time and place. There are constraints on local variations, but there are still enough differences to preclude using any particular practice as the Army System. There is a formal doctrinal system for field feeding (Appendix B). In simplest terms, this system uses the M-1937 type kitchen with B-Ration resupplied daily. This was adopted for use in the study as the present system with one modification. The B-Ration was assumed to be issued in modules as are all other food systems in the study. The technical feasibility of modularized B-Ration has been established (94). By assuming the modularized B-Ration, systems could be compared without having to determine the difference in cost between bulk and modularized issue. Costing out the difference between bulk and modularized supply would have been far beyond the time and resources available. The use of the modularized B-Ration as an alternative has only resulted in the omitting of bulk B-Ration as an alternative. In the study results the assumption of the doctrinal system was found not to have an important bearing on the results.

C. Resources Utilization in a National Emergency

Comparisons are based upon resource utilization expressed in dollars. These dollars represent relative drain on total available national resources. During periods of national emergency currency dollars can be manipulated to increase temporarily the fraction of the national resources available to the Armed Services, but can do little to make rapid increases in the total national resources available. To represent the drain properly, a factor should have been applied to the costs reported to adjust them for use of resources in short supply. For example, engine-generators should have been costed higher as they can be expected to be in short supply during an emergency. The cost differentials shown are thus biased to some undetermined extent in favor of those alternatives which utilize material that may be critically short in an emergency.

D. Probable Error of Data

Two types of data were employed for development of the costs reported. Current experience costs, where available, were used. They were obtained from a large number of sources, both by direct request and from published documents. To the extent possible reported costs were cross checked by reference to several sources. When unreasonably large variances were found among several sources an effort was made to resolve the variance. In general, such resolutions were not a significant problem. Where experience costs were not available, estimates from experts were sought.

It was only in the area of refrigerated transportation costs that extensive combination and interpolation of input data had to be performed to obtain the costs reported. The probable error of some input data may have been as high as 50%, but of other data may have been lower than 10%. However, because the interpolation was performed by a discontinuous function, no overall estimate of the probable error could be computed. For the assumptions used (no stock level in the pipeline) the estimate given for mechanical refrigeration is believed to be unbiased although the probable error may be between 10% and 20%. It is a low estimate if a more realistic assumption of 30 to 60 day stock level is used, but is not seriously low, as the daily cost of operating the required mechanical unit is approximately $2 including maintenance. The estimate for liquid nitrogen refrigeration is low with an assumption of $.01 per pound overseas liquid nitrogen cost and no stock levels in the pipeline. The probable error may be as high as 20%. The estimate is still lower for a more realistic assumption of 30 to 60 day stock levels and $.05 per pound overseas nitrogen cost (Zone of Interior truck stop cost).

The probable error of equipment estimates could be as much as 50% without affecting the annual operating cost significantly. Food costs were based mostly upon recent market prices plus estimated packaging cost. The probable error of the module cost estimates should not be greater than 10%. In view of uncertainties of necessary KP staffing of various kitchens, it is reasonable to expect that actual personnel differences would be smaller than those shown in the report.

The probable error of the cost totals used for comparison is a complex summation of the component probable errors weighted by the contribution of the component cost to the total cost. (Probable errors are random functions that cannot be summed by arithmetical addition.) It is estimated that the probable error of the cost totals would not exceed 15%. Since probable errors are random functions, the possibility is very small that two systems being compared would both have extreme values of the error such that their sum (arithmetical) would be most or least favorable to one or the other system. As a gross approximation, a difference of less than 20% of the higher cost system would be the greatest difference that could be questioned on the basis of estimated probable errors. As a means of cross checking for computational errors, alternative methods were applied by different individuals whenever practical. This approach produced small differences in the results reported in various sections of the report because of differences in the way round-off options were exercised. In general, computations were carried to more significant figures than justified by probable errors of estimates used.

E. Mobility versus Portability

Mobility and convenience of conducting kitchen operations are factors in effectiveness. The M-1937 kitchen equipment is designed so that it can be operated either as a portable or mobile kitchen depending upon whether a tent or a truck is supplied. The Speed kitchen is in a pod configuration so the mobility is limited to that of the prime mover. Mobile kitchens are limited to less than desirable workspace by overall size limitations on vehicle size and as a result are not as convenient to operate as a portable configuration.

Future studies must determine the relative cost effectiveness of the mobile versus the portable kitchen configurations for all situations. It is anticipated that a fully mobile kitchen can be justified as cost effective for only a relatively small portion of the troop units, and that these units will be primarily combat and combat support units. For instance, it is unlikely that a rear unit depot company would need a fully mobile kitchen enough of the time to justify the expenditure of funds necessary to provide mobility which is rarely used.

F. Availability of Special Purpose Convenience Foods

Within the current state of the art, there is sufficient variety of non-perishable special purpose convenience food, with requisite stability, for a five day menu cycle. In general, the acceptable special purpose foods are those which, if prepared conventionally, could be reheated and served at the next meal without significant loss of acceptability, for example, casserole type dishes, meat loaf, spaghetti sauce with meat, and plain and buttered vegetables. The minimum number of dishes required for a 28-day menu cycle was not determined. The B-Ration, which for the most part is composed of general purpose convenience food, will provide enough variety for a 28-day menu cycle and contains 102 items. Considering that most items in the B-Ration can be served several ways, it is reasonable to assume that well over 100 special purpose convenience food items would be required for a 28-day menu cycle meeting customary Army menu practice.

Food processing technology available today was evolved over a long period largely by cut and try methods and as a result does not contain all the knowledge needed for development of new food items, i.e., ones that have not been processed before. This means that the development of each new special purpose food must employ some cut and try methods, including long term stability testing. The end product of the development would be a processing technique with some information on the permissible latitude in the steps of the process. The possibility of developing more than 100 special purpose convenience foods by 1977 appears remote.

Another aspect of availability is the existence of adequate specifications for large scale competitive procurement. The output of development could be converted into "design" specifications with quality control accomplished by in-process inspection. The trend in procurement and inspection policy over the last several years has been strongly in the direction of performance specification and mandatory contractor inspection for quality assurance (that the product meets performance requirements), with Government inspection of the product to verify that the contractor did in fact inspect in accordance with the contract. A complete reversal of these policies is not likely by 1977. The development process will not produce the information necessary for a performance-type specification. This type of specification requires simple, readily reproducible tests for each performance characteristic, and, further, it must be possible to report the results of the test in writing in a quantitative form without ambiguity. In essence, this requires a written description of the characteristics an acceptable menu item as served, together with methods of testing it, to determine to what degree the item actually complies with the description.

As a broad generalization it can be said that as the complexity of the recipe and the state of preparation increase, the complexity of the problem of documenting acceptability increases. This is largely a result of the apparently increasing importance of sensory factors in acceptability. For example, canned peas present few problems as their acceptance can be based largely upon readily determinable physical characteristics. On the other hand, the problem of rejecting bids by vendors of disliked brands of steak sauce appears no closer to solution than it was twenty-five years ago. Authorizing local purchase is an evasion of the problem, not a solution. In steak sauce, flavor appears to be the dominant factor in acceptance. In most special purpose convenience foods additional sensory factors such as texture, mouth feel, odor, and overall appearance will no doubt be important. Work done so far in attempting to develop definitive methods of evaluating sensory factors have served more to reveal the magnitude of the knowledge gaps than to provide solutions to the problem of large scale competitive procurement. Basic research will be required to fill the knowledge gaps before applied research can be directed toward providing useable methods for procurement purposes. Thus, it would be most unreasonable to expect that adequate quality assurance provisions could be available by 1977 for large scale competitive procurement, under the present procurement and inspection policy, of special purpose convenience foods.

It is believed reasonable to conclude that specifications cannot be made available by 1977 for procurement of special purpose convenience foods in sufficient variety and in requisite quality for special purpose convenience foods to serve as the primary foods for large scale feeding systems for the 1975-1990 time frame.

The foregoing conclusion applies only as specifically stated. There are already some items in the supply system that could be termed special purpose convenience foods. Most of the items are in individual rations. There are a few in A- and B-Rations. As the composition of A- and B-Rations tend to follow the pattern of items available to the consumer market, it is reasonable to expect that the number of special purpose convenience foods in A- and, to a lesser extent, in B-Rations will increase. Specifications will be required to support procurement. The problems discussed above will apply. Rejection of special purpose convenience foods as a feasible primary food for large scale troop feeding systems for the 1975-1990 time frame does not also reject the need for development work on these foods or, especially, the need for research on better quality assurance provisions with respect to sensory quality.

G. Probability of Feeding Hot Meals in Different Parts of a Combat Zone

A theatre of operations, for purposes of feeding hot meals, can be roughly divided into two areas; forward and rear. The forward area can be characterized as an area where the probability of occurrence of active large scale engagement with the enemy is high and low level engagement is frequent and may be continuous. The area is populated largely by combat and combat support units. The rear area can be characterized as an area where the probability of occurrence of active large scale engagement with the enemy is low. Low level engagement is, for all practical purposes, non-existent.

The population of the rear area is composed of combat service support type units plus combat and direct combat support units that are there for any of a number of reasons, such as security, refitting, retraining, rest and recuperation, staging in or staging out.

The line between the two areas is far from being sharp. For discussion it is assumed to be approximately coincident with division rear. The forward area thus takes in from the FEBA to about division rear. The rear area includes everything behind the forward area. At the FEBA, both operational and logistical considerations make the probability of being able to serve a hot meal from unit kitchens nearly zero. The probability rapidly increases as the distance from the FEBA increases and reaches the maximum in the rear area. Operational factors, i.e., personnel in transit, will limit this maximum probability to perhaps 98%. The increase in effectiveness (in terms of being able to feed a hot meal) can only be minimal in the rear areas regardless of the component and food used since the probability is already quite high under the present system. In the rear areas gain in personnel reductions by using centralized messes may be used to pay for the costs of raising the effectiveness in forward areas. This emphasizes the importance of the total systems approaches in future studies.

H. Follow-on Studies

Elsewhere in this report, the possibility is presented of a major study to determine the optimum system of providing hot meals in the field. This study, if undertaken, would be of considerable magnitude. Acceptance in principle of using large messes to accomplish a very large fraction of hot meal feeding immediately raises the question of the organizational placement of the messes. Hot meals account for between

85% to 95% of the food used in a theater. At any one time combat (division) elements represent a minority of a theater population and only a part of these elements are actually in active combat. Large messes are not suitable for forward area feeding (other simpler and more effective means are available for feeding hot meals to troops in forward areas). However, between perhaps 80% to 90% of the troops in a theatre could be fed in large messes, but the specific units being fed would change from time to time. Obviously, there is a question of the desirability of making large messes organic within divisions. Non-combat elements do not have a fixed organizational pattern comparable to a division structure. A readily apparent alternative is to operate the large messes as service elements assigned when and where required. This alternative immediately raises the problem of the management and organizational structure to supervise and manage the large messes and leads to consideration of such structures as a separate feeding corps managed at theater level. Determining the optimum structure to accomplish feeding through large messes is no small, simple problem and it is complicated by the strong interaction between the feeding structure or system and other systems operating within a theater. As the concept represents a quite radical departure from the concept of feeding at the company, it is reasonable to expect a rather high emotional factor in any study to optimize and evaluate it. In addition to the problem of structuring, there are at least 40 elements within DoD that participate to some degree in the total feeding system (see Appendix B). The study should consider the impact on these elements as well as the interactions with garrison feeding.

The team estimates 20 - 30 manyears of professional effort per year for five years as a minimum for a proper systems analysis, assuming that a workforce this large, already reasonably knowledgeable of military operations is available, i.e., appreciable time will not have to be spent in educating and integrating the workforce. Current rates for systems analysis run from $35,000 to $50,000 per manyear, depending upon the non-professional support required, computer time and similar factors. This provides a dollar estimate in the order of $1,000,000 per year for a total of $5,000,000. The assumptions made concerning the workforce imply its prior existence and operation as an integrated team or, in frequently used terms, a source with the competence in being. This is an exceptionally large Systems Analysis team and very few organizations are likely to have such competence in being. Sources should have the competence in being to do the study without entailing a loss in time and funds for education and integration of the workforce. Investigation of sources should follow an acceptance in principle of the use of large messes to accomplish most of the hot meal feeding in the field.

I. <u>Master Menu Problems</u>

During the course of the study there was occasion to look into the meal variety available in B-Rations. In this review, the Master Menu system (14,18) received some attention. In the early days of

World War II, when the Army changed from the garrison ration system to the field ration system, there was insufficient data for projecting what is now called the Annual Food Plan. The Master Menu was created to provide a rational basis for developing the equivalent of an Annual Food Plan. It was recognized that in the rapid build-up of forces it would be unreasonable to expect the field to have personnel who could translate food issues into acceptable menus. The Master Menu was provided to the field to alleviate the scarcity of people familiar with menu formulation, and as an attempt to obtain some balance in utilization of food stocks. There was no intent that the Master Menu be utilized as a means of relieving the company commander, the mess steward and the head cook of the responsibility of finding out what the men liked to eat and satisfying these desires as fully as possible within the limits imposed by issues. If, say, chicken were issued, it was expected that it would be prepared and served in the way the men liked best regardless of what the Master Menu suggested.

Today, the Master Menu is derived from the Annual Food Plan and thus is not being used for the purpose for which it was created. The Master Menu is no longer necessary for developing the Annual Food Plan. Today, the Master Menu is published in a Supply Bulletin. While it contains a brief paragraph authorizing local deviations, its overall format is the same as any formal DA order or directive, i.e., it closes with "By order of the Chief of Staff". It is thus open to the interpretation that the Chief of Staff has directed that on a certain day a certain meal will be served and the authorization to deviate is intended only to cover situations beyond local control that may prevent serving the meal directed. This can be a very convenient interpretation since, if the company commander and the kitchen staff have prepared the meal specified according to standard recipes, they have then completely fulfilled their responsibility for feeding the men. By extension, there is no responsibility at a level lower than the Chief of Staff for determining and attempting to satisfy the preferences of the men. As far as is known there is no intent on the part of DA to relieve the company commander or anyone else of the responsibility for satisfying troop preferences to the maximum extent possible within limits imposed by the food issued. As this point was not particularly germane to the study objective, it was not explored in significant depth. However, the small amount of insight obtained would suggest there is some tendency in the field to interpret the Master Menu to minimize responsibility for troop satisfaction at the local level. If this tendency is widespread, it would appear that the Master Menu concept has not only outlived its original purpose but has reached a point where it may actually be impeding rather than promoting progress toward better troop feeding. A disinterested investigation would appear desirable.

J. Air Transport

An analysis of air transport requirements for food for Vietnam was made. It was estimated on the basis of the daily weight and cube of food required that practically all the C5-A's publicly announced as being on order in the Fall of 1968 would be needed to transport from Continental United States to Vietnam the food required for troop feeding.

K. Batch vs. Continuous Production

Army practice is to feed the whole company at once whenever the situation permits. This represents a "worst case" but occurs so often that it must be considered as the condition that establishes the capacity requirement. Policy establishes 45 minutes as the dinner (noon) period, but does not specify the breakfast or supper period. This sets 45 minutes as the meal period for capacity determination. So far as is known, there is no established ratio of serving time to eating time; however, 30 minutes appears to be a reasonable allowance for serving. Thus, the kitchen capacity in terms of rate of delivery can be stated as serving 200 men in 30 minutes, three times a day at periods about five hours apart.

There are two general approaches available to meeting the requirements. First, use the resources available to prepare the food required from a conventional general food input (B-Ration) in simple batch type equipment. The second approach is to use high speed equipment operated for a short period before and during the serving period. The limiting factor on total time to prepare and serve is the form of the food input. Cooking time of the food must be reduced to a minimum through the use of special purpose convenience foods. Heating time must be made short which means heating in small batches of perhaps 25 to 50 servings at a time to keep the size and power requirements of the equipment within reasonable limits.

The two categories of approach represent opposite ends of a scale that for practical purposes can be considered as continuous. By choice of food input and equipment, a kitchen operation of almost any desired level between primitive and highly advanced can be designed. For analytical purposes it is necessary to consider only the ends of the scale.

The batch operation can produce food of a given level of quality, on a food input with low delivered cost. No specialized processing, packaging or high cost handling is required. The number of line items to meet variety requirement is near minimum, because most components can be prepared in more than one way. This low cost, relatively simple food input is possible using the skill the cooks must have to be able to prepare fresh food when it is available and the time available between meals to prepare the input for cooking and carrying out the cooking operation. Labor time and skill for preparation are modest. Cooking time, which requires little or no labor time, is not much more than that required to bring the food to serving temperature for most items. The time available can also be used to simplify the equipment by designing it to handle food in batches large enough to serve 200 men. Cooking time is roughly proportional to the amount of food. Perhaps the most difficult skill to master in this operation is that of sequencing the preparation of the meal so that all components are ready to serve at the same time. In this type of operation all kitchen work can be done before serving starts and all cooks are available to do the serving.

In the batch type operation both labor and clock time available have been utilized to minimize the cost of food input and permit use of simple, low cost equipment.

The high speed production operation is made possible by using convenience food readied for serving in small batches rather than any particular type of equipment. Microwave heating is not absolutely essential to high speed operation, but food convenience is. The high speed operation has a start-up time that is only a fraction of the time available between meals and, once started, can continue production of meals at a rate somewhere between 400 and 700 meals per hour, based upon field experience with the Speed kitchen. The high speed production requires that preparation continue during the serving period which in turn requires a high level of strenuous effort and closely coordinated team work on the part of the cooks from the beginning of start-up to the end of the serving period. Thus, the high speed production operation is characterized by specialized food input of higher cost than general purpose food input, coordinated effort during start up and serving, and more expensive equipment than is required for the slower, large batch type operation.

When kitchens are organic to the company the batch type operation is represented by the M-1937 type kitchen using B-Ration. As presently issued the kitchen for a 200 man company would have a nominal capacity of 225 meals per batch and a maximum of around 300. In a 12-hour day, at least 900 meals could be prepared and probably not more than 1,200.

Thus, there is a reasonable match between the requirement and the capacity furnished and the Army is not paying for much capacity it is not using. With same number of cooks the high speed production kitchen, presently represented by the SPEED concept, could produce between 4,800 and 8,400 meals in a 12-hour day. When the high speed production kitchen and special purpose convenience food combination is used for one company, the Army is paying for a large amount of capacity it is not using. This large excess capacity comes from the rate of serving (200 men per 30 minutes) requirement and cannot be reduced without extending the serving period. Extending the serving period would reduce the equipment cost but would have little effect on the daily operating expense as this cost is largely food cost. It is to be noted that both kitchens require the same staffing, three cooks per shift, but the high speed production facility, when operated with convenience foods, makes no use of the skills the cooks must have for fresh food capability, nor does it make full use of labor and clock time available.

If the Army had a requirement to feed 400 to 700 meals per hour all day long, the high speed production combination could meet the requirement more economically than using the M-1937 in multiple. Since the company kitchen feeding is no more than 750 meals per day at three separate times, there is a tremendous waste of capability in using the high production approach at the company level.

The Army objective to feed hot meals to the maximum extent possible could be stated as maximizing the ratio of the number of hot meals fed to all troops, to all the meals fed all troops in a theater over an extended period of time. This ratio is a measure of effectiveness of the overall system. Stated in this form it places the same value on a man in combat receiving a hot meal as a man (combat or non-combat type) not in combat receiving a hot meal. The equal value assumption appears reasonable when the effectiveness measure is applied to systems for feeding 200 man groups through organic kitchens but puts no value on the effect of a hot meal to men in combat. It recognizes, in a less rigorous manner, that tactical situations alone will preclude serving hot meals to the group as a whole.

The difference between the high production and batch kitchens that would affect the effectiveness measure is the lead time between start of preparation and start of serving. For high production systems the lead time will run from one-half to one hour depending upon the menu issued. Because of the inflexibility inherent in special purpose convenience food, there will be little the high production kitchen personnel can do to shorten the lead time for a meal even when the need for shortening lead time is known in advance. When the batch kitchen is used with general purpose food, kitchen personnel can shorten lead time to perhaps an hour and a half by changing recipes or menu item selections. With advance warning, the lead time can be cut to an hour by selecting the modules which permit shortest lead time. On an average basis this is roughly a half hour difference in lead time.

For most situations, a half hour difference would be of little importance. In the remaining combat situations, where ability to serve a hot meal is assumed to be system dependent, this half hour difference in lead time may be of some importance in determining whether a hot meal or an individual combat meal will be served. It must be determined, therefore, how much this increased effectiveness is worth. As in most cases this is unlikely to be cost effective for other than possibly a small number of units (primarily combat) and in no case for rear area troops.

L. Modularization

Meal modules were assumed for all food in examining the company level situation, primarily because of the intuitive appeal of modularization as a means of supply simplification. There is no question that modularization does give some reduction in labor required for breakdown. It cannot entirely eliminate the need for breakdown and may not make a significant reduction in the number of breakdown points. With a 28-day menu cycle there will be 28 dinner modules, 28 lunch modules and 28 breakfast modules for a total of 84 separate line items. SB 10-495 lists 102 line items with 16 alternates for B-Ration (24). So, modularization does not give a large reduction in line items. There will still be supply planning and control by line item. Supervision at each breakdown point will be required. The problem of maintaining balanced stocks will remain. The level of difficulty of this problem may not be much affected. Bulk B-Ration seems to offer greater flexibility in use of substitutions for balancing stocks than modularization. Higher stock levels of modularized food may be necessary to assure that each company can receive a proper issue and that proper sequencing of menus can be maintained. Modules obviously eliminate the need to break open cases during breakdown for issue. Bulk B-Ration has a decided economic advantage when it becomes possible to provide more desirable components such as perishables, frozen meat, salad vegetables, shell eggs, fresh fruits, etc. The flexibility of bulk B-Ration permits retention of replaced items in stocks for subsequent issue as substitutes to balance stocks and thus avoid economic loss. With modularized meals the addition of more desirable items becomes an unrecoverable overissue as the replaced items would, for all practical purposes, be impossible to return to stock and subsequent issue. On balance, it would appear that the advantage of modularization over bulk issue may not be as large as is popularly supposed, and it is not beyond possibility that the advantage may be negative instead of positive. A larger investigation than the study team could afford to conduct would be necessary to evaluate the direction and magnitude of the difference between bulk issue and the modularization of B-Ration.

V. SUMMARY AND CONCLUSIONS

A. Summary

This study started as an attempt to evaluate over 3,000 different technical solutions to the problem of reducing resources, particularly personnel, to feed hot meals, at least as good as those provided by the present doctrinal system, through company level kitchens. The result of this evaluation revealed that personnel requirements for feeding hot meals is probably more a function of the management and organization employed rather than the equipment or food employed. Arbitrary selection of equipment and food can greatly increase the dollar cost of feeding. Skill, and hence training, requirements are established by the requirement that kitchens have fresh food capability and would be little affected by the equipment used or food used when fresh food is not available. The M-1937 kitchen with current product improvements utilizing some form of a modularized B-Ration makes most effective utilization of resources for providing hot meals through company level kitchens under conditions of a major mobilization.

It was recognized in Phase I that resource requirements, particularly personnel, were determined by the management, organizational, and operational structure used for providing not meals. Several arbitrarily selected systems were analysed in Phase II to see what effect abandoning the concept of providing all hot meals through company level kitchens might have on resource requirements. The result of this exploratory effort shows that modification of the present Army structure for providing hot meals could provide substantial saving in resources expended (both dollar cost and personnel reduction). Optimization of the feeding structure would involve examination of the entire structure of the Army in the field and require a major study effort.

Should the Army decide that there is no longer a requirement that all hot meals be fed through company level kitchens, current RDT&E guidance related to hot meal feeding will be unsuitable. There are recognized knowledge gaps in areas such as equipment design, kitchen layout, food processing, packaging, and especially quality assurance measures. These gaps are essentially independent of the feeding system to be employed, i.e., filling of these knowledge gaps will be required for expeditious and effective implementation of almost any system that might result from a future systems study.

The study illuminated the essentiality of a total system approach to hot meal feeding. There are powerful interactions between field and garrison feeding systems that affect the overall economics of troop feeding and combat readiness. It appears that similar systems must be used for garrison and field if severe penalties in combat readiness and economics are to be avoided. The knowledge gaps related to garrison feeding are approximately the same as those for field feeding.

During the course of the study, it was discovered that the Army has been utilizing essentially the same formula for computing TO&E allowances for KPs since World War II or before. Considering all the changes that have taken place, it is possible these allowances are excessive. It is believed that properly conducted time and motion studies on KP requirements in the field might allow a significant reduction in KP allowance. A concurrent accounting study should be conducted. There were some indications that KPs may be performing some functions, especially in garrison, that may be more properly chargeable to other than feeding operations. While this accounting study is not likely to affect the staffing requirements of a unit, it may reduce the number identified as KPs and thus alleviate some of the adverse criticism of employing soldiers for traditional KP duties.

B. Conclusions

a. Assuming retention of the present Army policy of company level feeding the resource expenditure cannot be reduced by the use of special purpose convenience foods and advanced kitchens to a point below the level of the present M-1937 kitchen and B-Ration resource utilization.

b. There is a minimum staffing level limitation imposed by a company feeding policy.

c. Other organizational structures utilizing both larger and smaller than company kitchens can reduce resource expenditure for field feeding.

d. A standard kitchen for use by all units in all situations (including the M-1937 and B-Ration) is uneconomical and this concept should be abandoned.

e. Current QMDO and QMR RDT&E guidance calling for a single kitchen concept becomes unsuitable, based on conclusion d.

f. A major systems analysis study should be undertaken to determine the optimum management and organization of the total feeding system including methods, equipment, facilities and the related foods required for both field and garrison feeding.

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APPENDIX A

Differential Analyses of Company Size Feeding Systems

Phase I of the study was to determine the cost effectiveness of various systems of feeding company size (200 men) units in the field within the time frame 1975-1990. A basic requirement for the systems studied was that all components must be within the current state of the art and must have an adequate mobilization base assured by 1978. All kitchens are to be organic to the company. Each system was required to furnish hot meals with a quality at least as good as those currently provided by the M-1937 kitchen, as currently modified, utilizing the current B-Ration as defined in SB 10-495 (24).

A. <u>System Components</u>

The major system components studied in establishing costs were food, kitchens, and transportation.

In addition, a number of means of providing bread and pastries was included in the study. However, this system component was later deleted from final cost comparisons since it was found that preparation of bread and pastry in company kitchens required excessive manpower when compared to large or small central bakeries. Preparation in company kitchens was found to require the addition of one to four men per kitchen depending upon the type of ingredient input. Total additional manpower requirements to supply 500,000 men would range from 2,500 to 10,000. In contrast a maximum of 1,050 men would be required if either large or small central bakeries were used.

Food. Alternative general food types studied were:

a. Frozen special purpose convenience food, preportioned

b. Frozen special purpose convenience food, bulk packaged

c. Non-perishable special purpose convenience food, preportioned

d. Non-perishable special purpose convenience food, bulk packaged

e. Non-perishable conventional food, bulk packaged (B-Ration).

For costing purposes, all food types were assumed to be supplied in modules providing food for 25 men for one meal.

Kitchens. Appropriate kitchen types were studied for each of food types (a) through (d) above. In addition, three kitchen types were studied for (e) Non-perishable conventional food, bulk packaged: powered (electrical) kitchens, non-electrical kitchens, and the M-1937 kitchen.

Each kitchen type was required to have performance or effectiveness at least equal to that of the current field range kitchen (M-1937). Effectiveness in this case was defined as the probability of being able to prepare a meal assuming that all inputs are available and the tactical situations are the same.

The following assumptions were made for the kitchen systems:

a. Each kitchen will be capable of supplying three meals per day for a 200 man field mess on a continuous day-to-day basis.

b. Storage space will be provided for one day's rations for 200 men. This will be based on the weight and cube of the particular types of food being supplied to the kitchen.

c. Determination of mobility/portability of kitchens will be made in follow-on studies.

d. Configuration of serving line or recommended serving procedures will facilitate meal service to 200 men in 30-45 minutes under all operating conditions.

e. Adequate means will be provided for sanitation of cooking utensils, mess gear and/or mess trays. In addition, disposal methods will be provided for the use of expendable mess gear.

f. The kitchen will be capable of serving a simple meal with at least one hot component in addition to coffee and soup within one hour after arrival at a feeding site.

g. The capability to serve hot meals at a distance from the kitchen is assumed to be an add-on capability that is independent of the design of the kitchen, i.e., insulated containers for delivery of hot foods can be added to any system.

h. For kitchens using other than conventional foods a fully developed product range of beverages, entrees, vegetables and desserts within each of the five food categories will be assumed available and will be issued as a unitized pack with all ingredients. Salads will not include tomatoes and leafy green vegetables but will be limited to certain non-perishable components such as dehydrated cabbage and onions.

Transportation. Three types of transportation were studied:

a. Dry (non-perishable)

b. Frozen (conventional refrigeration)

c. Frozen (liquid nitrogen refrigeration).

The use of the super-chill transportation system was eliminated from the study as investigation indicated that there is a large amount of research and experimentation necessary to determine the technical feasibility and economic desirability of the process.

Preliminary work on the development of a composite pipeline for computing a respresentative average world wide transportation cost indicated that such a task was beyond the resources of the present study. As an alternative, a sea leg from San Francisco to Saigon plus a total overland haul of 1/10 this distance was assumed. Based on a study by the National Research Council (50), total transportation was costed as twice that of the sea leg. This assumption includes a dock-to-dock time of 30 days which includes 15 days for direct fair weather sailing and 15 days for loading time, queuing time at POD, bad weather time, and time lost in convoy or evasive sailing.

Costing of the transportation system was based on the use of a standard 8' x 8' x 20' shipping container. Any refrigeration equipment required was assumed to be contained within each container.

B. Systems

The appropriate system components of food, kitchens, and transportation were combined to develop nine systems for cost analysis:

a. Frozen preportioned special purpose convenience food-kitchen-conventional refrigeration.

b. Frozen preportioned special purpose convenience food-kitchen-liquid nitrogen refrigeration.

c. Frozen bulk special purpose convenience food-kitchen-conventional refrigeration.

d. Frozen bulk special purpose convenience food-kitchen-liquid nitrogen refrigeration.

e. Non-perishable preportioned special purpose convenience food-kitchen-dry.

f. Non-perishable bulk special purpose convenience food-kitchen-dry.

g. Non-perishable conventional food-powered (electric) kitchen-dry.

h. Non-perishable conventional food-non-electrical-dry.

i. Non-perishable conventional food-M-1937 kitchen-dry.

C. Cost Analysis

Each major system component was costed as indicated in the discussion following. The total cost of each of the resulting major systems (a) through (i) above was the total of the costs of the components.

Kitchens. The annual operating cost of the kitchens is given in Table A1. It was assumed that the systems being studied were in the Army long enough so that the initial investment cost of kitchens could be considered a sunk cost.

Food. The weight, cube, and cost per meal for the five food types are shown in Table A2.

Transportation. The cost of each pipeline is a composite of the investment cost, the operating cost, and the shipping cost. The methodology followed in cost derivation is shown in Table A3. Costs for the three transportation systems are shown in Table A4.

Systems. Cost per meal and differential annual operating costs for the nine systems are shown in Table A5 and A6, respectively. The bulk packaged non-perishable conventional food (B-Ration) with M-1937 kitchen system is used as the base cost. Incremental costs are shown for the optimal (least expensive) kitchen input for each of the other systems.

D. Summary.

Based on the cost analyses of the various systems, it was found that the B-Ration-M-1937 Kitchen-Dry Transportation system was the most cost effective of those studied.

TABLE A1. ANNUAL KITCHEN OPERATION COST[a,b,c/]

1. Frozen Preportioned Special Purpose Convenience Food

	ANNUAL	PER MEAL
Steam	$42,300	$.193
Convection Oven	42,900	.195
Gasoline	43,400	.197
Liquid Petroleum Gas	44,500	.203
Microwave	59,200	.27

2. Frozen Bulk Special Purpose Convenience Food

Steam	42,300	.193
Convection Oven	42,800	.195
Gasoline	43,400	.197
Liquid Petroleum Gas	44,600	.203
Microwave	59,200	.27

3. Non-Perishable Preportioned Special Purpose Convenience Food

Liquid Petroleum Gas	40,600	.185
Fuel Fired	40,800	.185
Elect-w/o Microwave w/o Turbine	44,100	.201
Elect-w/Microwave w/o Turbine	47,300	.215
Elect-w/o Microwave w/Turbine	56,700	.258
Elect-w/Microwave w/Turbine	59,000	.271

4. Non-Perishable Bulk Special Purpose Convenience Food (Same as 3 above)

5. Non-Perishable Bulk Conventional Food - Non-Powered

Preparation Center	38,300	.174

6. Non-Perishable Conventional Food - Powered

Electric	44,100	.201
Microwave	59,500	.271

7. Non-Perishable Bulk Conventional Food (B-Ration)

M-1937	37,600	.171

a. Does not include cost of KPs and Food
b. Costs of KPs

1 KP	3,245	.0148
2 KP	6,490	.2096
3 KP	9,735	.0444
4 KP	12,980	.0592
5 KP	16,225	.0745

c. Source: Reference 34.

TABLE A2. COMPARISON OF FOOD TYPES (per meal basis)[a]

FOOD TYPE	WEIGHT (lb)	CUBE (ft^3)	COST ($)
Bulk Frozen, Special Purpose Convenience[b]	2.71	.112	.79
Preportioned Frozen, Special Purpose Convenience[b]	2.72	.155	1.23
Bulk, Non-Perishable, Special Purpose Convenience[b]	1.88	.108	.98
Preportioned, Non-Perishable Special Purpose Convenience[b]	1.37	.099	1.48
Bulk Non-Perishable, Conventional[c]	1.34	.037	.40

a. Source: Reference 30.
b. Based on menus, days 1 through 5, SB 10-261, exclusive of bread and pastry.
c. Based on 7 experimental modules of 25-man B-Ration with weight and volume exclusive of bakery and condiment packs but with cost based on total ration value (April 1966).

TABLE A3. COST FACTORS FOR TRANSPORTATION SYSTEM

INVESTMENT COST	OPERATING COST	SHIPPING COST
Investment cost is defined as the cost of one container, ready for use. In general, the investment cost is a composite of three elements: the cost of the container itself, the cost of the refrigeration unit, and the cost of the insulation. Initial investment cost was treated as a sunk cost.	The operating cost is that cost charged to the system for fuel needed to operate the refrigeration unit, maintainance cost, and replacement cost based upon service life of ten round trips (1/10 investment cost per round trip).	Shipping cost is defined as the charge for shipping a container overseas. (Only the sea voyage or the pier to pier portion (San Francisco to Saigon) of the entire trip was considered in this section. The land legs were discussed in the basic report.
1. Dry (Non-perishable)		
Since, by assumption, frozen food cannot be used in a non-perishable system, the container need not be equipped with insulation or any other means of preserving frozen food. Thus the investment cost in the non-perishable system consists solely of the cost of the container (96).	By assumption, the non-perishable system cannot be used to ship frozen food. There is, therefore, no necessity for a refrigeration unit, and the operating cost is limited to replacement costs only.	The shipping cost is the cost per short-ton mile to ship subsistence overseas times the distance covered (in miles) times the weight of the container in tons. From a MTCT study (51) was generated the cost per short-ton mile for shipping subsistence overseas in ships. The cost included all charges incurred from the time the shipment is picked up from dock side storage for loading aboard ship until shipment is put in dock side storage at the end of the voyage. The weight of the dry container is composed of the weight of the container per se plus the weight of the food. Weight and cube limits must be considered when determining how much food a container can carry. The present standard 8' x 8' x 20' container has a total weight limitation of 44800 pounds for the container and contents. The cargo weight is also limited by the total usable space inside the container. The standard 8' x 8' x 20' container has a total usable cargo space of 1140 cubic feet. The weight-cube-interrelation limitation was determined on the basis of food density data (Table A2).

Table A3. (Continued)

INVESTMENT COST	OPERATING COST	SHIPPING COST
2. Frozen (Conventional Refrigeration)		
It was decided that each refrigerated container would carry an internally housed refrigeration unit of the size and type consistent with the job being performed. In this system the refrigeration unit is mechanical in nature and consists of a refrigeration system, diesel generator, battery and diesel fuel tank (98). The industry standard is four inches of insulation on all internal surfaces for conventionally refrigerated containers. Because of its relatively low K-factor, Urethane Rigid Foam was selected as insulation.	In this system, the operating cost is the cost of diesel oil required (based on the cost data from the Defense Fuel Agency), replacement cost, and maintenance cost (included in fuel cost).	As in the previous system, the shipping cost is the cost per short-ton mile times the distance times the weight. In this system the gross weight consisted of sum of the weight of container, refrigeration equipment, diesel generator, battery, fuel tank, fuel, and insulation. The total usable cargo space is reduced by the volume of insulation, refrigeration unit (to include the fuel tank), and space needed for air circulation.
3. Frozen (Liquid Nitrogen Refrigeration)		
The investment cost for the liquid nitrogen system is composed of the basic three elements. The liquid nitrogen refrigeration unit consists of a tank (or tanks) of liquid nitrogen and a control and dispensing system. The controls release liquid nitrogen in the container as required. Heat reduction is approximately 170 BTU's per pound of liquid nitrogen. The size of liquid nitrogen tank depends on the amount of insulation of the container and the amount of time between refills of the liquid nitrogen tank. The investment cost for the liquid nitrogen system was interpolated from the known sizes of liquid nitrogen tanks. A 30-day capacity was assumed to be the minimum feasible for worldwide use in all levels of conflict.	The operating cost in this system is the cost of liquid nitrogen required for 30 days, replacement cost, and maintenance cost.	The weight of the liquid nitrogen container is the sum of the weight of the container, insulation, fuel (liquid nitrogen), refrigeration unit, and food. The weight of the liquid nitrogen refrigeration unit is directly proportional to the size of the liquid nitrogen tank. The total usable cargo space is reduced by the space occupied by the refrigeration unit, the insulation, and the space needed for the expansion of the liquid nitrogen.

TABLE A4

Transportation System Cost

The following data are constant for each system:

Weight of diesel generator	- 800 lb.
Weight of batteries	- 44 lb.
Diesel fuel per day	- 10 gal.
Container weight	- 3800 lb.
Weight of insulation	- 2.38 lb./ft^3
Distance (sea leg)	- 6878 n. miles

Shipping cost per short-ton mile	-$.0039
Cost per gallon for diesel fuel (includes .04 per gal for maintenance)	-$.16
Cost per pound for liquid nitrogen (CONUS)	-$.01
Cost per pound for liquid nitrogen (OVERSEAS) (includes $.001 per pound for maintenance)	-$.05
Cost per cubic foot for insulation	-$8.30
Container cost	-$2000.

The following data are for one container:

	DRY	MECHANICAL	LIQUID NITROGEN REFRIGERATION*
1. Insulation thickness (in)		4.00	8.50
2. Insulation weight (lb)		532.11	1047.49
3. Weight of fuel (lb)		2214.00	5151.64
4. Weight of fuel tank (lb)		600.00	1667.23
5. Weight of refrigeration unit (lb)		712.00	1667.23
6. Maximum possible cargo weight (lb)	41000.00	36097.89	33133.64
7. Cubage after construction (ft^3) (includes insulation)	1139.31	915.74	699.19
8. Cubage of refrigeration system (ft^3)		125.42	154.02
9. Air space (ft^3)		14.47	39.39
10. Total usage cubage (ft^3)	1139.31	775.86	505.79
WEIGHT OF CARGO SHIPPED (lb)	21441.90	15804.17	10302.88
11. Gross container weight shipped (lb)	25241.90	24506.28	21969.24
SHIPPING COST GOING (lb)	338.55	328.68	294.65
12. Gross container weight returned (lb)	3800.00	6488.11	6514.72
SHIPPING COST RETURNING (lb)	50.97	87.02	87.38
13. Fuel Cost ($)	104	72.00	297.80
14. Maintenance Cost ($)		24.00	11.30
15. Replacement Cost ($)	200.00	1028.77	1185.87
OPERATING COST ($)	200.00	1124.77	1494.97
16. Insulation Cost ($)		1855.66	3653.00
17. Refrigeration unit cost ($)		3059.00	6205.72
INVESTMENT COST ($)	2000.00	10287.66	11858.72

* The design of the liquid nitrogen container was adjusted to minimize the cost of sea leg shipping of a given large quantity of modularized frozen food. The design would not minimize shipping cost per container (the transportation industry optimization) nor would the design be optimum for bulk frozen food or food requiring only chill conditions.

TABLE A5. OPERATING COST

$ per meal

FOOD		PIPELINE		KITCHEN[a,b]		TOTAL
BASE SYSTEM: B-Ration	.40	DRY	.07	M-1937	.17	.64
Frozen Preportioned Special Purpose Convenience	1.23	Conventional Refrigeration	.34	Steam	.193	1.763
Frozen Preportioned Special Purpose Convenience	1.23	Liquid Nitrogen Refrigeration	.59	Steam	.193	2.013
Frozen Bulk Special Purpose Convenience	.79	Conventional Refrigeration	.34	Steam	.193	1.323
Frozen Bulk Special Purpose Convenience	.79	Liquid Nitrogen Refrigeration	.59	Steam	.193	1.573
Non-Perishable Preportioned Special Purpose Convenience	1.48	Dry	.07	L.P. Gas	.186	1.736
Non-Perishable Bulk Special Purpose Convenience	.98	Dry	.07	L.P. Gas	.186	1.236
Non-Perishable Bulk Conventional	.40	Dry	.07	Non-electrical	.18	.65
Non-Perishable Bulk Conventional	.40	Dry	.07	Powered (Electric)	.20	.67

a. Kitchen types shown are the most cost effective within each category.
b. Does not include KPs or disposable utensils:

1 KP	.015
2 KP	.030
3 KP	.045
4 KP	.060
5 KP	.075
Disposable utensils shipped in non-perishable modules	.14
Disposable utensils shipped in frozen modules	.16

TABLE A6. DIFFERENTIAL ANNUAL OPERATING COST (500,000 man theatre)

($ MILLIONS)

FOOD		PIPELINE		KITCHEN[a,b]		TOTAL OVER BASE
BASE SYSTEM: B-Ration	0	Dry	0	M-1937	0	0
Frozen Preportioned Special Purpose Convenience	454	Conventional Refrigeration	146	Steam	12	612
Frozen Preportioned Special Purpose Convenience	454	Liquid Nitrogen Refrigeration	287	Steam	12	753
Frozen Bulk Special Purpose Convenience	214	Conventional Refrigeration	146	Steam	12	372
Frozen Bulk Special Purpose Convenience	214	Liquid Nitrogen Refrigeration	287	Steam	12	513
Non-Perishable Preportioned Special Purpose Convenience	591	Dry	0	L. P. Gas	8	599
Non-Perishable Bulk Special Purpose Convenience	318	Dry	0	L. P. Gas	8	326
Non-Perishable Bulk Conventional	0	Dry	0	Non-electrical	2	2
Non-Perishable Bulk Conventional	0	Dry	0	Powered (Electric)	16	16

a. Kitchen types shown are the most cost effective within each category.
b. Does not include KPs or disposable utensils:

1 KP	8,112,900
2 KP	16,225,800
3 KP	32,451,600
4 KP	[illegible]0,364,500
5 KP	48,677,400
Disposable utensils shipped in non-perishable modules	77,500,000
Disposable utensils shipped in frozen modules	87,500,000

APPENDIX B

Present Army Field Feeding

The feeding of the Army in the field involves three basic areas:

a. The management of the feeding system.

b. The subsistence supply system.

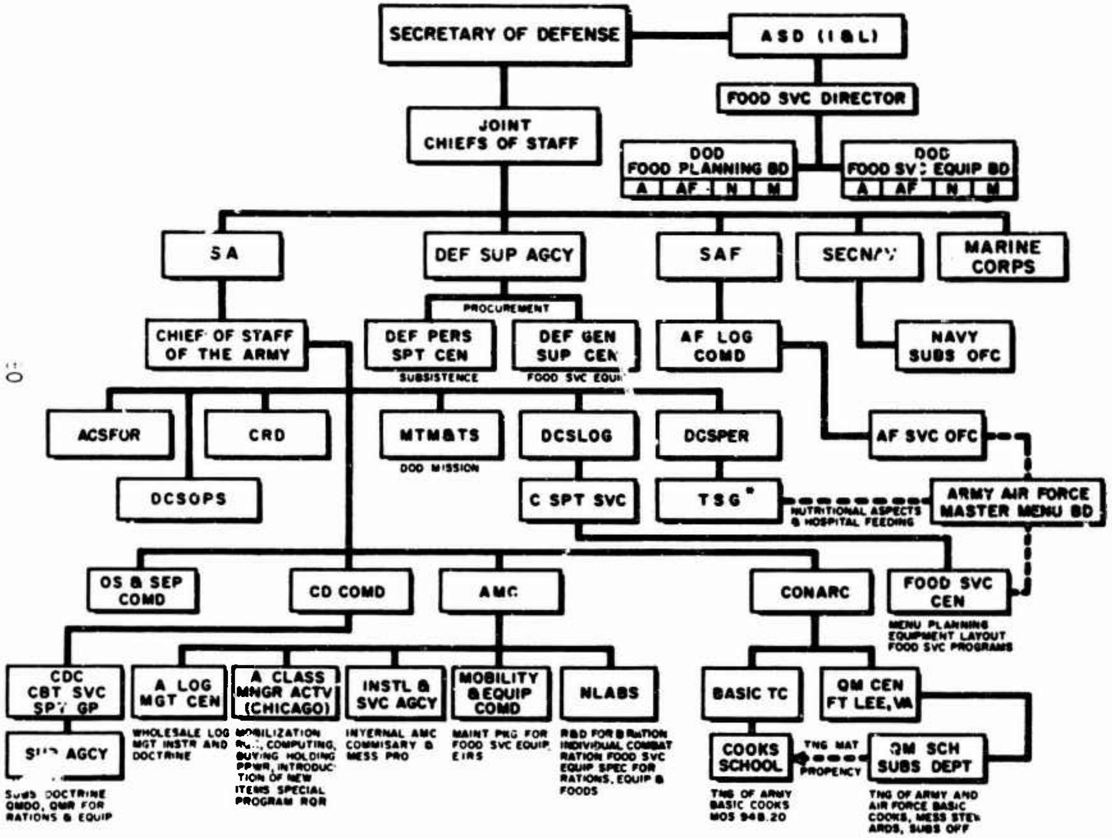
c. The Army food program.

Management

Figure B1 shows the most important elements within the DoD which affect in one way or another the management of the Army Feeding System. It is an evolved complex organization. Much of its complexity is based on the manner in which the present feeding system evolved.

Prior to World War II, most Army feeding was done on the garrison ration basis; i.e., the organization responsible for feeding the individual received a fixed amount of money per day per individual. The money was used as the organization saw fit, buying, more or less to the tastes of the men, on the local market and from the commissary officer. This arrangement worked quite well until the mobilization and expansion of the Army just prior to World War II. Local market areas could not supply sufficient quantities of perishables for both Army camps and civilian needs. This problem was given to the Quartermaster General to solve. He called a meeting of the military and civilian food experts which resulted in the QM Market Center System (QMMCS). This organization consisted of regional offices located in the major food producing areas of the U.S. with the headquarters in Chicago. This organization

Figure B1. DoD Management Structure Affecting Army Field Feeding.



*STAFF SUPERVISION OF VETERINARIANS WHO ARE FOOD INSPECTORS IN ALL COMMANDS procured all perishables for the Army by buying in centers where and when the crops were produced and shipping to posts, camps and stations all over the U. S. Nonperishables were bought by separate procurement agencies until 1953 when the QMMCS assumed all food buying.

In order to plan for buying in an orderly fashion, an annual food plan was developed which determined how much of each food component was to be fed each year. The Master Menu, based on the annual food plan, stated what specific menus were to be fed each day. The garrison ration that was mentioned earlier practically vanished and was replaced by the field ration or issue-in-kind. The term "field ration" is not to be confused with field feeding which means any troop feeding away from fixed garrison messes. The name, QM Market Center System, was changed to Military Subsistence Supply Agency when the Army was given single managership for food for all the services. The Office of The Quartermaster General retained all responsibility for food procurement until the OQMG was abolished in 1961. When the OQMG was dissolved and the subsistence procurement mission was given to the Defense Supply Agency, the Chicago Headquarters then became one of several Defense Supply Centers. The Defense Subsistence Supply Center was later consolidated with several other centers at Philadelphia to become the Defense Personnel Support Center (DPSC). Through all these changes, the method of operation for procurement of subsistence has changed very little. The significant action here is that the Army now has practically no responsibility for procurement of its own subsistence for field feeding. There are some local procurement actions for both garrison and field feeding.

The reorganization of the Army gave the Army structure its functionalized approach. The Combat Development Command (CDC) was organized to develop the concepts and requirements of future warfare. The Supply Agency of CDC, Combat Service Support Group, became responsible for Qualitative Materiel Development Objectives, Qualitative Materiel Requirements for rations and food service equipment. These requirements, when approved by DA, become the basis for research and development efforts by the Army Materiel Command (AMC). AMC has a dual function of procuring and managing certain Army peculiar supplies, and for research and development. To deal with wholesale logistics problems, the Army Logistics Management Center develops doctrine and trains wholesale supply managers. Although procurement of subsistence is not an Army function, there is a small organization called Army Class Manager Activity, located in Chicago, which determines Army subsistence requirements and furnishes them to DPSC. This AMC activity also manages the Army's stocks of prepositioned war reserves. This enters into the field feeding picture here, since these stocks consist mainly of combat and B-Rations which must be rotated. The rotation of stocks must be phased into the system by coordination with the using command and DPSC. For example, in Vietnam arrangements were made to receive stocks of combat rations from Europe. The Installations and Services Agency is concerned with internal AMC commissary and mess procedures. This activity has, however, furnished assistance to overseas commands and, in particular, Vietnam, through the AMC Customer Assistance Program.

Maintenance of food service equipment and the maintenance package for major items of equipment are responsibilities of the Mobility and Equipment Command (MECOM). Although garrison food service equipment procurement responsibility belongs to Defense General Supply Center under DSA, major items of equipment, such as the current mobile field bakery, are managed by MECOM. If an Army field kitchen were to be developed and put into supply channels, this activity would have supply responsibility.

AMC's Natick Laboratories is the only research and development activity for food and food service equipment in the Army. This activity also prepares specifications for food and food service equipment for the rest of the services, since the majority of all item specifications produced by Natick are eventually procured by either DGSC or DPSC.

Another major functional command is Continental Army Command (CONARC). Within its Quartermaster Center, the Subsistence Department provides training for Army and Air Force basic cooks. Subsistence officers are also trained here for utilization as subsistence procurement officers in DPSC. The QM School also provides training material and doctrine for all CONARC basic training centers that have cooks schools.

The overseas and separate commands are shown, since these are the ultimate users of subsistence, equipment and trained personnel produced by the system.

Moving up to the DA staff level, the most important activity found as an operational element under the DCSLOG's Chief of Support Services is the Food Service Center. This activity has primary responsibility for the Army Food Program. The annual food plan and the Army-Air Force Master Menu are prepared here. The Army-Air Force Master Menu Board approves the master menu for both services. The Army's Surgeon General is also involved with nutritional aspects of the menu and hospital feeding. The Navy and Marine Corps also have observers at meetings of the Master Menu Board.

An Army agency which is very important in the overall subsistence system is the Military Traffic Management and Terminal Service (MTMTS). This agency operates the CONUS ports and transportation services with a DoD wide mission.

Moving over to the Defense Supply Agency, the two main procurement agencies, as far as food is concerned, are DPSC for subsistence and DGSC for food service equipment.

A fairly recent development in Armed Forces food service programs is the Food Service Director, under the Asst. Secretary of Defense for Installations and Logistics. This office is dedicated to the development of a more uniform food service program among the separate services. This office has established two joint service boards to deal with food and food service equipment problems for all the services.

There are several other agencies and staffs which have responsibilities for DoD food service actions which will in turn affect the Army

Food Service Program. One of those which is beginning to exert more influence is the DDR&E. This office is very interested in standardization of field kitchens, for example.

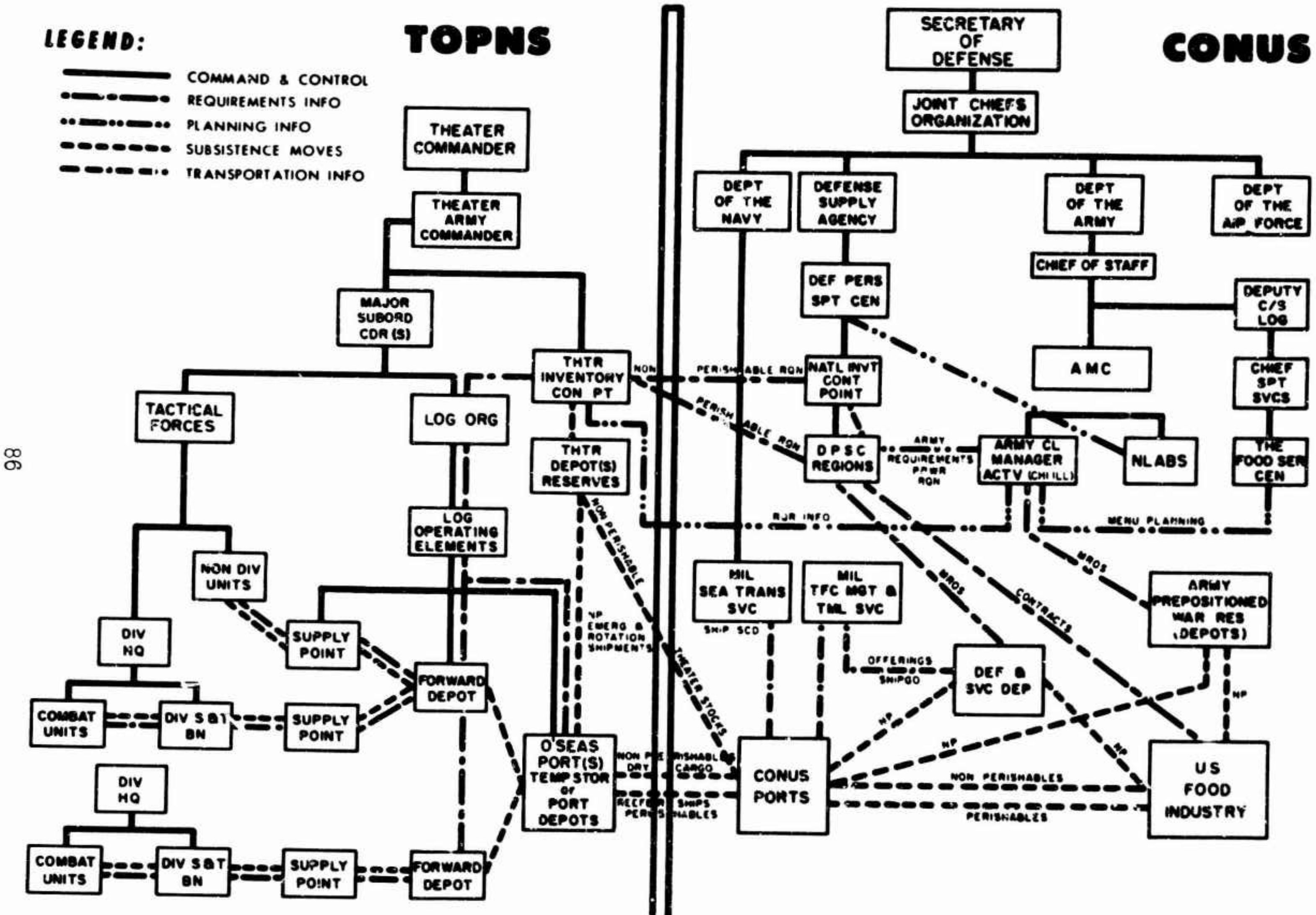
Outside the DoD there are a number of agencies which affect food service to some extent: General Services Administration in the supply of expendables; the Department of Agriculture, Meat Inspection Division, through USDA grades and furnishing of surplus milk, butter and eggs; and in the Department of Health, Education and Welfare, the Food and Drug Administration which gives clearances of food and food additives. The list could go on since the amount of food consumed by the Army and the other services is a significant portion of the agricultural production of the U.S. and many agencies of the local, state and federal government have potential interests.

Subsistence Supply

Figure B2 is a schematic diagram of the subsistence supply system from CONUS to an overseas theater of operations. This diagram does not describe any specific theater. It is difficult to draw a typical organization, since there are peculiarities to each subsystem serving Europe, Alaska, Vietnam, etc., that are not found throughout. There are also certain functions, such as local procurement and off-shore procurement, that are not shown since their presence depends on the local situation.

The chart depicts a continuous cycle. Current doctrine for establishment of a new theater calls for the use of non-perishable B-Ration

Figure B2. The Subsistence Supply System.



and Meal, Combat, Individual on an automatic resupply basis, until sufficient refrigerated storage space is acquired in the Theater of Operations (TOPNS). The prepositioned war reserves would form the basis of initial stockage for the new theater and requirements information would be furnished to DPSC to start filling the pipeline. The Food Service Center would plan the A-Ration type menu for the TOPNS and the requirements projections would be furnished to DPSC. By this time, the overseas logistical organization or the theater inventory control point would start regular requisitioning and stop the automatic resupply phase.

Requisitions for nonperishable subsistence go direct to the National Inventory Control Center where Materiel Release Orders (MROs) are sent out to the appropriate Defense or Service Depot. The depot reports its ready shipments to MTMTS and, upon receipt of a shipping order, these shipments are sent to the port. The Military Sea Transportation Service is responsible for the ships into and out of all CONUS and overseas ports. Dry cargo ships holding all classes of supplies are loaded according to supply priorities on requisitions in accordance with military standard requisitioning and issue procedures (MILSTRIP).

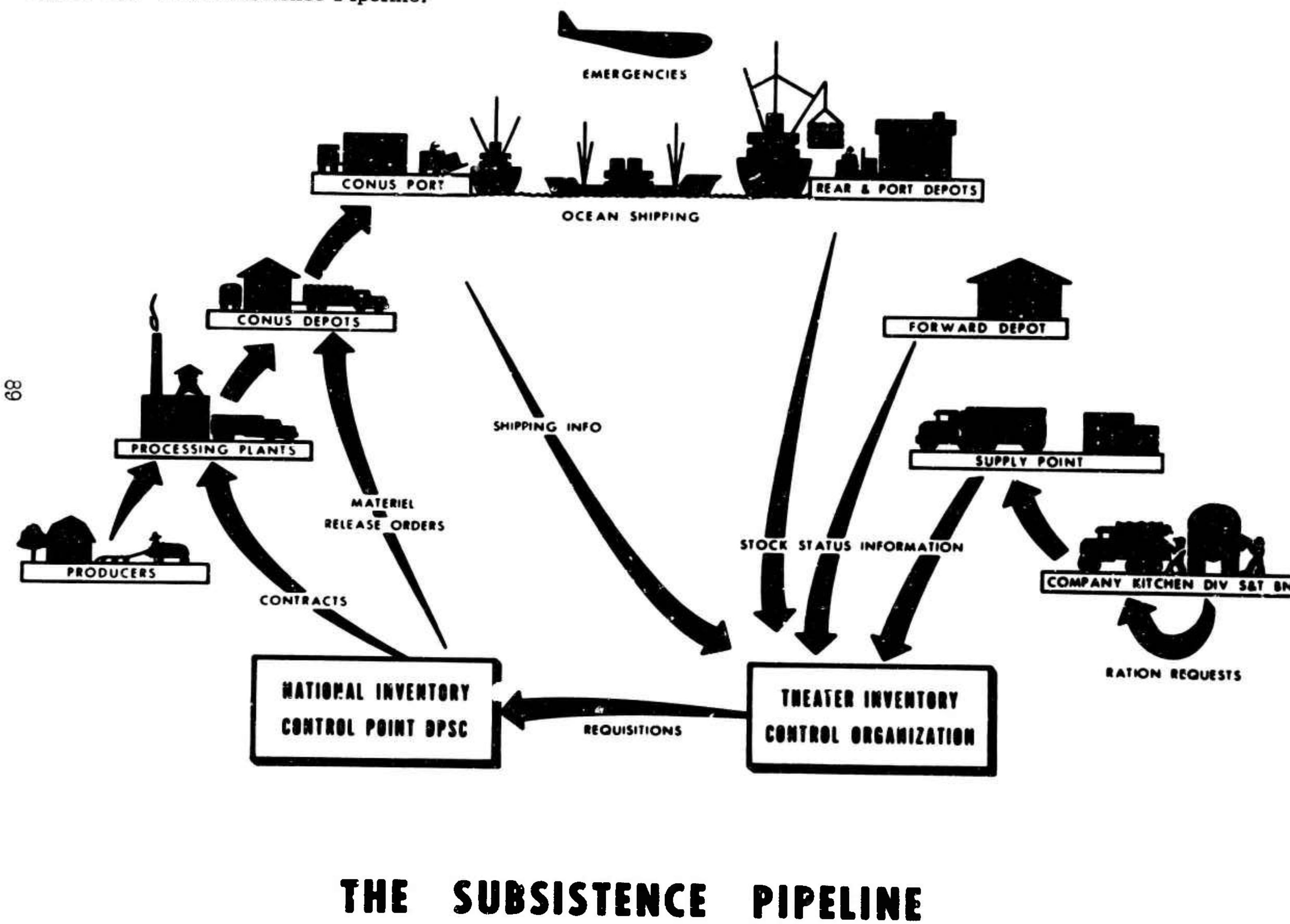
Perishable requisitions are handled differently in that they are sent direct to the DPSC region responsible for supporting the overseas command. Perishables, requiring much more critical control, are carefully scheduled directly into the port to meet reefer ship sailing schedules.

In the TOPNS, the logistical organization receives the subsistence into the port and moves it to forward depots and supply points. It is then issued on the basis of a ration request by type from using units. In the case of divisional units, the division supply and transport battalion draws in bulk and distributes to the division's messes. The type of ration issued, i.e., A, B or Meal, Combat, Individual is dependent upon the type of operations in which the unit is engaged.

The logistical organization must obtain accurate stock status reports from its depots and supply points to compute requirements and make intratheater moves, if necessary. This continuing cycle closes the entire loop in the form of requisition and future requirements information from the theater inventory control point back to DPSC and the ACMA.

This Subsistence Supply System is a continuing action and, at times, is referred to as the Subsistence "pipeline". Figure B3 is a simplified graphic portrayal of the entire cycle from the user back to the processor. The "pipeline" must be full at all times to ensure that the subsistence is delivered regularly at the receiving end. This is normally insured by maintenance of certain stock levels to preclude interruptions in support. These stock levels are proscribed by DA and changes must be approved at that level.

Figure B3. The Subsistence Pipeline.



Army Food Program*

The current collection of food, equipment, and food service personnel which does the job of feeding the Army is usually referred to as the Army Food Program. The Army Food Program was established to help commanders at all echelons maintain standards in all phases of food service. It provides central direction with decentralized control.

The specific objectives of the program are:

a. To provide an adequate variety, quantity, and quality of subsistence for troop feeding and to maintain the highest possible dietary standards for the soldier.

b. To provide adequate facilities and operating personnel for the receipt, inspection, storage, and issue of subsistence; for the sale of food and household supplies; and for the preparation and serving of food.

c. To provide continuous training for the personnel required to support the program.

Commanders at all levels are responsible for achieving the objectives of the food program by insuring that the best qualified and trained personnel available to the command are used in the food program and that close supervision is exercised over all food facilities down to and including consumer levels. The food advisor is responsible for helping the commander

* The information following is based on a presentation to the Advisory Board on Military Supplies, Division of Engineering, National Research Council, by a member of the study team. It is based essentially on TM 10-405, Army Mess Operations, and does not constitute a judgment or opinion of the present system by the study team as a whole.

to achieve the objectives of the food program. The food advisor plans and coordinates the food service program of his command and exercises technical supervision over the food service activities of the command. At first it might appear that the program is a system by another name but most important to understanding the differences between the program and a "system" is that the various level commanders are not there solely to see to the feeding of troops. This is just one of many functions assigned as the responsibility of the commander. The commander's mission at all levels is essentially either to engage in combat or support combat missions in some way. Since the personnel who plan and coordinate the program are only advisory, the local commander's interest and desires determine the emphasis given to the feeding aspect. Different commanders place different values upon the worth of the food service program, and differences can and do occur at all levels within the same command. Since commanders are required to make most efficient use of what they have in the way of resources, the effectiveness of each feeding operation is dependent upon the initiative, foresight in planning, and cooperation of the commander with the food service personnel assigned. Since the local situation can vary so widely and local commanders are more or less autonomous, the food program is the most effective way that the DA staff agencies can give broad policy guidance without infringing upon the commander's responsibilities. The "present feeding system" is not fully integrated although it can have the appearance of a system. In the final analysis the local commander has the basic responsibility for feeding his men in the best way that he sees fit with the food, equipment, and trained personnel that he has at his disposal.

In the civilian world, a centralized food service organization may furnish foods, equipment, and trained personnel to local units, along with policy guidance. The local manager is then judged on how effectively he manages these resources, usually in the form of net profits. The Army also furnishes food, equipment, and trained personnel to local commanders but their effective utilization only forms a small part of the basis on which his total effectiveness is judged. In other words, does he accomplish the mission of his unit without allowing food service to hinder his accomplishment of that mission?

Rations

The various kinds of food furnished in the field are generally defined as follows:

a. Field Ration A

(1) Field Ration A, the basic ration of the Army, is composed of fresh foods so far as possible and also includes frozen, canned, and dehydrated foods. This ration is issued in kind - that is, actual food items are issued and no monetary credits are allowed. In CONUS the meals served and the food items issued are those specified by Supply Bulletin (SB) 10-260 as amended by the installation menu board. Overseas commands may develop their own master menu or use the CONUS master menu.

(2) Field Ration A is used in all Army feeding facilities operated from appropriated funds except in the cadet mess of the U.S. Military Academy; in messes on Army harbor boats and other small craft; in messes

of units, organizations, and activities specifically excepted by the Department of the Army; and in messes at fixed Army medical treatment facilities. Messes at fixed Army medical treatment facilities are operated in accordance with Army Regulation 40-2. Troops in the other excepted messes are subsisted on the monetary allowance ration.

b. Monetary Allowance Ration

The monetary allowance ration and field ration A are essentially the same in components, methods of storage, preparation, and service. However, the monetary allowance ration differs from the field ration in that the monetary allowance ration is purchased by the using unit. The amount of the allowance is determined by the unit's present-for-duty strength, the number of days in the ration period, and the current cost of the basic components of the ration. The basic components of the ration are given in AR 31-202 (14). Menus for the monetary allowance ration are prepared by the mess steward, subject to the commander's approval.

c. Operational Rations

An operational ration is composed of nonperishable foods and is prescribed for individuals performing operational duty in time of war or other emergency. Operational rations are used in peacetime for emergencies, travel, or training, or for rotating stocks; they may also be used when refrigeration is not available.

d. Standard B-Ration

The standard B-Ration is designed for large group feeding and is used in areas where cooking facilities are available but where refrigeration facilities are not. Components of this ration are as nearly like those of field ration A as possible except for the substitution of food items requiring no refrigeration. The standard B-Ration menu (24) provides a 15-day menu of nonperishable foods.

e. Other Operational Rations

Other operational rations, such as the individual combat meal, the frigid trail individual ration, the general purpose survival food packet, and the long-range patrol subsistence packet have been developed for use by individuals or small groups and are described in DA Pamphlet 30-1.

Field Messes

The two types of field messes are the rear area (semi-permanent) type and the forward area (temporary) type. The forward area field mess consists of a mobile kitchen or a forward area mess tent. Any type of canvas or tarpaulin that is available to the unit may be used as a cover. Each type of field mess operates with equipment authorized by its unit Table of Organization and Equipment and, if combat conditions permit, with field expedients built from locally available materials.

a. Facilities

The chief differences between the field mess and the garrison mess are in the types of equipment available for use, the conditions under which the equipment must be operated, and the manner in which the troops are fed. Buildings are rarely available for field messing and equipment is limited; meals must be prepared and served in the open in all kinds of weather. The area available for setting up a field mess frequently has many undesirable features, and the storage and sanitation facilities characteristic of the garrison mess are makeshift at best in the field mess and may be lacking entirely.

b. Training

Mess personnel must be taught the techniques of messing in the field. The mess steward should constantly strive to make the field mess as much like the garrison mess as possible. When troops are training under simulated combat conditions, as is often the case when field exercises are conducted in the continental United States or in overseas staging areas, field messes should be operated as they would be under actual combat conditions.

c. Sanitation

The importance of observing proper sanitation procedures in field messing cannot be overemphasized. Field Manual 21-10 contains information on field mess sanitation (19).

Menus

Each theater of operations either publishes a master menu or uses the CONUS menu. The menu must be used as a guide for the proper use of field and operational rations. Items listed on the menu are subject to change in accordance with local conditions of procurement and supply. If the unit is subsisting on the B-Ration, the menus in SB 10-495 must be used. If the unit is subsisting on packaged rations, the menu furnished with the rations must be used.

Request for and Delivery of Rations

Rations are requested and delivered in accordance with AR 30-46, FM 29-3, and FM 54-2.

Equipment

Since the cooking equipment used in all types of field messing is essentially the same, we should discuss this just before moving to the various types of field messes.

The main piece of equipment that is seen throughout the unit messing methods is the field range. There are two field ranges which are currently in the hands of using units: the M-1937 range and M-1937 fire unit and the M-59 range with the M-2 burner unit. Although the M-59 is the improved version of the range, there are still many of the older models still in use. Throughout the following presentation it will be seen that these two ranges form the basis of all field food preparation activities for large groups (usually over 50 men).

The fire units may be used with either range. The M-1937 range has three positions for the fire unit and the M-59 has two positions. A rough estimate of its support capability is about one range per 50 individuals.

An accessory kit is issued for every group of four or fewer ranges. This consists of tools, toolbox, tiedown chains, and some kitchen equipment.

Foods may be cooked on either range by baking, roasting, boiling, griddle cooking, and deep fat frying if the fire unit is placed in the proper position in the unit. The fire unit can also be used alone, either with pot racks or by improvised angle iron arrangements.

Rear Area Messing

The site of the rear area mess will change as the lines of battle move but it may remain at the same location for months. Because of its semi-permanent nature there is time for improvement of facilities, and personnel can be fed with less difficulty than in the forward area.

Either the M-1948 kitchen tent or the general purpose tent may be used for the rear area mess. The interior arrangement in the tents varies according to the tent used. Of course, if a permanent building or shed is available, rear messes are established using the same basic equipment.

Forward Area Messing

The lines of combat change frequently and the combat area is often subjected to heavy enemy fire, particularly during daylight hours. It is not feasible in most situations to establish even temporary unit messes. Where the tactical situation prohibits the use of rear area messes that we have just seen, the troops are fed from a mobile kitchen truck or out of insulated food containers.

The mobile kitchen is a converted two and one-half ton general purpose truck and contains all equipment necessary to prepare, store, and cook food. Whenever possible, a trailer containing certain accessory equipment and food is provided for the mobile kitchen. The suggested kitchen cabinet is not furnished through channels but is fabricated by units from locally available materials. It has provisions for storage of ice, bread, food, etc., as well as providing work space for the cooks. The idea is that the entire operation can be disassembled and moved out with only a very short notice.

Railcar Messing

The same basic equipment can be utilized to equip a baggage car for rail operations.

Small Group Feeding

The field cooking outfit, small detachment consists of a stove, attachments, and cooking utensils required to prepare rations for from 15 to 40 men. It is designed for outdoor use by isolated detachments. It can be carried on two packboards. The 5-gallon gas can can be carried on a third packboard.

Other methods of cooking or heating do exist, e.g., ration heating on a Yukon tent stove using the individual canteen cup and mess kit skillet.

APPENDIX C

Definitions

1. Definitions of several terms widely used in the food service field are given below·

a. Convenience Food is a broad general term applied to foods upon which some preparation work has been done by the supplier. The term is not specific as to the amount of preparation done. Most canned food, and frozen food falls within this category as do frozen entrees and other heat-and-serve type foods. Preportioned raw meat is a form of convenience food.

b. Preprepared or ready foods are generally quite similar to convenience foods. Preprepared, ready or similar terms are usually applied to products made in-house, whereas the term convenience is usually applied to products purchased from a supplier. The terms preprepared, etc. usually imply a product processed to permit storage. There does not appear to be a generally used term for products intended to be transported hot from the point of production to the point of serving.

c. Central preparation is a term used to identify an in-house operation in which food is processed in one location for subsequent use in several other locations where the food is served to the consumer. The term is ambiguous in that it is used interchangeably to identify operations that produce preprepared foods and operations that produce food to be shipped hot to point of serving. It is no exageration of the ambiguity to say the term is used both for in-house production of convenience food and for operation of a central kitchen for remote serving points.

2. Within the study the following definitions apply:

a. Convenience food, when used without a modifier, is defined the same as 1a.

b. General Purpose Convenience Food is defined as issue items upon which some preparation work has been performed by the supplier and which can, in preparation for serving, be modified to provide more than one dish, usually with the addition of other ingredients. For example, canned peas can be merely heated and served or can, by additions, be served as buttered peas, creamed peas, and in other ways. B-Ration, except staples such as salt, sugar, and flour and condiments, is composed of general purpose convenience foods. Many A-Ration components are also general purpose convenience foods.

c. Special Purpose Convenience Food is defined as heat-and-serve type food, requiring practically no preparation skill or preparation time beyond that required to heat the item. In general, the item will be a menu item and cannot be modified to serve other than the intended dish. For example, peas in natural juices, buttered peas, creamed peas and other pea dishes would all be separate items. In this sense, Single Purpose Convenience Food would perhaps be a more descriptive term.

3. SPEED kitchen refers to the specific type kitchen pod now on hand at NLABS. It is a high speed production kitchen designed around the use of

two microwave ovens for high speed heating or cooking of food. It also has some more conventional equipment, a refrigerator and an incinerator for disposal waste and disposable eating utensils. A more complete description will be found in Cornell Hotel and Restaurant Administration Quarterly (Vol. 9 No. 1).

4. The SPEED concept refers to a concept of operation of field kitchens employing the SPEED kitchen in combination with special purpose convenience food. The concept as originally presented in Subsistence Preparation by Electronic Energy Diffusion by the then Major Oscar P. Snyder, Jr. included a companion microwave bakery pod; however, the concept as used in this study does not include the bakery pod. An objective of the concept was to make the lead time between start of preparation and start of serving very short through the combination of microwave ovens and special purpose convenience foods, but did not preclude the use of other forms of food including A-Rations. When other forms of food are used, the lead time is then the time of whatever component of the meal that takes the longest to prepare and cook.

5. Conventional or Mechanical Refrigeration as applied to 8' x 8' x 20' containers refers to the use of a mechanical refrigeration unit plus a power source such as an engine generator unit to cool a container incorporating 4 inches of insulation in accordance with commercial practice.

6. Liquid Nitrogen Refrigeration as applied to 8' x 8' x 20' containers refers to an insulated container of 8' x 8' x 20' overall dimensions with liquid nitrogen tanks of suitable size for the shipping time used.

Cooling of the load is accomplished by direct expansion of the liquid nitrogen into the load space. For study purposes the design was optimized to make the total cost of the port to port shipping of a given quantity of food a minimum for the assumed 30 day dock-to-dock shipping time.

7. Super Chill as applied to shipping food in containers of 8' x 8' x 20' overall dimension refers to a concept of cooling frozen food to a very low temperature (around -300°F) through use of liquid nitrogen and then shipping in a well insulated container. Heat losses through the container walls are offset by warming of the load. As the load represents a sizable heat sink (the load can warm from -300°F to 0°F with little risk of spoilage) extended shipping times are theoretically possible. For the present, Super Chill is in the theoretical category as the necessary data for engineering design has not yet been developed.

8. A system is defined as an organization of men and machines to accomplish a purpose. There are two important corollaries: every system is itself a subsystem of a larger system, and a system may almost always be broken down into subsystems in more than one way. This deceptively simple definition is the foundation of Systems Analysis. Within the study whenever the term system is used, it is intended to imply the whole field feeding system, which while actually a somewhat circular process, can be envisioned to encompass everything that occurs from the event that initiates a requisition for food and ends with the consumption of that food by the soldier.

9. Management structure, as used within this report, is defined as the pattern of assignment of responsibility for operation of various subsystems of the feeding system to organizational elements participating in the feeding system.

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13. ABSTRACT
An analysis was conducted of a large number of potential systems for feeding hot meals to the Army in the field during the 1975-1990 time frame. Systems selected for detailed study were essentially synthesized from the major elements of both on-going developmental projects and other proposed systems. Major objective was resource expenditure reduction through food service personnel reduction and general system simplification. The study gives a cross sectional view of the effects of adoption of systems employing advanced food preservation and preparation techniques in comparison to the present doctrinal system of company level feeding. An analysis of alternative mixed systems (company level and higher) is also made indicating greater potential for food service personnel reduction and system simplification than in any of the solely company size systems evaluated. Conclusions suggest need for extension of the study to determine more clearly the direction of required reorientation of RDT&E effort.

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Food processing			8			