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TECHNICAL REPORT

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**A PROPOSED COMBAT FOOD SERVICE  
SYSTEM CONCEPT FOR THE ARMY IN 1990**

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New shelf stable T-ration items with associated development of a new mobile food service unit to provide a means to heat on the move and serve meals immediately on arrival is proposed for use in the active combat zone. The new concept also addresses foodservice in the COMMZ and theatre areas and the interface between field and garrison operations.

The recommended new system has the potential to reduce foodservice staffing requirements by approximately 50%. The annual savings for the new system are projected at 166-314 million dollars. The volume of water consumed is reduced by two million gallons per day and fuel requirements are at least 220,000 gallons less per day.

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# A PROPOSED COMBAT FOOD SERVICE SYSTEM CONCEPT FOR THE ARMY IN 1990

## EXECUTIVE SUMMARY

1. **INTRODUCTION.** The US Army Natick Research and Development Command (NARADCOM) was tasked and funded, in FY 74, to initiate a project to investigate the current methods of combat feeding by the Army and Marine Corps, to develop and evaluate both short and long range improvements to these systems. The tasking was subsequently modified, in FY 76, to also include and consider Army Medical Department requirements.

The project was conducted in two major phases, the first of which addressed present food service operations, and determined those improvements that could be implemented with only minimum follow-on development efforts. This included testing prototypes of improved systems, and completing a cost benefit analysis comparing them to the existing systems. This phase was concluded in FY 77, and a number of technical reports were issued containing the results, conclusions and final recommendations deriving from these efforts.<sup>1-6</sup>

<sup>1</sup>Smith, R., Stefaniw, I., Davis, M., and Kirejczyk, H. **A System Evaluation of Consolidated Field Feeding for the Army.** Technical Report 75-83 OR/SA. Natick, MA: US Army Natick R&D Command, February 1975.

<sup>2</sup>Baritz, S., Bustead, R., Kirejczyk, H., Kulinski, M., Meiselman, H., Silverman, G., Smith, R., Stefaniw, I. and Symington, L. **The Camp Pendleton Experiment in Battalion Level Field Feeding.** Technical Report 7T-4-OR/SA. Natick, MA: US Army Natick R&D Command, July 1976.

<sup>3</sup>Baritz, S., Bustead, R., Bonczyk, T., Davis, M., Kirejczyk, H., Meiselman, H., Silverman, G., Smith, R., Stefaniw, I., and Symington, L. **The Camp Edwards Experiment in Battalion Level Consolidated Field Feeding.** Technical Report 76-45-OR/SA. Natick, MA: US Army Natick R&D Command, December 1975.

<sup>4</sup>Kulinski, M., Smith, R., and Stefaniw, I. **A Cost and Systems Effectiveness Analysis of the XM-75 and XM-76 Field Feeding Systems for Marine Corps Divisions.** Technical Report 7T-10-OR/SA. Natick, MA: US Army Natick R&D Command, July 1976.

<sup>5</sup>Kirejczyk, H., Baritz, S., Byrne, R., Kulinski, M., Smith, R., and Stefaniw, I. **A Cost and Systems Effectiveness Analysis of Consolidated Field Feeding for Army AIM Divisions.** Technical Report Natick/TR-77/003. Natick, MA: US Army Natick R&D Command, October 1976.

<sup>6</sup>Kirejczyk, H., Bonczyk, T. and Hertweck, G. **Evaluation of Alternative Field Feeding Systems for the Army Field Medical Units.** Technical Report. Natick, MA: US Army Natick R&D Command, July 1978.

The second phase of this project, initiated in FY 78, was directed towards developing a totally new combat food service system concept for the future Army. The major thrust of this effort has been to define a system which takes maximum advantage of new food and packaging technology, providing the mobility, flexibility and responsiveness necessary to deliver high quality, hot meal service to all troops on the battlefield; the capability to transition from combat to ceasefire and, eventually, to base development operations; and, finally, to improve operational efficiency, thereby reducing the need for scarce manpower resources to perform the food service function.

In May 1978, a preliminary report was published, outlining the basic concept of the new combat feeding system.<sup>7</sup> This report expands on that concept, and offers a detailed cost analysis of the new system in comparison with the existing system. Certain modifications to the basic concept were made as a result of coordinating the preliminary report with the Army.

## 2. DISCUSSION.

a. **Background.** Very early in the study several important factors became evident. The battlefield in 1990 will engage highly mobile tactical units, widely dispersed over a broad range of combat situations and locales. The existing methods of preparing meals from either frozen and/or canned ingredients, to be consumed on site or delivered to the troops at a remote site in insulated containers, and requiring sanitation, cannot be very well adapted to this kind of situation. Recent advances in food and packaging technology, particularly in the area of custom prepared foods, allow the consideration of new methods of food service where heating and serving the food on disposable trays are the only food service functions performed on the battlefield. This type of operation would provide the capability to be highly mobile, allow for heating on the move, to achieve a high level of responsiveness, and maximize the opportunity for hot meals to be served to the combat forces, subject to prevailing conditions.

b. **Scope.** The new concept has been formulated to satisfy the feeding requirements for all the troops in the theater of operations. In the process, considerable attention was devoted to the transition from combat to base development type feeding operations which would occur after a ceasefire, and to the effect that the new system would have interfacing with peacetime garrison feeding operations.

c. **Assumptions.** The following assumptions were specified after coordination and concurrence by the US Army Training and Doctrine Command, (TRADOC) Message 112144Z JUL 78. These assumptions were rigorously followed, and significantly influenced the definition of the recommended system:

(1) The needs of the combat field feeding system will drive the requirements for field feeding subsystem whether used in garrison or in training.

<sup>7</sup>Byrne, Robert J. **A Proposed System for Army Combat Forces in the 1990's.** Technical Report Natick/TR/025. Natick, MA: US Army Natick R&D Command, May 1978.

(2) The actual numbers and locations of units and troops in the theater of operations will be based on the numbers and locations called for in the TRADOC Standard Theater Level Scenario. The numbers and locations of units and troops in a Corps Area will be based on the TRADOC Standard Scenario, Europe 1, Sequence 2A, which is compatible with the Theater Level Scenario for the first ten days or a revision of this Scenario, which would be more applicable. These forces will be extrapolated to a 1984 force structure using FY 84 program forces. This force will be used to reflect the 1990's forces and is the best available information.

(3) The defined system will be flexible enough to respond to any Scenario, however, the use of the TRADOC Standard Theater Level Scenario will be sufficient to develop the cost and effectiveness comparisons of the new system.

(4) In the Army of the 1990's, the preponderance of infantry in Europe will be mechanized. Those troops carried on and fighting from armored vehicles will be directly assigned to the vehicle as team members. Dismounted operations will remain a valid requirement during this time period.

(5) The Army field feeding system must be capable of dealing with high intensity combat.

(6) After a ceasefire, the theater feeding systems will transition from a combat system to a base development system. Eventually, this base development system may transition to a full garrison type system.

(7) A single minimum standard of support will prevail throughout the theater. This minimum standard will be one hot meal each day for all personnel whenever combat conditions and situations permit.

(8) Food service operations will be curtailed in any NBC contaminated area.

(9) No host nation support will be considered.

(10) A water distribution system is not a function of the food service system and will be addressed in a separate TRADOC effort.

(11) This study will not be restricted by current TOE and food service management structures.

**d. Methodology.**

(1) The mission requirements of the future battlefield, during the next decade, were considered. A model battlefield was created, from which specific distributions of all troops were derived.

(2) A review of existing and projected food, packaging and equipment technologies was conducted, and alternative system capabilities defined.

(3) The various system alternatives were projected onto the model battlefield, and their performance assessed. This was an iterative process, which gradually focussed on those alternatives that provided the greatest potential for the best performance and efficiency. Various operational methods were examined until the most effective concepts were defined.

(4) The existing method of combat feeding was projected onto the model battlefield and detailed food, manpower, equipment, fuel and other resource requirements and costs determined.

(5) The new system was similarly evaluated, and its total resource requirements and costs determined.

(6) The peacetime manpower requirements of both the existing and the new system were computed using current Army TOE personnel strengths.

(7) All of the results obtained were then used to complete a cost and benefit analysis.

### 3. NEW SYSTEM DEFINITION.

a. **General Concept of Operations.** Food service during the combat period for troops in the divisional brigade areas will consist of at least one hot meal daily, when conditions permit, with the other meals being operational rations. The hot meals will be shelf stable, convenience foods in bulk packs, e.g., steam table pans, which are simply heated and served on disposable dinnerware from a small trailer mounted, food service unit, designed for company level operations. In addition, it is proposed that combat vehicles be equipped with a capability to heat components of the individual rations, as substitute for hot meals, for use when these troops are engaged in high intensity or continuous combat, and cannot receive meals from the food service unit.

Food service in division rear, corps and the Communications Zone (COMMZ) areas, except for medical units, during this time, will usually consist of two hot meals daily, and the remaining meal an operational ration. The hot meals will be the same rations as used in the combat zone, but will be augmented with limited perishables, (i.e., salads, milk, etc.), as possible. The food will be prepared at unit level from a modular field kitchen, which is comprised of modern, fuel burning food preparation and sanitation equipment in a soft frame-type shelter. Meals may be served on disposables, or on permanent plastic, compartmented trays.

These unit kitchens will, as soon as practicable, be integrated into area kitchens, with a capacity to offer improved menus and service for up to 800-1000 troops daily on a continuous basis. This will be dictated by the missions of the units involved, and combat conditions within a particular geographic area. Therefore, as time passes beyond the initial force deployment in the theater, increasing numbers of large kitchens may be found operating in the rear and support areas.

Following combat, food service will transition to base development operations, during which three high quality, hot meals will be offered each day. These meals will be a combination

of T and A ration items. In order to achieve this transition, unit kitchen resources, including food service personnel, to the extent possible, will be combined into large area kitchens. Those combat elements authorized trailer mounted food service units will be issued additional equipment and shelters sufficient to allow them to establish battalion kitchens. It will make little sense to continue to operate small, independent kitchens with limited food service personnel and restricted variety and quality of hot meals, when larger, more efficient operations can provide substantially better food service.

Management of the new food service system will not be considerably different than at present, but there will be a need to reinforce and emphasize command control at battalion, or a corresponding level, to insure the orderly and efficient consolidation of smaller units into battalion or area kitchens, as required.

A representation of this concept of operations is depicted in Table 1, but it should be understood that, in the reality of a dynamic combat environment, the situation, is generally not expected to be so well-defined and structured as indicated.

b. **Food Products.** As previously emphasized, convenience foods were considered necessary to be responsive to combat mission requirements. After all potential candidate foods were investigated, those selected and recommended are the new thermally-processed, shelf-stable products, which consist of high quality prepared foods packaged in half steam table pans, ready for heating and serving, which have been tentatively designated as the T Ration. Frozen convenience food systems were rejected during the investigation because of logistic considerations. Other food preservation methods, such as freeze dried and/or compressed foods, were found less acceptable for use in the combat zone because the need for water, reconstitution, food preparation, additional equipment and personnel would reduce system responsiveness to the combat mission. These foods, however, must be considered as an alternative for use in other areas of the theater, because their reduced volume minimizes the related logistic support requirements. Irradiated preserved convenience foods were not considered a viable candidate, but they should not be completely rejected from future consideration. If this preservation process can produce fully prepared, shelf-stable products, of better quality and at less cost than those recommended, a change to irradiated foods can be made at a later date. Also, irradiated raw products, such as meats, could be substituted for perishable ration items which are designated for use during the base development period.

The T-ration is the basic building block of the new combat food service system, which will provide for a hot food capability almost anywhere on the battlefield. Selected food products, which are now commercially available to be included in this type ration, are shown in Figure 1.

These new food products were a follow-on development to the flexpack rations, and use the same thermoprocessing techniques for preservation. In developing the flexpack foods, it was apparent that the flat, thin geometry of the package reduced the time and temperature sterilization factors significantly, thereby increasing the quality of the finished product.

The proposed system concept requires sustained consumption of this new ration on the battlefield. Therefore, a wide variety of menu items will have to be developed to insure that

TABLE 1

CONCEPT OF OPERATIONS

	INITIAL PHASE OF CONFLICT	STABLE PHASE OF CONFLICT	POST-CONFLICT
DIVISIONS FORWARD	46% T Rations 54% MRE Food Service Unit Disposables	46% T Rations 54% MRE Food Service Unit Disposables	
DIVISIONS REAR	46% T Rations 54% MRE Modular Kitchen Tent Disposables	46% Augmented T Rations 54% MRE Modular Kitchen Tent Disposables or Trays	100% A Rations Consolidated Kitchen Trays
CORPS	57% T Rations 43% MRE Modular Kitchen Tent Disposables	57% T and A Rations 43% MRE Consolidated Kitchen Trays	
COMMZ	95% T Rations 5% MRE Consolidated Kitchen Trays	95% A Rations 5% MRE Consolidated Kitchen Trays	



**CHICKEN STEW**



**BEEF STEW**



**SLICED ROAST PORK AND GRAVY**



**SLICED BEEF IN ITALIAN SAUCE**

**FIGURE 1. T-RATION ITEMS**

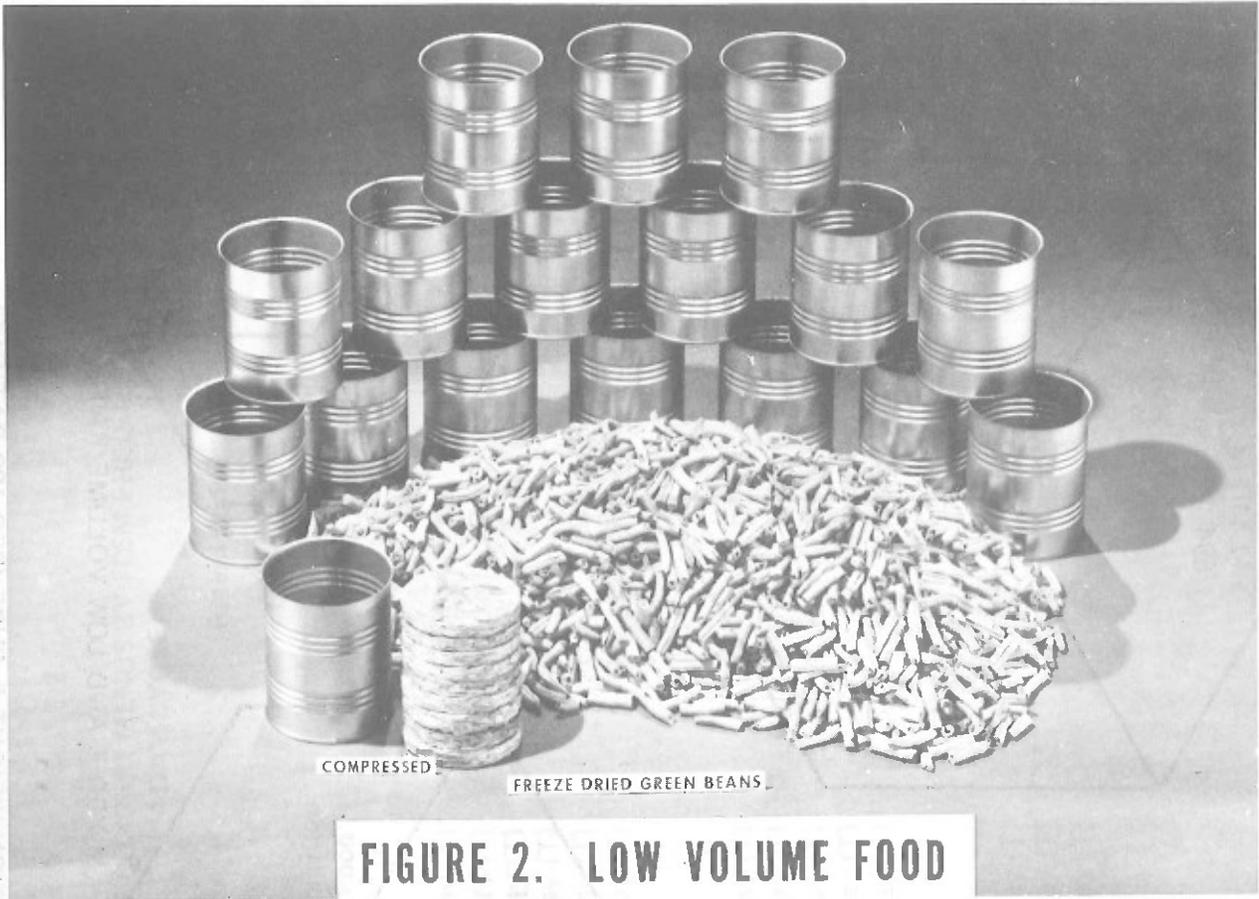
troop acceptance remains high over extended periods of time. Even though there are some limitations on the kinds of menu items that can be processed in this manner, within the range of the types of products that can be made available, significantly more variety can be achieved in combat feeding than ever before, because of the simplicity of the heat and serve requirements as compared to the conventional food preparation methods. Therefore, it can reasonably be projected that a sufficient variety of high preference menu items can be developed to maintain high troop acceptance over lengthy periods of use.

In addition to the T ration, low volume foods were considered because of the obvious logistical advantages. An example of the possible cube reductions for some food items is illustrated in Figure 2. These foods were not included for use in the combat zone because of the need for water, reconstitution, and preparation activities, which would reduce system response time and increase equipment and labor requirements. But, a mixed T and low volume ration has been developed as an alternative to a total T ration for use in the corps and COMMZ areas if logistic support operations are constrained. The necessary equipment will be available in the modular field kitchens to prepare and serve this type menu. Final determinations with regard to the use of the T ration or a mixed T and low volume ration will have to be based upon whether the savings in cube, as shown on Figure 3, warrant the additional investment in food service personnel needed to prepare and serve the mixed T and low volume ration. Differences in troop acceptability should also be evaluated and considered.

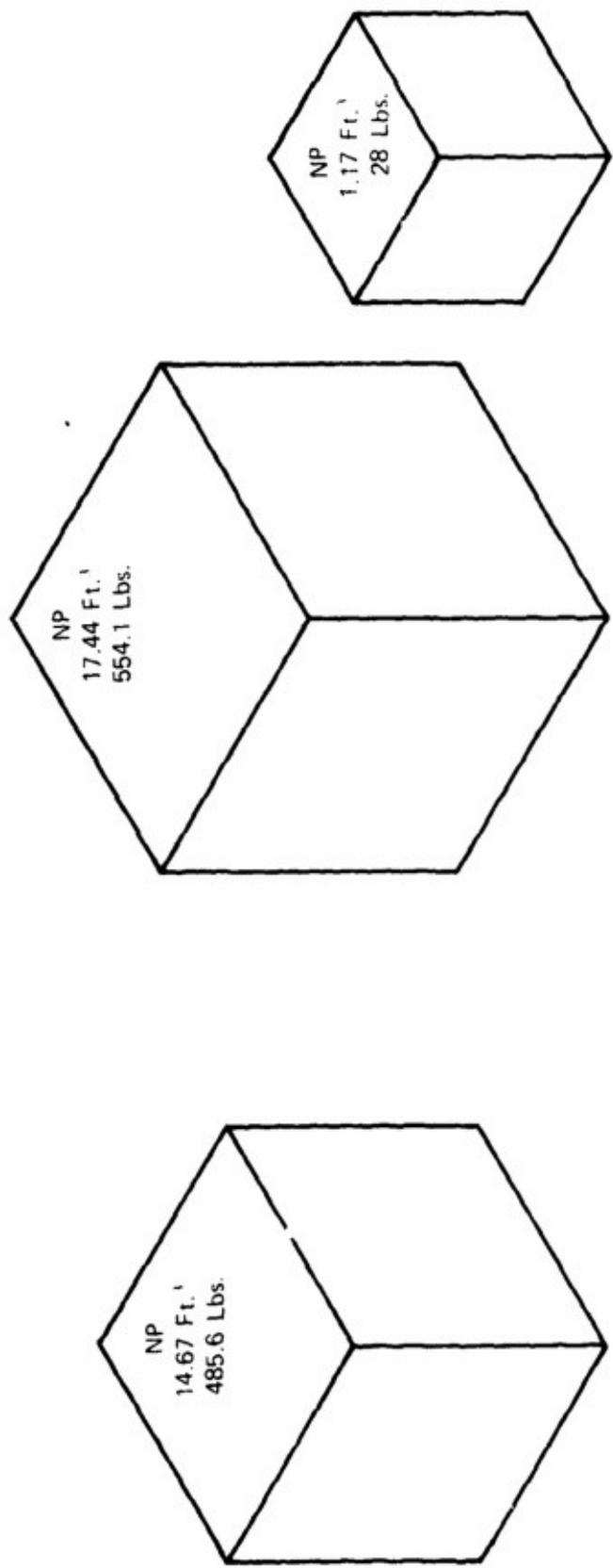
The design of the new system required the definition of the type and variety of foods that will be prepared and served. A menu was not necessary, since the daily schedule of menu items is not a paramount consideration in the design process. However, a list of foods and their frequency of serving was essential to determine food costs, cubes, weights, equipment, and personnel requirements. In developing these lists, the major objective was to obtain high levels of troop preference. This was achieved by using a recently developed mathematical computer model to determine those foods which maximize troop preference subject to cost and nutritional constraints.<sup>8</sup> The computer input included a menu item file with costs, nutrition, and troop preference data. The cost constraint input was the Basic Daily Food Allowance, and the nutritional requirements were those specified by the Office of The Surgeon General. In addition to the above information, the length of the menu cycle also had to be established. Using these inputs, a list of menu items and their frequency of serving was produced that maximized troop preference subject to the indicated constraints. This list of foods, which was in generic form, was then converted to specific T ration menu items, mixed T ration and low volume menu items, and A ration menu items. A sample of the selected menu items is shown on Table 2.

A summary of costs and cube of these foods are compared in Table 3. In comparing these tables, it is apparent that a premium cost, weight and volume will be paid for the T

<sup>8</sup>Balintfy, J., Ross, G., Sinha, P., and Zoltners, A. A Mathematical Programming System for Preference-Maximized Nonselective Menu Planning and Scheduling, Part I: Modals and Algorithms. Research Report 3-75. Amherst MA: University of Massachusetts. Food Management Science Laboratory, November 1975.



**FIGURE 2. LOW VOLUME FOOD**



Weight & Cube Per 100 Rations

P = Perishable  
NP = Non Perishable

FIGURE 3. RATION WEIGHT & CUBE (PER 100 RATIONS).

TABLE 2  
COMPOSITION OF CONCEPT MENUS BY ITEM FREQUENCY  
(14 DAY CYCLE)

Category/Items	T-Ration		Ration Concept		A	
	Freq of Serving	Composition of Food	Freq of Serving	Low Volume Composition of Food	Freq of Serving	Composition of Food
<b>Entrées</b>						
Roast Beef	2	Tray (T)*	1	Tray (T)	2	Froz (F)
Grilled Beef Steak	3	Tray (T)	3	Dehy (D)	3	Froz (F)
Beef Pot Roast/gravy	1	Tray (T)	1	Tray (T)	1	Froz (F)
Peppersteaks	1	Tray (T)	-	-	-	-
Swiss Steak/Tom. Sauce	2	Tray (T)	1	Dehy (D)	1	Froz (F)
Meatloaf, gravy	1	Tray (T)	1	Tray (T)	1	Froz (F)
<b>Starch</b>						
Baked Potatoes	3	Tray (T)	2	Dehy/Fabr (D)	3	Fresh (F)
Hash Browns	4	Tray (T)	4	Dehy (D)	4	Dehy (D)
Mashed Potatoes	4	Tray (T)	4	Dehy (D)	4	Dehy (D)
Beans, Baked	1	Tray (T)	1	Dry (D)	1	Dry (D)
Spanish Rice	1	Tray (T)	1	Dehy (D)	-	-
<b>Vegetables</b>						
Green Beans	4	Tray (T)	4	Dehy/C (DC)	4	Froz (F)
Peas	3	Tray (T)	3	Dehy/C (DC)	5	Froz (F)
Whole Corn	4	Tray (T)	4	Dehy/C (DC)	4	Froz (F)

\*T - Tray packed, thermally processed  
D - Dehydrated, dry  
DC - Dehydrated, compressed  
F - Fresh/Frozen, perishable

**TABLE 3**  
**RATION PARAMETERS**

<b>Ration</b>	<b>\$/Ration</b>	<b>ft<sup>3</sup>/Ration (NP/P)*</b>	<b>lbs/Ration (NP/P)</b>
<b>T Ration</b>	<b>\$ 3.91</b>	<b>0.147/0.000</b>	<b>4.86/0.00</b>
<b>Low Volume Ration</b>	<b>3.83</b>	<b>0.113/0.012</b>	<b>3.17/0.28</b>
<b>A Ration</b>	<b>3.13</b>	<b>0.070/0.101</b>	<b>2.19/3.80</b>

\*NP — Nonperishables

\* P — Perishables

ration. However, the increased ration costs will be more than made up by savings in food service personnel costs, so that the total annual operating cost of the new food service system is less than the conventional system, as discussed in paragraph 3.e. Cost Analysis. Of most importance, however, is that the T ration is essential to be responsive to and support combat mission requirements. Also, as reported in the logistic analysis conducted herein the reduction of fuel and water usage associated with the new custom food system will eliminate or significantly reduce the overall logistic penalties.

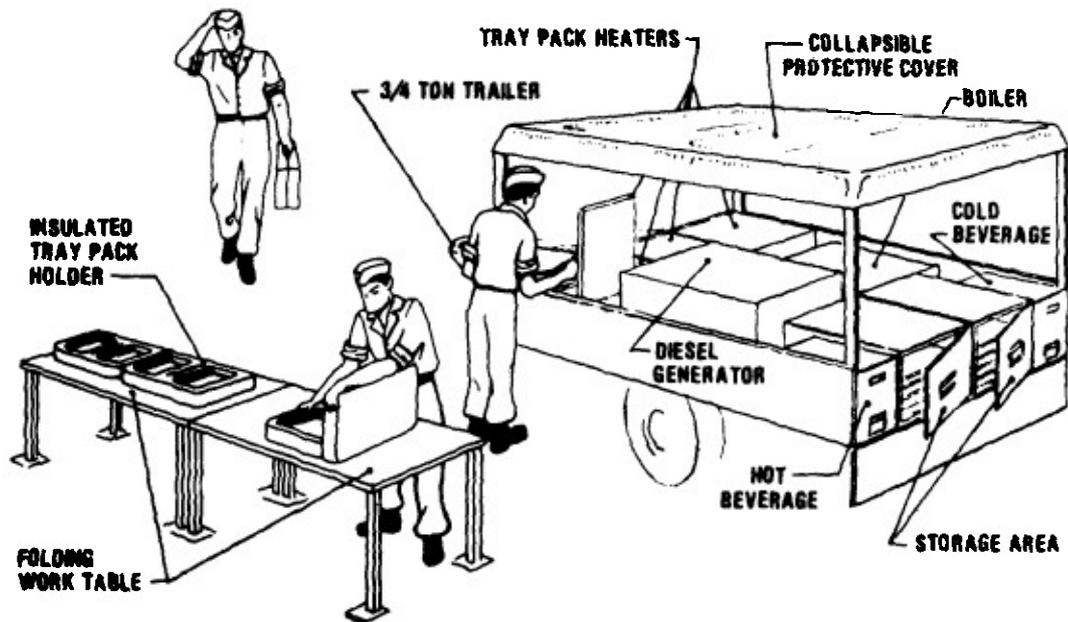
It should not be forgotten that the rations employed for combat feeding must be maintained as war reserves in peacetime; and, have to be integrated into the garrison feeding program for rotation purposes, to sustain an adequate industrial base for wartime production, and to preserve the proficiency for combat feeding. In most respects, the T ration conforms very well to these requirements.

c. **Equipment.** Given the new T ration, and the mission and operational considerations expressed herein, the necessary equipment systems are proposed for development.

The troops in the combat zone need a food service system which can be responsive to the battlefield situation and deliver high quality, hot meals on demand. The T ration is ideally suited for this application. In addition, a highly mobile, food equipment system is necessary to heat, deliver, and serve this ration. A small trailer mounted, food service unit, shown as an artist's concept in Figure 4, is recommended for this purpose. The food service unit will contain a small, military standard, engine-driven generator set; a hot water boiler with controls and circulating pumps; T ration heater; serving line equipment; hot and cold water dispensers, for beverages; and, the necessary storage for rations, disposables, and supplementary food items, such as bread, and other necessary supplies. It is intended only to heat and serve the T ration, and does not otherwise provide for any food preparation capabilities.

Over fifty percent of the combat troops in the forward combat zone will be assigned to or operating from combat vehicles. During periods of intense and continuous conflict, these troops will generally be unable to obtain hot meals from the trailer mounted units, and they will have to subsist on individual rations. It is proposed that these vehicles be equipped with a simple heating device, so that components of the ration can be heated as a substitute for the hot meal. This ration heater will be designed so that it will not exceed the space now claimed in these vehicles for existing rations and beverages, and will not interfere with vehicle mission power capabilities. Preliminary studies have indicated that such a capability is technically feasible within the electric power and stowage constraints of three representative vehicles analyzed M60A1 tank, M113A1 personnel carrier, and Infantry Fighting Vehicles.<sup>9</sup> The ration heater concept will include an individual folding or collapsible fabric, electric heating pouch, of minimum power requirements, that will plug into a vehicle and that will accept and heat the flexible packaged entree item of the Meal-Ready-to-Eat (MRE) ration. A concept of this pouch is depicted in Figure 5. The final version of the heater design will, of course,

<sup>9</sup>Rose, Harold, et. al. **Combat Vehicle Crew Feeding Study.** Technical Report 12329. Warren, MI: US Army Tank and Automotive Command. October 1977.



### MOBILE FOODSERVICE UNIT

Figure 4 Trailer Mounted Food Service Unit

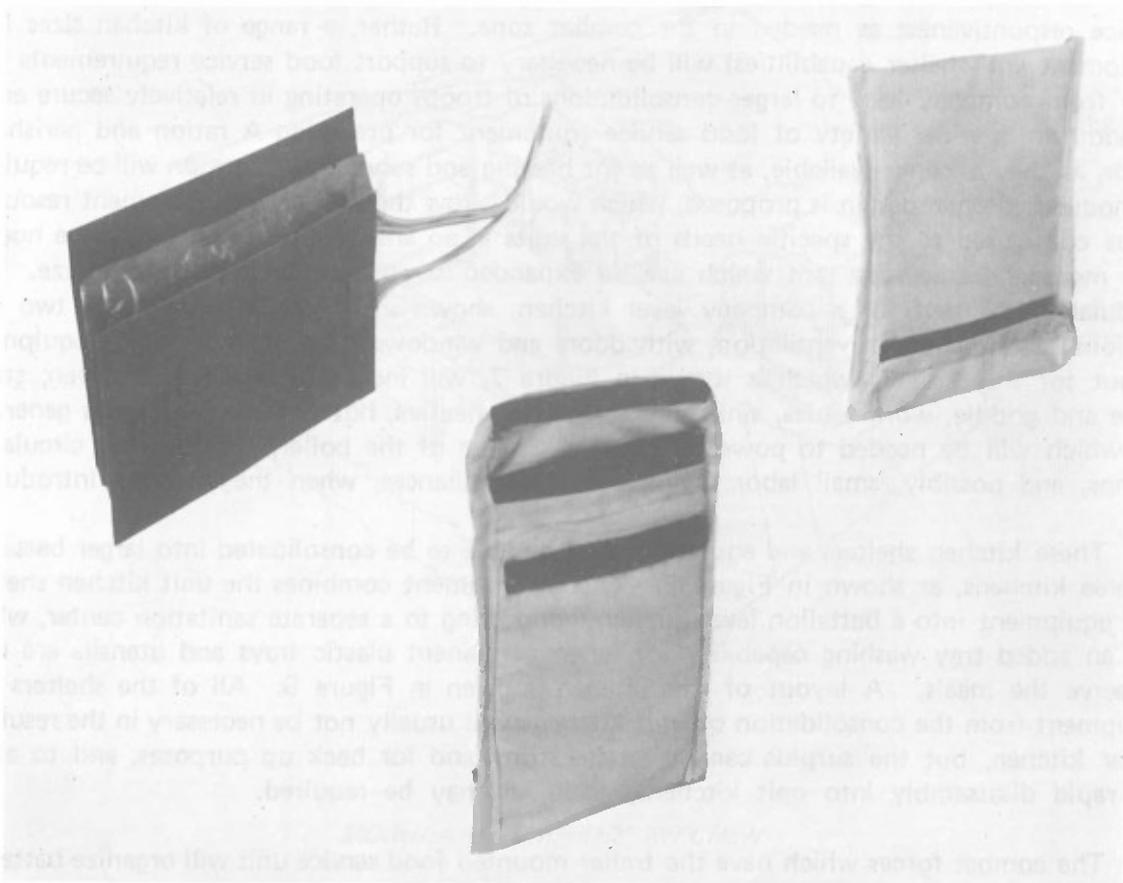


Figure 5 Crew Ration Heating Device

require further vehicle studies, and concept development and evaluation of alternatives under field operating conditions.

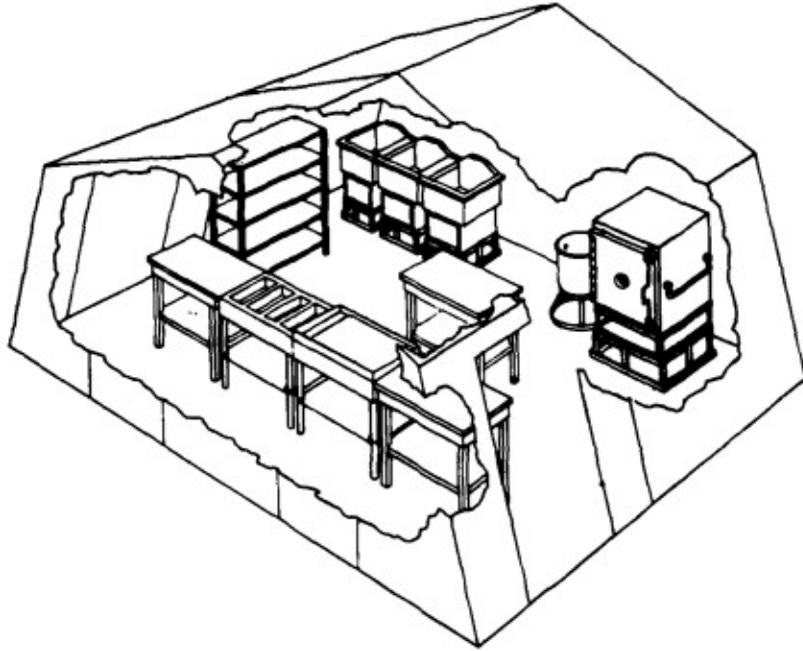
The troops in the corps and COMMZ areas will not require the same high degree of food service responsiveness as needed in the combat zone. Rather, a range of kitchen sizes (i.e., equipment and shelter capabilities) will be necessary to support food service requirements that vary from company level to larger consolidations of troops operating in relatively secure areas. In addition, a wider variety of food service equipment for preparing A ration and perishable foods, as they become available, as well as for heating and serving the T ration will be required. A modular kitchen design is proposed, which would allow the shelter and equipment resources to be configured to the specific needs of the units in an area. These kitchens will be housed in a modular frame type tent which can be expanded to any required, reasonable size. This modular frame tent for a company level kitchen, shown in Figure 6, consists of two tent sections, a tent fly for ventilation, with doors and windows. An example of an equipment layout for this kitchen which is shown in Figure 7, will include a fuel burning oven, steam table and griddle, work tables, sinks, racks, T ration heaters, hot water boiler, and a generator set which will be needed to power automatic ignition of the boiler, controls and circulating pumps, and possibly, small labor savings electric appliances, when they can be introduced.

These kitchen shelters and equipment can be able to be consolidated into larger battalion or area kitchens, as shown in Figure 8. This arrangement combines the unit kitchen shelters and equipment into a battalion level kitchen, connecting to a separate sanitation center, which has an added tray washing capability for when permanent plastic trays and utensils are used to serve the meals. A layout of this kitchen is given in Figure 9. All of the shelters and equipment from the consolidation of unit kitchens will usually not be necessary in the resulting larger kitchen, but the surplus can be retained on hand for back up purposes, and to allow for rapid disassembly into unit kitchens, again, as may be required.

The combat forces which have the trailer mounted food service unit will organize battalion kitchens, when they are located in a secure reserve area or after a ceasefire, to create a more effective food service operation. A layout of this type is contained in Figure 10. This is similar to the type of kitchen consolidation just discussed, but retains the trailer mounted equipment to allow for quick redeployment purposes. The ability to establish such kitchens requires that shelters, ovens, steam tables, griddles, sanitation equipment, and other items of equipment, be held in reserve during the combat period. This equipment would then be issued to these units when they are in reserve status in secure areas, or after a ceasefire.

In summary, three different equipment systems have been recommended:

- (1) a company level, trailer mounted food service unit to heat and serve T rations to troops in the combat zone;
- (2) a simple, individual ration heater for use during periods of intense and continuous combat by vehicle crews and mounted troops; and,
- (3) a modular, soft shelter kitchen for use in the corps and COMMZ, and by all troops after a ceasefire. As noted, supplementary equipment and shelters will be maintained for use



*MODULAR COMPANY KITCHEN*

Figure 6      Modular Field Kitchen

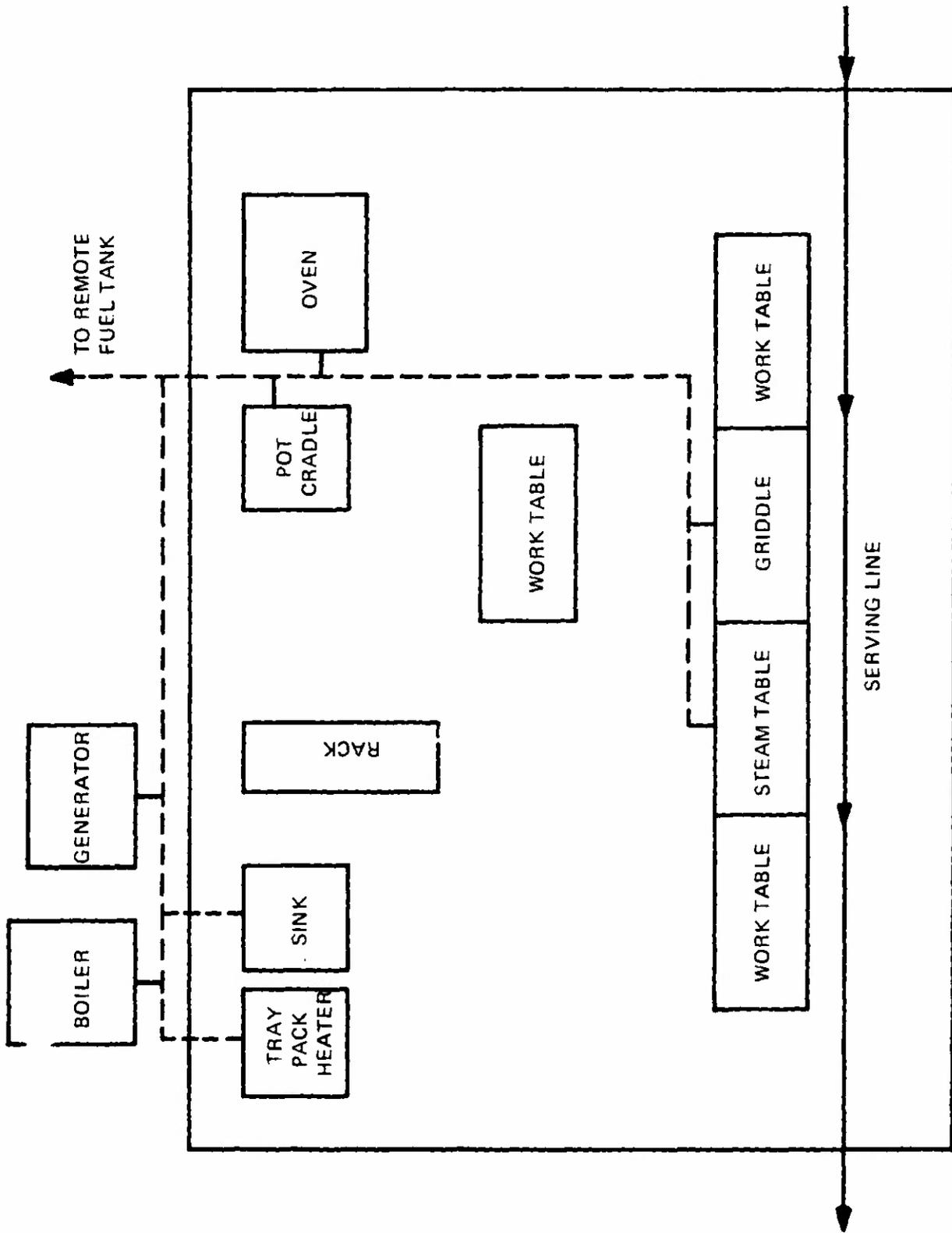


FIGURE 7. EQUIPMENT LAYOUT OF COMPANY KITCHEN

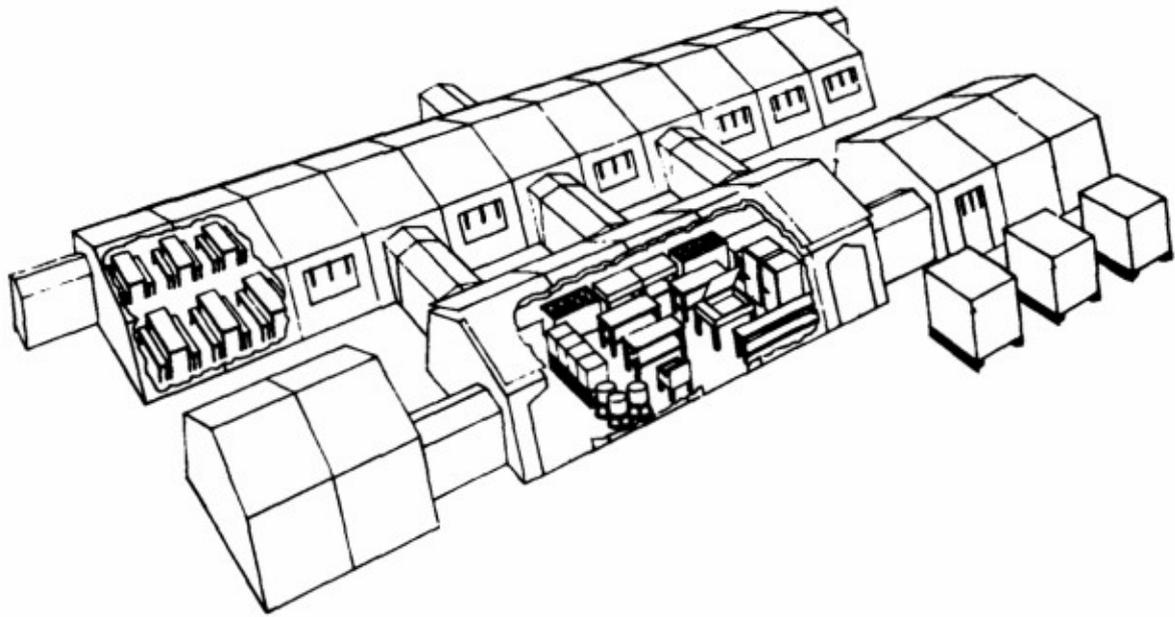


Figure B Battalion Area Kitchen Tent

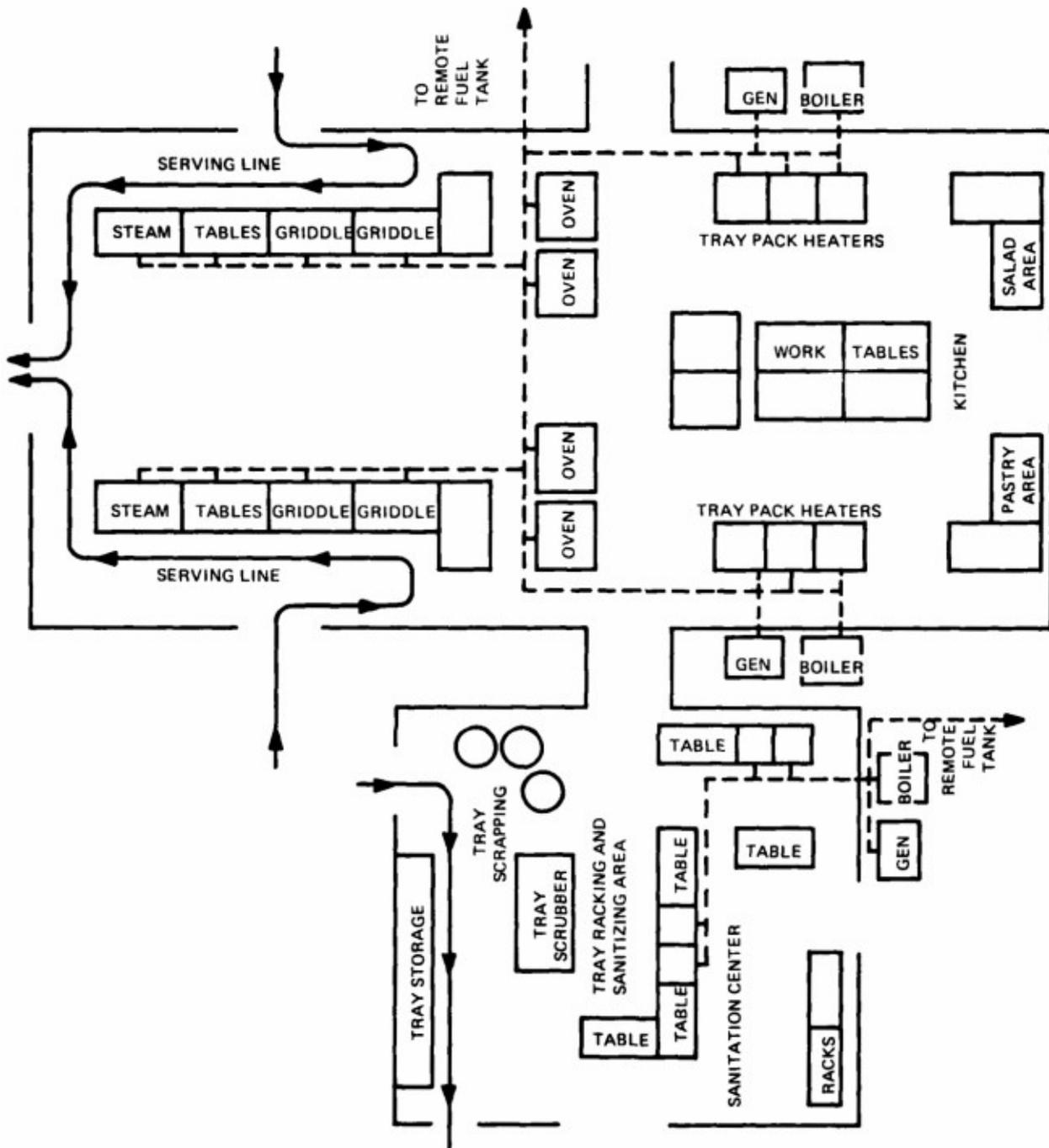


FIGURE 9. EQUIPMENT LAYOUT OF BATTALION/AREA KITCHEN

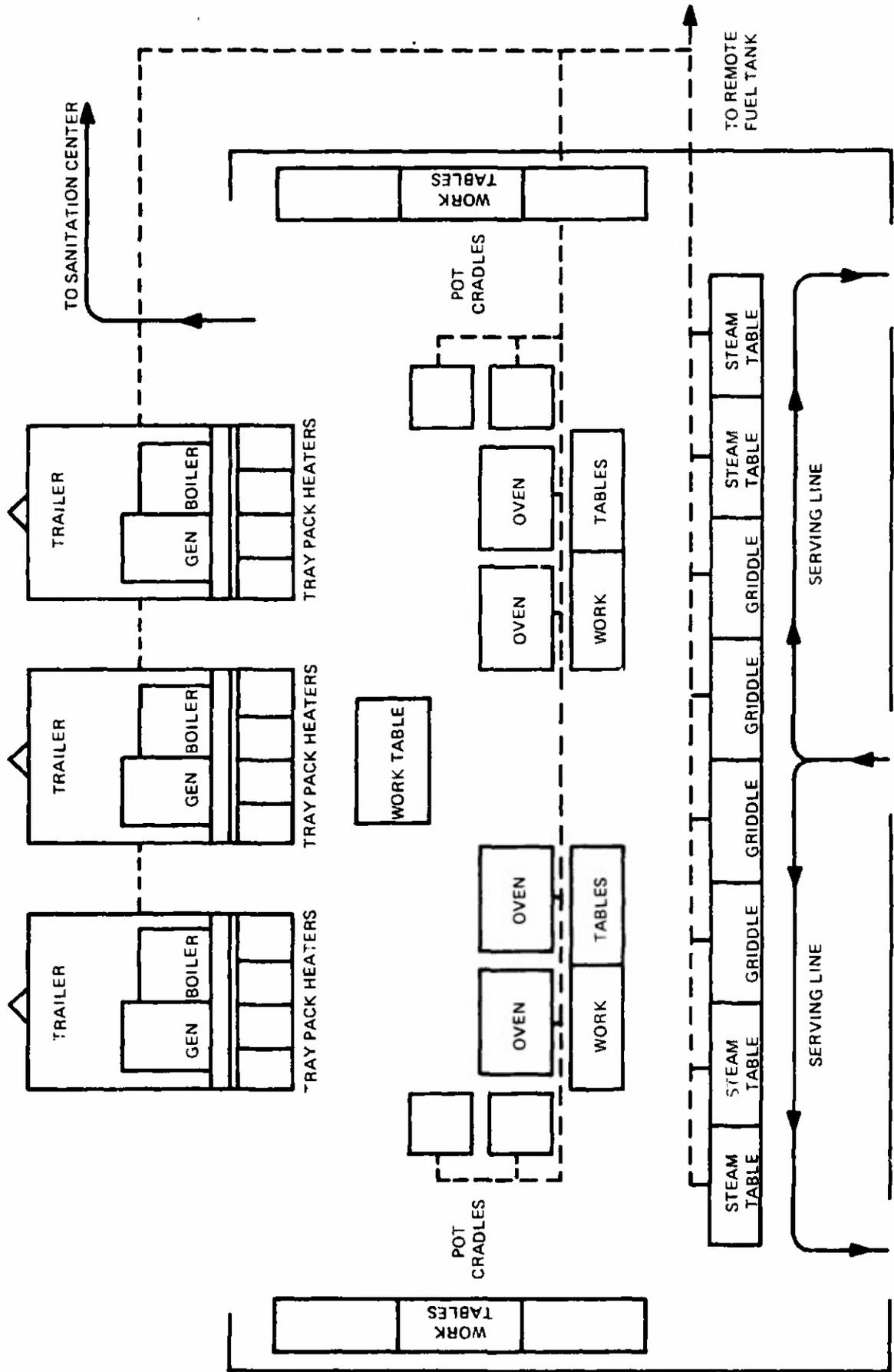


FIGURE 10. EQUIPMENT LAYOUT OF BATTALION KITCHEN FOR COMBAT TROOPS

by combat troops, in combination with their trailer food service units, when they are in the reserve for reasonable periods of time, and after a ceasefire.

One other major equipment item must be mentioned. It is assumed that the bread components of the daily menu will be produced and supplied by the new Automated Bakery System, now under development at NARADCOM.<sup>10</sup> The ABS will exploit current technology to achieve considerable improvements in product quality and significant manpower savings relative to the M-1945 Baking System, which is being replaced. It will consist of automated production equipment, for continuous or nearly continuous bread making operations, from assembly of ingredients to wrapping of the finished products. These equipment components will be assembled in six shelters designed to the cargo container specifications of the "International Organization for Standardization" (ISO), thus will be compatible with available mechanical handling equipment and other lift devices, and transporters and carriers. The bakeries will be located and operate at the general support level, supplying bread products to division support for subsequent distribution with the rations.

d. **Personnel Requirements.** Three different combat and combat support food service systems were considered in determining personnel requirements:

(a) Conventional company level operations with A and B rations, that is the current standard Army system.

(b) The new T ration system proposed for company level use in the combat zone, and as company level and/or larger kitchen configurations in the corps and COMMZ areas during the combat period.

(c) Food service for base development operations, which include consolidated kitchen operations with A and T rations after a ceasefire. Each of them was analyzed with respect to the TRADOC Standard Theater Level Scenario to determine the number of food service and KP personnel that are, or would be, required to operate the different systems.

The number of personnel required for the conventional system was based upon the current TOE and AR 570-2.<sup>11</sup> For the new combat T ration system personnel requirements were best judgement estimates, based on limited experience with total convenience food systems. The number of personnel required for the base development system were derived from extensive

<sup>10</sup>US Army Training and Doctrine Command. ATCD-SP-P. Letter of Agreement for an Automated Bakery System, USATRADOC ACN 22035. Letter Fort Monroe, VA: 10 April 1977.

<sup>11</sup>US Department of the Army. Army Regulation 570-2: Manpower and Equipment Control, Organization and Equipment Authorization Tables - Personnel. Washington: 22 July 1969 (Changes 1-8).

data collected in field exercises using large consolidated kitchens.<sup>12,13</sup> The number of personnel required by the peacetime garrison system was determined from an evaluation of recent headcount and attendance data, obtained from four combat divisions located at CONUS installations, and the food service staffing authorized and necessary to meet these headcounts.<sup>14</sup>

Food service personnel requirements for the different systems supporting the approximately 1.1 million troops in the TRADOC Standard Theater Level Scenario are shown in Table 4. The total food service manpower requirements of 68,076 food service personnel for the conventional system amounts to about 6.37% of the total force involved in the scenario. Since no food preparation is necessary with the T ration, only 30,685 food service personnel are required to operate the new combat system. This is a significant decrease of 37,391 from the number of personnel required for the conventional system, reducing the total food service personnel to only 2.92 percent of the theater scenario force.

It is important to emphasize that saving food service personnel was not the driving force behind the design of this new concept. Review of the future battlefields revealed that a highly mobile, flexible and responsive food service system, which could feed small, widely dispersed units, was essential, if high quality, hot meals are required to be delivered to the troops during combat operations. However, a major benefit of this new concept is that significantly fewer personnel are needed to operate the food service system. Therefore, the personnel savings, made possible by this more efficient system, can be invested into other priority requirements, when the new system has been developed and deployed.

In general, the personnel requirements for the T ration system represent a conservative high estimate. There are many activities required to operate a company kitchen other than food preparation, so allowances for necessary supply support and other efforts, such as set-up and relocation of kitchens, was included in the analysis of personnel requirements. The final determination of the accuracy of these estimates will have to depend upon future field evaluations.

An important dimension of this system and analysis design was to recognize the need for transitioning from the combat system, after a ceasefire, to base development operations, which would begin to approximate a peacetime garrison feeding system. To meet this need, it is recommended that the modular field kitchens, and food service units with supplemental equipment and shelters be consolidated into area kitchens, which can offer troops three hot

<sup>12</sup>Baritz, S., et. al., "The Camp Edwards Experiment in Battalion Level Consolidated Field Feeding," 76-45-OR/SA, US Army Natick R&D Command, Natick, MA: December 1975.

<sup>13</sup>Baritz, S., et. al., "The Camp Pendleton Experiment in Battalion Level Field Feeding," 7T-4-OR/SA, US Army Natick R&D Command, Natick, MA July 1976.

<sup>14</sup>US Department of the Army. Army Regulation 570-2: Manpower and Equipment Control, Organization and Equipment Authorization Tables - Personnel. Washington: 22 July 1969 (Changes 1-8).

**TABLE 4**

**FOOD SERVICE PERSONNEL REQUIREMENTS**

	<b>Cooks</b>	<b>K.P.'s</b>	<b>Total</b>
<b>Conventional System (A and B Rations)</b>	<b>38,308</b>	<b>29,768</b>	<b>68,076</b>
<b>New Combat System (T Rations)</b>	<b>21,144</b>	<b>9,541</b>	<b>30,685</b>
<b>Base Development System Consolidated Kitchens (A and T Rations)</b>	<b>25,752</b>	<b>16,595</b>	<b>42,347</b>

A or T ration type meals daily. As shown in Table 4, a total of 42,347 personnel are needed to operate the base development food service system, an increase of 11,662 in the staffing required for the new combat food service system. Since these personnel requirements are based upon a projected customer headcount of 100% of roster strength, which will decrease eventually to peacetime headcount levels, it is expected that they will be reduced accordingly. Therefore, this investment of almost 12,000 additional personnel in the base development food service will be of a temporary nature.

Fortunately, KP requirements can be met, immediately after the ceasefire, by assigning more personnel from the duty rosters. Subsequently, military KP personnel can be reduced consistent with the expected lower headcounts, ultimately to be replaced by civilian food service workers, as is now done in Korea and Germany. Those military units that remain dispersed in the field following the ceasefire should still be expected to perform their own KP duties.

The additional increment of 4,608 cooks that would be required to transition to the base development system present a more serious dilemma. If these cooks are not needed to support peacetime garrison meal headcounts, nor to operate the combat system, it makes little sense to carry them through many years of peacetime, just to be ready for temporary base development operations in an overseas theater after combat has ended. Other options, such as establishing a reserve force of cooks or temporary employment of civilian cooks, seem to be more expedient solutions. Continued use of the less labor intensive T ration menu during base development operations is another possible alternative, but this would add substantial operating costs.

An analysis of the peacetime garrison food service system was conducted to determine the cost of readiness in terms of food service personnel. The numbers of food service personnel required in garrison were computed using detailed headcount and personnel authorization data obtained from four Divisions in CONUS. The results were then prorated over the current estimated total Army strength to obtain the total estimates for each of the three systems. These results are presented in Table 5.

This analysis shows that with the current separate rations policies and dining hall headcounts, the conventional system requires the Army to retain 11,800 TOE cooks in peacetime just to be ready for mobilization. Since, logically many more years of peace rather than wartime can be forecasted, these personnel will be excess to garrison needs for many years. The cost associated with carrying these excess food service personnel during peacetime might better be spent in maintaining other combat ready forces during the same periods. The new combat system would require only 3,300 excess TOE cooks for mobilization purposes, which would result in a net reduction of 8,500 cooks from the readiness requirements.

The base development system, which follows after combat, would require another 2,300 cooks more than the new combat system, or a total excess of 5,600 cooks, which is still much less than required with the conventional system. However, staffing to meet the base development requirements does involve a relatively high cost during peacetime. Since these cooks would not be needed until cessation of the conflict, and then only temporarily, there should be sufficient time to recruit and train the necessary personnel, when required, rather than maintain them as part of the standing force.

TABLE 5  
ANALYSIS OF PEACETIME FOOD SERVICE PERSONNEL READINESS REQUIREMENTS  
(Current Estimated TOE Strength Army 530K)

	Estimated Daily Combat Rations	Number Of Cooks Authorized Wartime	Estimated Daily Peacetime Rations*	Number Of Required Cooks In Peacetime	Number Of Cooks Carried For Combat Readiness
Conventional System (A and B Rations)	530,000	19,000	122,500	7,200	11,800
New Combat System (T Rations)	530,000	10,500	122,500	7,200	3,300
Base Development System with Consolidated Kitchens (A and T Rations)	530,000	12,800	122,500	7,200	5,600

\*Data from the four divisions indicates that approximately 23% of the roster strength of 530K troops, both separate rations and rations in kind personnel, attend meals in the garrison dining halls. Attendance rates may be slightly higher if current attendance data from OCONUS installations is included, but cook requirements would not increase proportionately.

In summary, the personnel requirements have been defined for the new food service system and compared to the personnel needs of the existing system, both in combat and peacetime. The comparison shows that the Army can reduce its food service personnel requirements by 8,500 in a peacetime, and by 37,391 in the expanded mobilization as required by the theater scenario, if the recommended new system of combat feeding is developed and deployed. The issue of whether to carry an excess of 2,300 cooks during peacetime to be ready to support the temporary base development operations after combat ends, has been addressed, and it is recommended that these excess not be permanently retained in the TOE force. Other options are available to fulfill these requirements.

e. **Cost Analysis.** The existing and new combat food service systems were also compared on the basis of costs. Four major variables were involved in this analysis: the mode of system operation, the number of troops to be supported, the mix of rations served, and the food service staffing levels. Each system is analyzed in the combat mode, in the base development mode, and in the peacetime garrison mode of operation. Based on the TRADOC Standard Theater Level Scenario, approximately 1.1 million troops are to be supported in the combat and base development modes of operation. The number of troops to be supported in garrison corresponds to the current Army TOE strength of about 530,000 troops. The mix of rations in the combat mode of operations is 60 percent B and 40 percent MRE for the conventional system, and 60 percent T and 40 percent MRE for the new system. The base development and peacetime modes of operation envision one hundred percent A rations in both cases. Food service staffing requirements for each system were determined in the previous section of this report.

The comparative system costs presented are based upon the annual cost method. This method is most consistent with Government decision making because it emphasizes costs, and not return on investment. All major costs necessary to provide food service to the troops were included, although over 85 percent of the total system costs are related solely to food and labor, and the results are relatively insensitive to other costs factors, such as equipment and supplies.

The question of how to treat military KP labor costs was resolved by deciding to charge these costs to each system based upon the amount of KP labor required. Even though a savings of KP labor does not always result in an actual cost savings to the Army, it does represent a real cost reduction to the food service system.

The total estimated annual costs for each system are included in Table 6.

Under the combat mode of operation, the total annual operating cost of the new food service system is approximately 166-314 million dollars less than the conventional system. This means that the increased costs of the T ration is more than compensated for by the consequent reduction of labor costs. During the base development mode of operations, the new system would reduce the total annual cost of food service by approximately 484 million dollars. This savings is achieved by the reduction of 25,729 food service personnel within the theater made possible by operating consolidated or area kitchens. Also, since both of the systems will primarily use A rations in this mode of operation, there is no cost penalty

**TABLE 6**  
**ANNUAL SYSTEM COSTS (M\$)**

Type of Operation	Existing System	New System
Combat (1.1 M troops)	2973 M (60B/40 MRE)	2659 M – 2807 M <sup>2</sup> (60% T or T-Aug/40% MRE)
Base Development (1.1 M troops)	2791 M (100% A)	2307 (100% A)
Peacetime <sup>1</sup> (530K TO&E troops)	320 M (100% A)	177 M (100% A)

<sup>1</sup> Food service personnel costs only.

<sup>2</sup> The 2807 M system cost includes additional food costs for a T ration augmented with salads, soup, and cereal.

assigned for the use of T rations, as above. Finally, the annual operating cost of the new system in peacetime is 143 million dollars below the cost of the conventional system, which is directly attributable to a reduction of 8,500 food service personnel that are excess to garrison headcounts in the conventional system, but are carried during peacetime for readiness purposes. Since this is an annual savings, that will accrue for the many more years of peace than war, this savings can escalate to over a billion dollars during ten years of peacetime.

In summary, this cost analysis shows that the new system of food service offers considerable cost advantages over the conventional system. The annual savings in operating costs with the new food service system in the combat and base development mode of operations, supporting 1.1 million troops, and in the peacetime mode of operations, supporting 530,000 troops, are substantial. The issue of whether reductions in personnel requirements are real savings, or whether these spaces should be allocated elsewhere to improve the combat effectiveness of the force is a subject best addressed by those most familiar with overall Army objectives and needs. Regardless of how this issue is settled, the significant potential reduction of manpower within the food service system is of considerable value to the Army, and presents an opportunity to save millions of dollars annually.

f. **Logistics.** One final comparison that is highly relevant, is to determine the potential logistical impact of the new combat food service system relative to that of the existing system. Some concern exists regarding the apparent increased burden of the higher weight and cube of the T ration and the added volume of disposables on available transportation and shipping, that may already be taxed to the limit by the other highly critical supply demands.

The situation investigated was selected so as to reveal the greatest differences between the operations of the two systems, under conditions that required the maximum of logistical support. It was assumed that the existing system would be operating nonconsolidated company level kitchens with B/MRE rations in the conventional manner; and, that the new system would be providing T/MRE rations from the Food Service Units and Modular Field Kitchens, also in a nonconsolidated mode of operation. In the latter case, only disposables are used in the divisions, and in corps and COMMZ areas, meals are served on permanent, reusable plastic trays that must be washed after each use.

Detailed estimates of the daily supply requirements were calculated for each system — rations, bread and bread ingredients, fuel, water, disposables and expendables, i.e., dishwashing compounds, scrapers and brushes — as would be necessary to support the total 1.1 million troops in the theater, which are summarized in Table 7. The corresponding shipping and transportation resources required to deliver and distribute these supplies to the theater were then determined, as shown in Table 8.

Based on these results, there are moderate differences in the shipping requirements into the theater, due to the higher weight and cube of the T ration and the added load of disposables, amounting to the equivalent of about one nominal shipload every three weeks for the total force of 1.1 million troops. These differences, however, are more than counterbalanced by the overall reduction in intratheater transportation, when water requirements are considered. The incremental increase in the number of intertheater semi-trailer trucks for the T rations

TABLE 7

SUMMARY OF DAILY SUPPLY REQUIREMENTS

Supply Item	B/MRE	T/MRE
Rations, ft <sup>3</sup>	182,913	204,563
Bread Ingredients, tons	121.8	120.1
Bread Product, tons	172.1	169.6
Water, gallons	3,689,214	1,791,092
Fuel, gallons		
- Mogas	275,813	35,026
- Diesel	169,536	189,650
Disposables, ft <sup>3</sup>	-	7,901
Expendables, ft <sup>3</sup>	946	704

**TABLE 8**  
**DAILY SHIPPING AND TRANSPORTATION REQUIREMENTS<sup>1</sup>**

Supply Items	B/MRE			T/MRE		
	Number Of Semi-Trailer	Trucks Fuel	Nominal Shiploads <sup>2</sup>	Number Of Semi-Trailer	Trucks Fuel	Nominal Shiploads <sup>2</sup>
Rations	173.1	-	0.306	191.0	-	0.342
Bread Ingredients	4.6	-	0.009	4.6	-	0.009
Bread Products	23.9	-	-	23.6	-	-
Fuel	-	65.4	-	-	32.6	-
Disposables	-	-	-	8.9	-	0.013
Expendables	0.8	-	0.002	0.5	-	0.001
<b>Total</b>	<b>202.4</b>	<b>65.4</b>	<b>0.317</b>	<b>228.6</b>	<b>32.6</b>	<b>0.365</b>

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**NOTES:**

<sup>1</sup> Plus 9,223 trailer loads of water with the B/MRE rations, and 4,478 trailer loads with the T&MRE rations.

<sup>2</sup> Equal to 597,600 ft<sup>3</sup>.

and disposables is more than compensated for by a corresponding reduction in fuel trucks. In effect, the number of trucks in both systems are nearly the same, but there is some change in the allocation of supply effort by the type of vehicle required. If water transportation requirements are considered in terms of the total volume of supplies, the new combat food service system is clearly the most advantageous, since a reduction in the transport of 2 million gallons of water per day can be achieved. Also, since fuel is a critical supply item to the highly mobile combat force, the reduction of at least 220,000 gallons of fuel per day which can be attained with the new system further substantiates the potential logistic advantages of the new system. In addition, if the assumption of pipeline delivery of fuel, which was used in this study, is relaxed, and over ocean shipment of fuel is necessary, the overall logistic advantage of the new system is even more significant.

g. **Interim System.** Near the end of this study, an awareness developed of the rather urgent need for immediate improvements in combat feeding to be consistent and compatible with the broad changes in organization, weapons, tactics and doctrine that are planned to occur during the next five or six years. This new combat food service system proposal is only in the concept formulation stage. A considerably longer period than another five years will probably be required to obtain the approvals for, and to complete a development program, to the point of fielding a fully approved, type classified system. However, it would be possible to make sufficient progress toward this goal, in a relatively shorter time, such that an interim system with many of the same capabilities and advantages of the new concept, can be available, which should provide for a satisfactory alternative until the new system acquisition process is completed.

The key components of the interim system are a limited T ration menu, a modification of the standard Mobile Kitchen Trailer (MKT), and an early version of the Modular Field Kitchen. Very briefly, the concept of operations would be as follows:

a. Companies in the Divisions and actually engaged in combat, or companies requiring high mobility would use the MKT, T ration and disposables to provide for hot meals at the company level. When these companies are not engaged in combat, and in a secure area or after ceasefire, food service operations would be consolidated at battalion level, with two trailers and a sanitation center, and using T and/or A rations.

b. Units located in the corps and COMMZ areas, would use the Modular Field Kitchen and a supplemented T ration menu, when larger kitchen operations would be vulnerable targets and/or logistics constraints prevent the introduction of A rations. Otherwise, unit kitchens can be combined into area kitchen operations as circumstances permit, or after combat ceases.

c. All troops will subsist on individual combat rations whenever hot meals cannot be delivered, or else are not available.

The interim system defined above can meet or exceed the minimum standard of one hot meal daily in combat, if conditions permit, while significantly reducing the food service personnel requirements and providing for some increase in responsiveness, as compared to the existing combat feeding system.

Development time should be minimal. The MKT is now being procured in quantity, and only minor equipment adjustments are required to accommodate the T ration. The Modular Field Kitchen is an adaptation of the standard Marine Corps M-75 system which was tested in FY 76.<sup>15</sup> Within the next year, it is expected that the variety of commercially available tray pack food items, along with the new items of this kind that can be developed at NARADCOM, will be adequate to establish the basic T ration menu. If this is the case, and the system is acceptable to the Army, it can probably be type classified on an urgent basis, and be ready for procurement and fielding within 3 years from the start of development.

#### 4. FINDINGS.

a. The existing system for providing food service during combat would experience considerable difficulty operating in the future conflict environment. This system, which evolved from World War II experience, still relies on delivering of A and B ration ingredients to the company level kitchen, where the food is prepared and cooked, and meals are either served at the kitchen site, or transported in insulated containers to remote troop locations for consumption. The associated sanitation operations are labor intensive, usually very demanding of transportation requirements, and are generally inadequate and ineffective. The missions on the new battlefield, which require more than fifty percent of the combat troops to be assigned to and operating with highly mobile task forces, requires a new system which can provide quality food service whenever the opportunity exists. This necessitates a capability to heat food on the move, and to serve meals immediately upon arrival. The current system simply cannot consistently and effectively, perform to these mission requirements. Therefore, the frequency with which hot meals can be delivered, with the conventional system in this situation will be minimal. Under these circumstances, it can reasonably be predicted that food service in the combat zone will consist almost totally of individual operational rations for extended periods of time.

b. Significant recent advances have been made in the state-of-the-art of thermostabilizing processes and packaging of food products, which can provide shelf stable, prepared foods of high quality which can be heated and served directly from the container. There are three particular characteristics which make these products excellent candidates for inclusion in a new Army combat food service system. Since they are completely prepared, and ready for serving from the package after heating, most of the time consuming labor of meal preparation is eliminated at the site of consumption. The products are potentially equal in quality to preprepared frozen products, which have achieved high consumer acceptance in today's market place. Finally, being shelf stable products, they are amenable to storage and do not require special handling or maintenance during shipping thereby simplifying combat logistics requirements.

<sup>15</sup> Kulinski, M., Smith, R., and Stefaniw, I. **A Cost and System Effectiveness Analysis of the XM-75 and XM-76 Field Feeding Systems for Marine Corps Divisions.** Technical Report 7T-10-OR/SA. Natick, MA: US Army Natick R&D Command, July 1976.

c. With appropriate food and equipment developments, a new combat food service system can be made available to meet the mission requirements, that can also provide the benefits of reducing logistic problems, and increasing food service efficiency.

d. Commercial development of these new food products is progressing at an accelerated rate. There are now more than six suppliers of these foods, and more than thirty five different food products available on the market. Further and continued expansion of the number of producers and products can be expected. The advanced position of NARADCOM relating to this technology, based upon their previous flexpack development efforts and experience, provides yet another opportunity to accelerate food products developments that will be necessary for system testing and deployment.

e. There are no equipment or anticipated equipment developments, in the military or industry, which satisfy the specific requirement for heating and serving the new rations in combat. Concepts of these equipments are defined herein. Because of the relatively simple design requirements, it is expected that the equipment development efforts can be accomplished expeditiously.

f. There are certain equipments in the Army inventory, or now being considered for development, which can be effectively used in the modular field kitchen, perhaps with some modifications, which could also be accomplished in an expedited manner.

g. The recommended new system could reduce food service staffing requirements by 37,391 cooks and personnel, in the TRADOC Standard Theater Level Scenario, and save about 8,500 Army cooks now carried as excess during peacetime for readiness purposes.

h. The annual operating costs for the new system during combat are 166-314 million dollars less than for the current system. The savings of labor costs associated with the use of the T ration more than balances the increased cost of the food. The annual operating costs during base development are approximately 484 million dollars less per year. This reduction is a result of the conversion from company kitchens to large battalion or area kitchen operations, and the use of A ration menus, which are less costly than the convenience foods used during combat. Finally, the annual costs of the current garrison food service system, operating during peacetime, can be reduced by 143 million dollars per year if the new combat system is adopted, because of the possible reductions in excess cooks retained in TOE units for readiness purposes.

i. With the new combat food service system, there is a modest increase in the shipping requirements for supplies delivered into the theater, but a very significant potential for reducing the total transportation required to distribute supplies within the theater. The volume of water consumed is reduced by 2 million gallons per day, and the more critical fuel requirements are at least 220,000 gallons less per day, with the new system. All of these factors, considered together, clearly indicate the obvious logistical advantages of the new system concept.

## 5. RECOMMENDATIONS.

a. Development and evaluation of an interim system, based on the new concept, be expedited to provide the necessary capabilities to satisfy the urgent requirements for improvements in combat food service that are evolving in conjunction with the extensive programmed changes in the Army force structures and weapons during the next few years.

b. The proposed new combat service system be approved for continued research and development under AR 70-1, and all other related regulations and directives.

c. That research, development, testing and evaluation be conducted on a total system basis, and not for the individual components of the system. Since the various components are interdependent, and interact to affect the performance and efficiency of the system, their separate development may produce less than optimal results. Therefore, numerous evaluations, trade off and cost analyses will be necessary during the development cycle. Another important consideration is that major changes in food service doctrine, training and logistics will be required, and must be developed in the context of the total system, rather than with respect to a component. All of these factors support the recommendation for a total system development.

d. The new food service system be designated a nonmajor system paragraph 2.5, AR 70-1, for purposes of development. The new system will necessitate broad changes in the way the Army feeds troops in combat, and may have an impact equivalent to that of a new weapons system, or major change in combat tactics. Therefore, it is considered essential that it be subjected to the same coordination and approval process as any other nonmajor system development. Army involvement in the project to this extent, should also provide the long range commitment and support necessary to completely develop and field the new system.

e. Research and development continue in the Conceptual Phase (6.2, Exploratory Development) until the feasibility of the concept is proven through field experimentation. Transition from the Demonstration/Validation Phase (6.3, Advanced Development), into the Full Scale Development Phase (6.4, Engineering Development) also depends upon successful field tests. Many assumptions and best estimates were used in developing the final system recommendations. These must be reduced to a minimum, by concept evaluation, before progressing to full scale development of the system can be justified. Further, the data are needed to verify the projected performance and efficiency of the new system concept, before considering and initiating any of the major changes in foodservice doctrine organization, etc., that would be necessary for system deployment.

f. A master plan be developed which will identify, schedule and cost all major conceptual, validation and development activities required to deploy this new system. This master plan will provide the basis for the Acquisition/Development Plan, required by AR 70-27 for the transfer from exploratory development into advanced development.

g. Efforts be initiated to plan and conduct concept evaluation. System evaluations will be accomplished with experimental prototypes, paragraph 2.14 (1), AR 70-1, while in the

Conceptual Phase (6.2), directed towards reducing technological uncertainties; proving concept feasibility by providing information relating to consumer acceptability, personnel staffing levels, and the operational effectiveness of the concept under simulated combat conditions; and, to obtain data for improved cost estimates. Further development and operational testing will be scheduled, as required, during full scale development.

h. Prepare and coordinate a Letter of Agreement (LOA) to outline the investigations needed to validate the system concept and to further define the operational, technical and logistics concepts necessary to proceed into Full Scale Development. The LOA, and the following advanced development results, form the basis for the system Required Operational Capability (ROC) that will be needed for entering into the Full Scale Development Phase. This action should be scheduled so that approval of the LOA can be obtained immediately after the results of the concept evaluation are available, so that advanced development can begin without interruption.

## APPENDIX A

### TECHNICAL PLAN AND RELATED DOCUMENTS

1. The approved revised technical plan, dated 11 November 1977, for the analysis and design of long-range concepts of food service systems for the Army in the field is presented as Annex 1. This version of the technical plan specifies the latest requirements of a phased multi-year effort by the Operations Research and Systems Analysis Office directed towards improving the effectiveness and efficiency of Army combat and field feeding systems and operations. In particular, the revisions incorporated into this plan were to accelerate the schedule for completion of this report, to allow for timely decisions necessary to insure the continuity of the research and development program required to implement the preferred system concept.
2. A copy of the current Memorandum of Understanding between the US Army Quartermaster School and the US Army Natick Research and Development Command, Annex II, delineates the roles and interfaces of the user and developer communities in those areas relating to subsistence, equipment, shelters and other aspects of field feeding systems. This Memorandum has been reviewed and continued, without modification, on two separate occasions since it was originally signed on 10 February 1976, and most recently in August 1978. Of particular interest is Appendix A, which defines the characteristics which should be included in the Army field feeding system for the 1985-95 time frame. This document provided the basic guidelines for developing the concepts described in this report.
3. In addition, there are a number of assumptions that are basic to this analysis, which are specified in TRADOC ATCD-S-A Message 112144Z Jul 78, Subject: Army Field Feeding Study Assumptions, included as Annex III.

ANNEX I TO APPENDIX A

TECHNICAL PLAN

SERVICE REQUIREMENT: JSR AM 3-1 (APPENDIX I)

TITLE: FOOD SERVICE SYSTEM FOR THE ARMY IN THE FIELD

LEAD LABORATORY: Operations Research and Systems Analysis Office

MSR/JSR MANAGER: Gerald Hertweck

PROJECT NO. & TITLE: ILI 62724AH99A Analysis and Design of Military Feeding Systems

TASK(S) NO.(S) & TITLE(S): AD, Long Range Studies of Military Feeding Systems

FUNDING CATEGORY VERIFIED: \_\_\_\_\_ DATE: \_\_\_\_\_

REVISIDN & DATE: 11 November 1977

APPRDVAL LEAD LABORATORY: ROBERT J. BYRNE  
Chief, OR/SA Off. *RJ Byrne* 23 NOV 1977  
Name & Position Signature Date

JTS REVIEW: JARRETT L. KENYON, LTC,  
USA REP, JOINT TECH STAFF *Jarrett Kenyon* Jan 78  
Name & Position Signature Date

SERVICE APPRVAL: JARRETT L. KENYON, LTC,  
USA REP, JOINT TECH STAFF *Jarrett Kenyon* Feb 78  
Name & Position Signature Date

I. REQUIREMENT INFORMATION:

- A. SUBMITTING SERVICE: Army DATE SUBMITTED: \_\_\_\_\_
- OTSG DATE SUBMITTED: \_\_\_\_\_

B. STATEMENT OF REQUIREMENT:

A critical need exists to significantly reduce the number of personnel engaged in support of the Army's field feeding system. This savings must be achieved without degrading the quality of meals served in a combat theater as well as in training. A need also exists to develop a food service system that will be compatible with existing modular field hospital equipment while simultaneously improving the level of dietary food service for these medical treatment units in direct support of divisional units.

## II. REQUIRED RESOURCES:

### A. IN-HOUSE PROFESSIONAL MANYEARS

(Figure no longer applicable)

### B. FUNDING (IN Thous \$)

#### 1. In-House

(Figures on longer applicable)

## III. PLANNED ACTION:.

### A. MAJOR OBJECTIVE OF TASK(S):

To define new technology alternative field feeding systems for the Army (to include medical and non-medical units) for use by the 1990 time frame. The primary objectives of this effort is to define and analyze feeding systems which will allow the Army to achieve significant reductions in the number of food service and K.P. personnel required to operate the system while maintaining or improving the quality of meals and increasing the frequency of hot meals served to troops in combat and training.

The following will be accomplished:

1. Characterization of the battlefield (European Scenario) based upon the new Army Division Restructuring concept in terms of troop or unit location, troop densities, troop dispersion and number of troops assigned to Wheeled or Tracked vehicles. This characterization will include the COSCOM rear area as well as the combat areas.

2. Based upon the dispersment of troops as determined (1) above, develop the total food service resource package, (i.e., food, water, workers, equipment, etc.) necessary to sustain all the troops on the battlefield. This will be developed for the standard conventional system and the feeding system as envisioned in the DRS concept.

3. Alternatives to the current field feeding systems will be identified based upon the characterization of the battlefield and the results from already completed technology surveys in food processing, preservation, packaging, and food service equipment, and the specialized feeding requirements of all Army troops in the overseas theater including field medical units.

4. The impact of each alternative considered upon the requirements of the garrison and field training feeding systems will be identified.

5. Based upon a systems analysis of the alternatives and comparison of the alternatives to the standard and proposed DRS systems the "preferred" system will be established and defined. The cost and operational effectiveness of the new alternative systems under combat conditions and under peacetime conditions will be established.

6. Prepare a technical report which incorporates the detailed analysis performed, provides detailed description of the preferred system, and establishes R&D requirements necessary to pursue final adoption and implementation.

### B. DETAILED TECHNICAL APPROACH:

The technical approach will be accomplished as follows:

#### 1. Force Structure Characterization

The proposed force structure for the European Scenario will be re-analyzed based upon the new Division Restructuring Concept. The dispersion of unit troops, and vehicles on the battlefield will be identified and recorded. The information on Division combat forces will then be used to create a COSCOM and the dispersion of units, troops, and vehicles within the COSCOM will be identified and recorded. For field hospitals and other field medical units establish the type and frequency of special diets, expected, the patient evacuation policy, expected number of ambulatory to non-ambulatory patients, and other requirements which will impact upon the feeding system for field medical units.

#### 2. Feeding System Characterization

Using the information from (1) above the entire feeding system required to support all the troops on the battlefield will be identified and located

on the battlefield. This should include all food service and related supply resources. Such things as types and numbers of rations, types and numbers of food service personnel, numbers of food service vehicles, controlled and non-controlled storage, and distribution centers will be identified, recorded and located on the battlefield. Two base line systems will be characterized. Both the standard company level system with MKT's and/or M1948 kitchen shelter and the Division Restructuring Concepts with consolidation will be characterized. These two systems will be analyzed and documented as to the amount of food service resources (food, people, equipment, etc.) necessary to support all of the dispersed troops. This documentation will be used as the baseline against which the new alternative systems are compared to.

### 3. Define Alternatives

Based upon forecasts of what improved or new food, packaging, and equipment capabilities can be made available to the Army in the 1990's and what is needed to support Army troops on the recorded scenario develop standard alternative field feeding menus and menu policies which would be consistent with the required level of combat and support activities. Concurrent with developing these menus and menu policies, develop and define alternative concepts of supply, transportation, food preparation, sanitation and disposal. Combine all of the subsystem alternatives into total system alternatives for the various units and sectors of the battlefield.

### 4. Systems Analysis

Establish evaluation criteria, develop model and methodology for analysis, perform cost and systems effectiveness analysis of alternative field feeding systems, including cost to maintain field feeding systems under peacetime or garrison environment. Based upon this cost and systems effectiveness analysis select the "preferred" system(s) and completely define the system.

### 5. Reports

Prepare and submit an initial report in January, 1979 summarizing recommendations for solution of the long range field feeding problems, including an evaluation of the combat feeding requirements, a description of the preferred system concept and the anticipated mode of operations, and an analysis of performance, effectiveness, costs and benefits of the recommended system as compared to the baseline systems. This report should be sufficient to permit staffing by the Army for a decision as to whether or not to proceed with research and development of the proposed system concept.

A final report will be prepared and submitted following the conclusion of this total effort which will completely document in detail, the systems and cost effectiveness analyses and recommendations, as well as the results of a comprehensive investigation of the garrison/field feeding interface and the impact of the new system concept on logistical considerations, particularly with respect to stockpiling of rations. In addition, the report will define the research and development requirements and program necessary to achieve and implement the system in the 1990 decade.

C. INDIVIDUAL WORK UNITS AND OBJECTIVES:

1. AD 032

Objective: Define a new field feeding system for the Army capable of implementation in the 1990 time frame which significantly reduces the number of food service and K.P. personnel required to operate the system while maintaining the quality of the meals and improving the frequency of hot meals provided troops in combat. The "preferred" system will be established based upon a cost and systems effectiveness analysis of the most promising alternatives identified.

2. AD 033

Objective: Provide the necessary technical support in food processing, preservation, packaging, and food service equipment to define, develop and evaluate alternative concepts as required.

D. APPLICABILITY TO RELEVANT ON GOING EFFORT

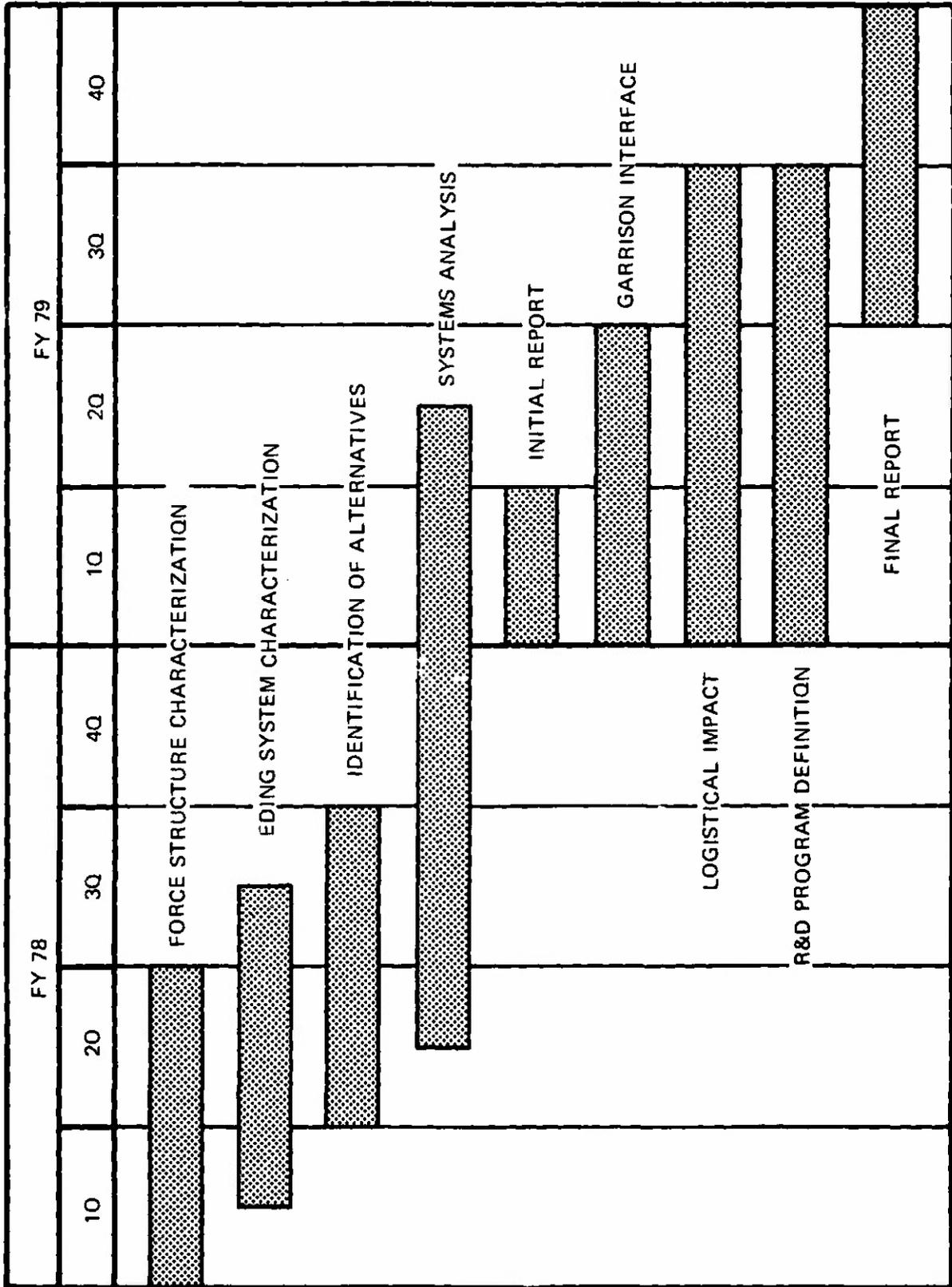
E. TIMELINED MILESTONE CHART: See Attached Figure

IV. REVIEW, REPORTING, TESTING, AND EVALUATION

A. METHOD OF REPORTING PROGRESS TO SERVICE AND JTS:

1. 1498's
2. Annual Research Evaluation
3. Reports and JFB Meetings
4. Informal Reports to JTS Upon Request
5. Informal and Formal Briefings as Required
6. Technical Report

MILESTONE SCHEDULE



**ANNEX II TO APPENDIX A**  
**MEMORANDUM OF UNDERSTANDING**  
**DEFINING SYSTEM CHARACTERISTICS**

Memorandum of Understanding  
between  
the United States Army Quartermaster School  
and  
United States Army Natick Research and Development Command

PURPOSE

The purpose of this Memorandum is to provide a basis of understanding between the US Army Quartermaster School (QMS) and the US Army Natick Research and Development Command (NARADCOM).

SCOPE

The document clarifies/amplifies the interfaces between and the respective roles of QMS as representing the User (The Army in the field) and NARADCOM as the developer in all areas of mutual interest including but not necessarily limited to subsistence, food service equipment, field service equipment, shelters and aerial delivery equipment.

EFFECTIVE DATE

This Memorandum will go into effect upon signature of both parties.

PERIODIC REVIEW

This Memorandum will be reviewed within six (6) months after the effective date and annually thereafter to determine whether it will be continued with or without modification or terminated. This Memorandum will expire one (1) year from the date it is signed unless renewed prior to that date. Amendments to this Memorandum must be signed by both parties.

COORDINATION REPRESENTATIVES

A. For the purpose of coordination and matters of policy and procedure pertinent to the interface between QMS and NARADCOM, the principal points of contact are:

- (1) QMS - Director, Combat Developments, ATTN: ATSM-CD
- (2) NARADCOM - Chief, Engineering Programs Management Office, ATTN: DRXNM-E

B. The office of record and point of contact for this Memorandum after signature will be:

- |   |   |
|---|---|
| (1) QMS:<br>Directorate of Combat Developments<br>ATTN: ATSM-CD-M | (2) NARADCOM:<br>Comptroller<br>Management/Force Development Division<br>ATTN: DRXNM-CM |
|---|---|

## CONCEPT

NARADCOM, in order to establish a technological base, define new systems and develop and/or improve materiel to meet the needs of the Army in the field requires guidance from the QMS. Such guidance in the form of doctrine, goals and objectives will be appended to this Memorandum. Appendices will be added, amended and updated through joint coordination and signed by Director of Combat Developments, QMS.

### A. INTERFACES

1. QMS and NARADCOM will hold semi-annual meetings to discuss such things as long range goals, doctrine, program status, etc. An agenda will be formulated by the host agency and coordinated with the invitee. Host for these meetings will alternate.

2. In order to maximize the effectiveness of this Memorandum, direct contact between QMS and NARADCOM personnel is encouraged.

### B. RESPONSIBILITIES

#### a. Quartermaster School

(1) The school will provide NARADCOM with up-to-date information on logistical doctrine to include, but not be limited to, manuals and pertinent studies completed by TRADOC which impact on the areas covered by this Memorandum.

(2) The school will submit, through TRADOC, requirements which provide the detailed guidance on materiel developments and studies which support doctrine for the Army in the field.

(3) The school will assist NARADCOM, on request, in preliminary preparation of technical plans for the DOD Food RDT&E Program.

(4) The school will review technical plans as received from NARADCOM to insure they are compatible with the needs of the Army in the field.

#### b. NARADCOM

(1) NARADCOM will inform the school on a timely basis of technical developments, changes to milestones, and DOD and other service actions of interest.

(2) NARADCOM will consider the appendices to this Memorandum when preparing technical plans.

(3) NARADCOM will update the QMS, on request, of advances in technology.

(4) NARADCOM will assist the QMS in formulating requirements in accordance with the DARCOM-TRADOC Materiel Acquisition Handbook.

c. Joint

(1) Standardization of equipment with allied nations will be considered by both the Quartermaster School and NARADCOM in performing their materiel acquisition responsibilities.

(2) There will be a high degree of action officer coordination on all projects.

DEAN VAN LYDEGRAF  
Major General, USA  
Commandant  
US Army Quartermaster School

RUFUS E. LESTER, JR.  
Colonel, QMC  
Commander  
US Army Natick Research and Development  
Command

DATE: \_\_\_\_\_

DATE: \_\_\_\_\_

## APPENDIX A

### ARMY FIELD FEEDING CONCEPT 1985-1995

The Army field feeding system for the 1985-1995 time frame should provide a mix of hot meals and operational rations consistent with the type and intensity of combat.

The following are characteristics which should be included in the Army field feeding concept:

- a. The best possible ration will be provided in the field in accordance with resources available and the intensity of combat (location/situation in the theater).
- b. Labor and skill level should be minimized by using foods that greatly reduce field preparation effort (preferably cooked or heated in and served from the package).
- c. Availability of selected foods in sufficient quantity prior to and upon mobilization should be assured by using food processing and packaging techniques that have a high degree of acceptability and a high probability of being commercially available before 1985.
- d. A capability to prepare raw food must be maintained in field kitchens, to maximize the use of indigenous food supplies.
- e. The distribution system for the food prepared must include equipment which is a significant improvement over the current insulated food container and compatible with associated transport equipment.
- f. The quality of sanitation, supported by training, supplies and equipment, must be an integral element of all feeding situations. Resources to accomplish sanitation should be significantly reduced.
- g. System responsiveness should be increased so that lead time between preparation and service is greatly reduced.
- h. Mobility characteristics should be compatible with the force supported.
- i. Equipment at the company level should be limited to heat and serve. Equipment must also be capable of heating water as well as food.
- j. Heat-and-serve capability in life support systems of selected combat vehicles should be considered.

k. Field food service equipment must use energy sources expected to be available in 1985-1995.

l. Refrigeration should be available where required. Non-mechanical refrigeration should be considered.

H. F. PENNEY  
Colonel, QMC  
Director of Combat Developments  
USA Quartermaster School  
Date: \_\_\_\_\_

**ANNEX III TO APPENDIX A  
TRADOC MESSAGE SPECIFYING  
BASIC STUDY ASSUMPTIONS**

PCD Food

NAME \_\_\_\_\_  
DATE/TIME \_\_\_\_\_

12 JUL 78 12 16 z

COMM/DEM

RATZYH/RUCLA1A9512 1932145-0000--RUCBNTA;  
INFO SOURCE  
RUCBNTA 1447 JUL 78  
FM CDR TRADOC FT MONROE VA//ATOD-S-A//  
TO RUEBAGA/COMDT GMSCH FT LEE VA//ATSM-CC-C//  
INFO RUEADND/CA WASH DC//CALD-5/CASG-TAE-T//  
RUEBAGE/CDRUSALBDC FT LEE VA//ATCL-C//  
RUCBNTA/CDRUSANARACOM NATICK MA//DRDNA-ZF//  
RUEBAGG/CDR USATSA FT LEE VA//CALD-TAE-T//  
RUEBATA/SLPT ARE FT SAN HOUSTON TX//HSA-CB//  
BT

UNCLAS  
SUBJECT: ARMY FIELD FEEDING STUDY ASSUMPTIONS  
1. MSG, ATSM-CC-C, USACMS, 021352Z JUN 78, SAB;  
2. THE FOLLOWING ARMY FIELD FEEDING STUDY ASSUMPTIONS HAVE BEEN  
STATED AND CONCURRED IN:  
A. THE NEEDS OF THE COMBAT FIELD FEEDING SYSTEM WILL DRIVE  
THE REQUIREMENTS FOR FIELD FEEDING SUBSYSTEM WHETHER USED IN  
OPERATION OR IN TRAINING;  
B. THE ACTUAL NUMBERS AND LOCATIONS OF UNITS AND TROOPS IN  
THE THEATER OF OPERATIONS WILL BE BASED ON THE NUMBERS AND  
LOCATIONS CALLED FOR IN THE TRADOC STANDARD THEATER LEVEL SCENARIO;

PAGE 2 RUCLA1A9512 UNCLAS  
THE NUMBERS AND LOCATIONS OF UNITS AND TROOPS IN A CORPS AREA WILL  
BE BASED ON THE TRADOC STANDARD SCENARIO, EUROPE 1, SEQUENCE 2A,  
WHICH IS COMPATIBLE WITH THE THEATER LEVEL SCENARIO FOR THE FIRST  
12 DAYS OR A REVISION OF THIS SCENARIO, SUBSEQUENT WHICH WOULD BE  
MORE APPLICABLE; THESE FORCES WILL BE EXTRAPOLATED TO A 1984  
FORCE STRUCTURE USING FY 84 PROGRAM FORCES, THIS FORCE WILL  
BE USED TO REFLECT THE 1985 FORCES AND IS THE BEST AVAILABLE  
INFORMATION.

C. THE DEFINED SYSTEM WILL BE FLEXIBLE ENOUGH TO RESPOND TO  
ANY SCENARIO; HOWEVER, THE USE OF THE TRADOC STANDARD  
THEATER LEVEL SCENARIO WILL BE SUFFICIENT TO DEVELOP THE COST AND  
EFFECTIVENESS COMPARISONS OF THE NEW SYSTEM.

D. IN THE ARMY OF THE 1990S, THE PREPONDANCE OF INFANTRY  
IN EUROPE WILL BE MECHANIZED; THOSE TROOPS CARRIED ON AND  
FIGHTING FROM ARMORED VEHICLES WILL BE DIRECTLY ASSIGNED TO THE  
VEHICLE AS TEAM MEMBERS, DISMOUNTED OPERATIONS WILL REMAIN A  
VALID REQUIREMENT DURING THIS TIME PERIOD;

E. THE ARMY FIELD FEEDING SYSTEM MUST BE CAPABLE OF DEALING  
WITH HIGH INTENSITY COMBAT;

F. AFTER A CEASE FIRE, THE THEATER FEEDING SYSTEMS WILL

PAGE 3 UNCLAS UNCLAS

TRANSITION FROM A COMBAT SYSTEM TO A BASE DEVELOPMENT SYSTEM;  
EVENTUALLY, THIS BASE DEVELOPMENT SYSTEM MAY TRANSITION TO A  
FULL GARRISON TYPE SYSTEM;

G. A SINGLE MINIMUM STANDARD OF SUPPORT WILL PREVAIL THROUGHOUT THE THEATER, THIS MINIMUM STANDARD WILL BE ONE HOT MEAL EACH DAY FOR ALL PERSONNEL WHENEVER COMBAT CONDITIONS AND SITUATIONS PERMIT;

H. FOOD SERVICE OPERATIONS WILL BE CURTAILED IN ANY NBC CONTAMINATED AREA;

I. NO HOST NATION SUPPORT WILL BE CONSIDERED;

J. A WATER DISTRIBUTION SYSTEM IS NOT A FUNCTION OF THE FOOD SERVICE SYSTEM AND WILL BE ADDRESSED IN A SEPARATE TRADEOFF EFFORT;

K. THIS STUDY WILL NOT BE RESTRICTED BY CURRENT TOE AND FOOD SERVICE MANAGEMENT STRUCTURES;

L. POC THIS ACTION IS MAJ J. F. YOHMAN, AUTOVON 688-3477;

BT

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NNNN

## APPENDIX B

### SCORES ANALYSIS

1. **INTRODUCTION.** The TRADOC Standard Scenario, Europe 1, Sequence 2A (1977-78), provided the basic frame of reference for determining Army combat feeding requirements in future conflicts. Data derived from the SCORES analysis of this scenario were used to establish the troop composition and distribution, i.e., strength, locations and density, in each area of the theater. Given this information, and a general understanding of the modes of operations of the different military units in these areas, feasible approaches to food service in this environment are characterized in this Appendix. Subsequently, food, equipment and other technologies were projected to define the specific alternative system concepts evaluated.

2. **DIVISION FORCE ANALYSIS.** In the Theater Level Scenario, the battle area is expected to be a very dynamic environment, with rapid and frequent changes in troop dispositions. Mobility will be a key attribute of the combat force. Large numbers of small, mechanized combat teams will comprise a significant part of the troop population, requiring food service.

Army combat divisions are, at present, structured according to the H-series Tables of Organization and Equipment (TOE). It may be, however, that at some future time, the force will be comprised of divisions with smaller, but more combat battalions, depending on the outcome and decisions with regard to the current Division Restructuring Evaluation (DRE). These divisions are described by a T-series TOE. Therefore, the crew/team and other force analyses will consider both types of divisions.

For this purpose, a crew is defined simply as the troops assigned as operators and/or combat teams to a vehicle that may be engaged in active combat, e.g., the four members of a tank crew. Teams are small units of troops that operate in various combat roles, detached from their main organizational elements, such as the NBC Decontamination Teams or the Reconnaissance Teams. This analysis is to establish the number of crews/teams within a nominal division as an indicator of the importance and magnitude of the associated crew/team feeding requirements.

It is assumed that:

(1) Recovery vehicles allocated to combat and combat support units in the forward areas have crews consisting of two operator personnel.

(2) All recovery vehicles authorized the maintenance units are not considered as combat vehicles, by the above definition.

(3) The only personnel assigned to Carrier Command Post vehicles designated as combat vehicle crewmen are those with the Armored Cavalry Squadron.

The TOE of each division unit was reviewed to determine the number of authorized combat vehicles and their crew sizes, and the number and sizes of any other combat teams, with the

informed and expert assistance of personnel from the US Army Quartermaster School and the Combat Arms Project Branch of this Command.

The results of this effort are summarized in Table B-1, and the distributions of crew/team sizes for each division are presented in Table B-2. Based upon this analysis, it was observed that approximately 43% of the H-series division and nearly 46% of the T-series divisions are identified as crews/teams. Of these, 93% are associated with combat vehicles. About 72% of the crews/teams in an H-series division consists of 4, 5, or 11 persons, while 76% in the T-series division are composed of 4, 5 or 9 individuals. A large proportion of the crews in either type of division are associated with two specific combat vehicles; an average of 45% with the personnel carrier (D12087), and an average of 16% with tanks (V13101).

Under the conditions described, a total food service capability organic to the unit, with all of the attendant equipment, personnel and functions to be performed, cannot reasonably be considered. It may not even be possible to assure, with any high degree of confidence, that the desired stated goal of providing these personnel with at least one hot meal per day can be achieved with consistent regularity. Hot meals can be routinely delivered in conjunction with the planned cycle of resupplying water, ammunition and fuel. In this manner, combat performance and effectiveness will not be significantly affected by any additional delay for feeding, since the crew/teams generally are not functional during this period anyway. At other times, during a lull in combat or as other opportunities are presented, additional hot meals can be delivered on request. However, this will require the food service system to be highly responsive to the uncertainties of combat; that is, it must be able to provide these meals on short notice, and to effectively cope with those contingencies that may arise which prevent or delay prompt delivery of the meals. In other circumstances, the crews/teams will have to depend on the individual combat rations as the primary form of subsistence. For crews, a heating capability integral to, and powered by, the vehicle will allow for occasional substitution of a heated individual ration at those times when hot meals are not otherwise available.

The division area was subdivided into four regions — battalion, brigade, division rear and DISCOM — as indicated in the diagram in Figure B-1. Then, based on the SCORES placement of division units for the Europe 1, Sequence 2A Scenario, and the results of the crew/team analysis, the distribution of the remaining division troops within these regions was established, Table B-3.

More than 80% of the division crew/teams are located in the battalion areas, and these represent 61% of the total battalion area strength. Food service requirements for the other battalion troops are essentially the same as for the combat teams, in that they will have to subsist on individual combat rations, and rely upon a highly responsive food service system to provide hot meals.

Units in the brigade area are removed from the immediate scene of the action, so that typically, there is not necessarily the same sense of urgency of response to food service requirements. Thus, this could be the basic level of food service activity, and companies and other small units on line would be supported from kitchens co-located with the battalion headquarters and other elements in this area. This kitchen would be properly equipped to provide at least a minimum capability for complete food service operations, but sufficiently

TABLE B-1

CREWS/TEAMS BY DIVISIONAL UNITS

Unit	Vehicle/Team* Designation	H-DIVISION			T-DIVISION		
		Number Per Unit	Crew/Team Size	Total Strength	Number Per Unit	Crew/Team Size	Total Strength
NBC Def Co	Decon Tm	9	6	54	9	6	54
	Recon Tm	3	9	27	3	9	27
HHC, Eng 8n Eng Co, Eng Bn	R50681	2	2	4			
	C2041				1	2	2
	D11049				2	2	4
	D11049				1	1	1
	D12087				15	8	120
	D12087	9	10	90	1	9	9
Bridge Co, Eng Bn	E56578	2	4	8	5	5	25
	C20414	6	2	12			
TA8	Survey Sec	2	8	16	2	8	16
	SF Plt Hq	2	3	6	2	2	4
	SF Cont Cent	2	16	32	2	20	40
	SF Obs Sec	8	4	32	8	4	32
	Rdr Sec	6	6	36	5	7	35
	Rdr Sec Mtlr	2	7	14	1	9	9
HHB, 155 8n 155 8try, 155 8n Svc 8try, 155 8n	D12087	4	5	20	9	5	45
	D12087	5	9	45	6	7	42
	D11049	6	5	30	8	4	32
	K57667	6	5	30	8	5	40
	R50544	2	2	4			

TABLE B-1

CREWS/TEAMS BY DIVISIONAL UNITS (Cont'd)

Unit	Vehicle/Team* Designation	H-DIVISION			T-DIVISION		
		Number Per Unit	Crew/Team Size	Total Strength	Number Per Unit	Crew/Team Size	Total Strength
HH8, 8" 8n 8" 8try, 8" 8n Svc 8try, 8" 8n	D12087	9	5	45	3	5	15
	D11049	4	8	32	4	6	24
	K56981	4	5	20	4	5	20
	R50544	2	2	4			
	R50681	1	2	2			
HHC, MI 8n	D10726				6	4	24
	D12087	3	2	6	2	3	6
	R50544	2	2	4			
	D10726	3	5	15			
	D11681	2	4	8			
Rifle Co, MI 8n	D12087	2	3	6	9	9	81
	D12087	1	4	4	3	5	15
	D12087	3	5	15	1	7	7
	D12087	9	11	99			
	R50681	1	2	2			
	D10741	4	5	20			
	D11681	12	4	48			
Cbt Spt Co, MI 8n	D12087	12	3	36	8	2	16
	R50681	1	2	2			
	D11681				12	4	48
	D12087				1	5	5
Anti-Armor Co, MI 8n					6	5	30
Sig Spt Op Co, Sig 8n	Cable Tms	8	5	40			
	Instal Sec	2	5	10			

TABLE B-1

CREWS/TEAMS BY DIVISIONAL UNIT (Cont'd)

Unit	Vehicle/Team* Designation	H-DIVISION			T-DIVISION		
		Number Per Unit	Crew/Team Size	Total Strength	Number Per Unit	Crew/Team Size	Total Strength
HHC, Tank Bn (T710/720)	C20414				2	2	4
	D10726				6	4	24
	V13101				3	4	12
HHC, Tank Bn (T730)	C20414				2	2	4
	D10726				6	4	24
	D11681				3	4	12
HHC, Tank Bn	V13101				3	4	12
	D12087	3	2	6			
	R50544	1	2	2			
Tank Co, Tank Bn	R50681	2	2	4			
	V13101	3	4	12			
	D12087	1	3	3	1	7	7
Cbt Spt Co, Tank Bn	R50681	1	2	2			
	V13101	17	4	68	11	4	44
	C20414	2	2	4			
HHC, Brigade	D10741	4	5	20			
	D11049				4	2	8
	D12087	11	3	33	3	2	6
HHT, ACS	R50544	1	2	2			
	D12087				5	4	20
	R50544	1	2	2	1	2	2
HHT, ACS	C20414				3	2	6
	D11049				3	2	6
	D12087	3	2	6	3	2	6
HHT, ACS	R50544	2	2	4			

TABLE B-1

## CREWS/TEAMS BY DIVISIONAL UNIT (Cont'd)

Unit	Vehicle/Team* Designation	H-DIVISION			T-DIVISION		
		Number Per Unit	Crew/Team Size	Total Strength	Number Per Unit	Crew/Team Size	Total Strength
Arm Cav Tp, ACS	A93125	9	4	36	9	5	45
	D10741	3	5	15	3	4	12
	D11538	1	5	5	1	5	5
	D11681				6	5	30
	D12087	15	3	45	7	5	35
	D12087	1	5	5	3	4	12
	D12087	1	10	10			
	D12087	3	11	33			
R50544	1	2	2				
Air Cav Tp, ACS	Recon Sqds	4	10	40	4	9	36
	Scout Sec				2	9	18
MP Co	Squads	15	10	150	15	10	150
Fwd Spt Co, Mnt Bn	D12087				3	4	12
	D12087				2	3	6
Mnt Co, Tank Bn	D12087				4	4	16
	D12087				5	2	10
Mnt Co, MI 8n	D12087				3	2	6
	D12087				1	4	4
	R50681				5	2	10
Mnt Tp, ACS	D12087				3	4	12
	R50681				5	2	10
Mnt Btry, 155 8n	R50544				5	2	10

TABLE B-1

CREWS/TEAMS BY DIVISIONAL UNIT (Cont'd)

Unit	Vehicle/Team* Designation	H-DIVISION			D-DIVISION		
		Number Per Unit	Crew/Team Size	Total Strength	Number Per Unit	Crew/Team Size	Total Strength
Mnt Btry, B'' Bn	R50544				1	2	2
	R50681				3	2	6
Mnt Btry, ADA Bn C/R	D12087				4	5	20
	R50544				2	2	4
Mnt Btry, ADA Bn V/R	D12087				3	4	12
	R50544				3	2	6
Cbt Intel Co	D12087	22	3	66			
	D12087	10	4	40			
	R50544	1	2	2			
ADA Btry, Vul, V/C Bn	D12087	1	7	7			
	D12087	3	3	9			
	J99694	12	4	48			
	R50544	1	2	2			
ADA Btry, Chap, V/C Bn	D12087	1	7	7			
	D12087	3	3	9			
	J95533	12	5	60			
	R50544	1	2	2			
HHB, ADA Bn, V/R	D11049				6	2	12
	D12087				2	4	8
	J96694				8	4	32
ADA Btry, Red, V/R Bn	Redeye Sec			9	10	90	
ADA Btry, Chap, C/R Bn	J95533				12	5	60
	Redeye Sec				6	10	60

**\*Line Item Number**

**Description**

A93125	Armored Reconnaissance Assault Vehicle
C20414	Bridge Armor Vehicle Launch, Scissors Type
D10726	Carrier, 81MM
D10741	Carrier, 107MM
D11049	Carrier, Cargo
D11538	Carrier, Command Post
D11681	Carrier, Guided Missile (TOW)
D12087	Carrier, Personnel
E56578	Combat Engineer Vehicle
J95533	Guided Missile, Chaparrel, Carrier Mounted
J96694	Gun, ADA, Self-Propelled, 20MM
K56981	Howitzer, Heavy, Self-Propelled, 8"
K57667	Howitzer, Medium, Self-Propelled, 155MM
R50544	Recovery Vehicle, Full Tracked, Light
R50681	Recovery Vehicle, Full Tracked, Medium
V13101	Tank, Combat, Full-Tracked, 105MM

TABLE B-2  
 DISTRIBUTION OF CREW/TEAM SIZE BY VEHICLE  
 FOR H AND T DIVISIONS

VEHICLE	1		2		3		4		5		6		7		8		9		10		11		16		20		Total		
	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	
H93125			27				27																					108	135
C20414																												32	48
D10726							90		45																			225	360
D10741							9		49																			245	36
D11049	3						72		54			12			12													366	465
D11538									3		3																	15	15
D11681							90		183		18																	360	822
D12087							33	96	239	25	69	124		4	63	45	15	165		39	144							3365	3500
E56578								8																				32	75
J95533																												120	120
J96694							24		24		24																	96	96
K56981											12																	60	60
K57667											54																	270	360
R50544							41	24																				82	48
R50681							48	83																				96	166
V13101									270		324																	1080	1296
Other							2	2	8	10	6	15	2	2	2	2	3	3	10	19	30		2					457	601
Tot Str	3						276	560	1809	1600	1505	90	42	112	376	162	1575	580	1580	300	0	0	0	0	0	0	0	7009	8203

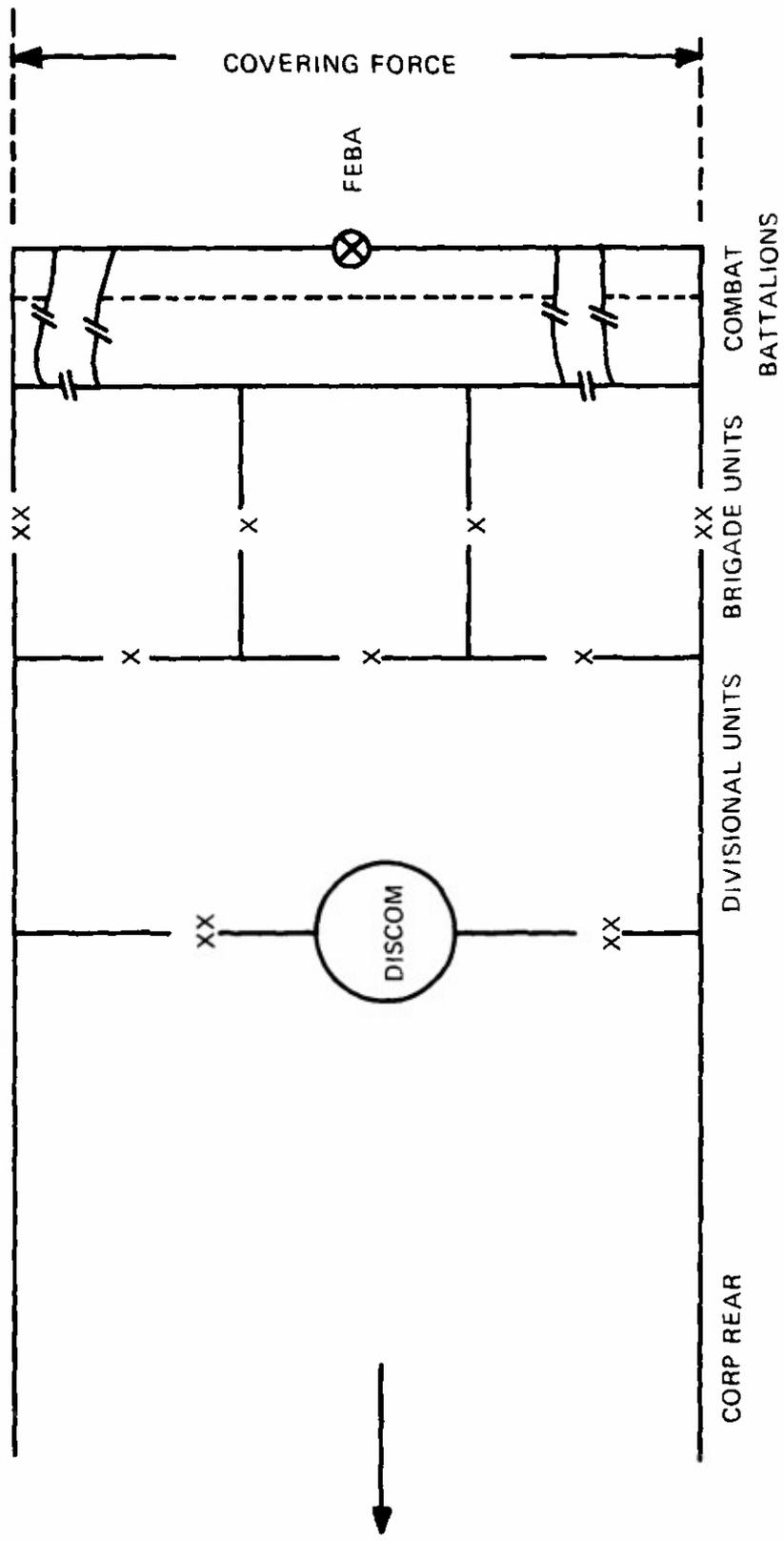


Figure B-1 Divisional Deployment in the Corps

TABLE B-3

## SCORES PLACEMENT OF H-SERIES DIVISION UNITS

Unit Designation	Adjusted <sup>1</sup> Strength	Number Of Units	Area							
			Battalion		Brigade		Div Rear		Discom	
			Crew/ Team	Other						
HHC, DIV	173	1				67				106
MP Co	195	1			90	9			60	36
HHC, CAB	80	1						80		
Avn Co, CAB	188	1								188
Atk Helo Co, CAB	233	2						466		
Tam Co, CAB	195	1						195		
CS Avn Co, CAB	152	1						152		
HHC, Sig Bn	98	1						98		
Cmd Op Co, Sig Bn	194	1				19		90		85
Fwd Comm Co, Sig Bn	165	1				165				
Sig Spt Op Co, Sig Bn	146	1							50	96
HHC Co, Eng Bn	184	1					4	180		
Cbt Eng Co, Eng Bn	146	4			294	144	9B	4B		
Bridge Co, Eng Bn	156	1			12	144				
HHC, Brig	102	3			6	300				
HHT, ACS	172	1	10	162						
Arm Cav Tp, ACS	154	3	453	9						
Air Cav Tp, ACS	198	1	40	15B						
HHB, Div Arty	203	1								203
TAB	158	1							136	22
HHB, 155 Bn <sup>2</sup>	211	3	195	438	(195)	(438)				
FA Btry, 155 Bn <sup>2</sup>	93	9	540	297	(540)	(297)				
Avc Btry, 155 Bn <sup>2</sup>	64	3	12	180	(12)	(180)				
HHB, B'' Bn <sup>2</sup>	193	1	45	148	(45)	(148)				
FA Btry, B'' Bn <sup>2</sup>	89	3	156	111	(156)	(111)				
Svc Btry, B'' Bn <sup>2</sup>	74	1	6	6B	(6)	(6B)				
Cbt Intel Co	217	1						109	10B	
HHB, ADA c/v	129	1						129		
ADA Btry Vul	102	2			132	72				
ADA Btry Chap	115	2			7B	37			7B	37
HHC Spt Cmd	108	1								108
Ag Co	273	1								273
Fin Co	88	1								88
Hgt Spt Co, Med Bn	142	1						142		
Med Co, Med Bn	75	3				225				
HHC, S & T Bn	36	1								36
S&S Co, S & T Bn	127	1				51				76
Tmt Co, S & T Bn	201	1								201
Hg & Mnl Co, Mn Bn	110	1								110
Fwd Spt Co, Mn Bn	182	3				546				
Hvy Mnt Co, Mn Bn	239	1								239
Msl Spt Co, Mn Bn	114	1								114
Div MMC	134	1								134
NBC Def Co	108	1			81					27
HHC, MI Bn	143	5	50	665						
Rifle Co, MI Bn	166	15	2235	255						

TABLE B-3

SCORES PLACEMENT OF H-SERIES DIVISION UNIT (Cont'd)

Unit Designation	Adjusted <sup>1</sup> Strength	Number Of Units	Battalion		Area Brigade		Div Rear		Discom	
			Crew/Team	Other	Crew/Team	Other	Crew/Team	Other	Crew/Team	Other
Cbt Spt Co, MI Bn	148	5	530	210						
HHC, TK Bn	156	5	120	660						
Tank Co, TK Bn	88	15	1095	225						
Cbt Spt Co, TK Bn	91	5	295	160						
<b>TOTAL</b>			<b>5782</b>	<b>3746</b>	<b>693</b>	<b>1779</b>	<b>102</b>	<b>1689</b>	<b>432</b>	<b>2179</b>
% of Crew/Team Strength			83%	-	10%	-	1%	-	6%	-
% of Total Strength			61%	-	28%	-	6%	-	17%	-
% of Total Division Strength			58%		15%		11%		16%	

NOTES:

1. Less authorized food service personnel strengths.
2. Artillery may be assigned to Brigade rather than operating in the battalion area.

flexible in design to be employed in whatever manner is appropriate to the prevailing combat conditions. That is, menus could be augmented and food service may be expanded as the situation permits.

Units located in the division rear and DISCOM are primarily combat support, combat service support and command functions. These units are even further removed from the active combat zone, thus responsiveness is even less critical. However, they normally operate somewhat independently, and are dispersed for tactical reasons. Thus, there is also a need for unit level kitchens to support the troops located in this area.

SCORES considers only H-series divisions, but the organization of T-series divisions are quite similar, with the primary differences being the numbers and the sizes of the various units. Hence, the results obtained apply, as well, to the T-series division, allowing only for adjustment to reflect minor differences.

**3. NON-DIVISION FORCE ANALYSIS.** The type, number and mix of units in the Corps and COMMZ areas, are less well defined, and much more varied, than for the divisions. Unlike divisions, which are normally deployed in total, these units tend to be deployed separately, on an as required basis. The types and numbers of these units are based upon such factors as level of combat activity, ton-miles of supplies to be moved, number of casualties expected, and number of troops to support.

a. **Corps Areas.** The composition of units in the corps rear areas may vary tremendously from one corps to another, in the same scenario, as well as a function of time. Characteristics of the three different corps in the European Theater Level Scenario are summarized in Table B-4, at two different points in time. As can be seen, troop strengths varied between corps by about a 3 to 1 factor on D-Day, and 2 to 1 on D+90. The build-up in the troop strength during this period ranged from 100-150% for two of the corps, to almost 700% for the other one. At the same time, the corps areas varied in size by a ratio of 3 to 1 on D-Day, to not quite 4 to 1 on D+90.

Based on an examination of the types of units normally located in the corps areas, it appears that certain of them would tend to be co-located, or at least, located in the proximity of certain other units, e.g., transportation units with general supply units; maintenance units with transportation units; and ambulance units with hospital units. At the same time, the density of units cannot become so great as to present an attractive tactical target to the enemy. Since the exact location of each unit within the corps was not precisely determined by the SCORES analysis, coupled with the wide variations in corps area characteristics, it was decided to establish food service requirements on a worst case basis. It is assumed that units in corps are uniformly dispersed throughout the area.

These units might initially operate with small individual kitchens, but as the areas become secure and conditions stabilize, these kitchens may be integrated into larger food service operations supporting up to 1000 troops.

The number of integrated kitchens required in each corps was calculated as the total strength, divided by 1000, and rounded to the nearest whole number. The area supported

TABLE B-4

CORPS AREA CHARACTERISTICS

Corps Area	D-Day		D+90	
	Strength	Area (1.c.)	Strength	Area, km <sup>2</sup>
A	31,164	2,450	214,045	3,000
B	92,644	3,500	139,636	4,800
C	70,526	7,700	107,561	11,250
Total	194,334	13,650	461,242	19,050

by each kitchen is then just the total corps area divided by the number of integrated kitchens. Assuming that the areas are square, and that the kitchens are located at the center of each square, the maximum possible distance to a unit being supported would occur when it is located at an extreme point of a square. The results of these calculations are graphed in Figure B-2. As can be seen, the maximum distance varies from 4.4 to 7.4 km, averaging 5.9 km, on D-Day; and 2.6 to 7.2 km, with an average of 4.5 km on D+90. In actuality, most units would be probably located closer to the kitchen. The average distance between the kitchen and any unit is approximately 54% of the maximum distance.

Based upon these results, Table B-5, corps area troops are sufficiently dense that integrated kitchens can be established as required.

b. **COMMZ Area.** The Communication Zone, or COMMZ, is located to the rear of the corps. Because of their location, units operating in this area are least vulnerable to the enemy threat, but are still somewhat dispersed for defensive purposes, to take advantage of the terrain and existing transportation networks, or for other reasons. The following guidance with respect to the SCORES placement of COMMZ units was provided:

(1) COMMZ units tend to be clustered in, and around, certain population centers, rather than being uniformly distributed throughout the area.

(2) The number of population centers remains constant, with troops being located within the same population centers between D-Day and D+90.

(3) Units within a given population center are uniformly distributed throughout the center.

(4) The relative density of troops within a given population center remains constant as a function of time, i.e., the area of the population center increases in size proportional to the total troop strength.

(5) Medical units, because of their relatively higher feeding strengths and unique feeding requirements, will maintain separate field kitchens.

The results of analysis are contained in Table B-6. The COMMZ was subdivided into two areas, with about twice as many troops in the rear area as in the forward area. Troops in the forward area are located in and around 33 population centers, while in the rear area, they are located at only 12 population centers. Assuming the number of integrated area kitchens required per population center is one per 1000 troops, or any fraction thereof, 55 are required in the forward area, and 85 in the rear area. The area of a population center is taken as circular about a given geographical point. The total area of all forward population centers is 12,000 km<sup>2</sup>, and for all rear population centers is 4,200 km<sup>2</sup>. The number of companies in a population center range from 3-24 in the forward area, and from 17-61 in the rear, which amounts to 3-8 companies per kitchen forward, and 5-6 companies in the rear. On the other hand, the average area of the population centers varies from 150-850 km<sup>2</sup> forward, and 30-650 km<sup>2</sup> in the rear, so that the average area supported by each kitchen in the forward

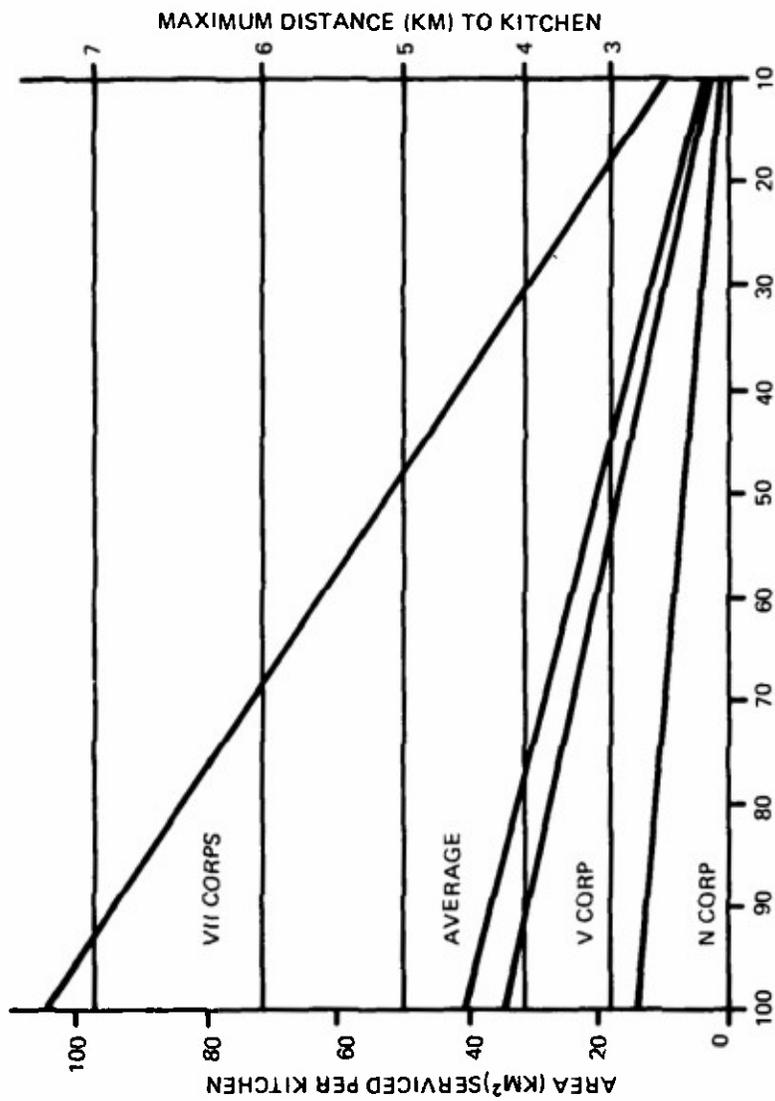


FIGURE B--2. % AREA IN WHICH TROOPS ARE LOCATED

TABLE B-5

INTEGRATED KITCHEN CHARACTERISTICS - CORPS AREAS

(1000 Troop Kitchen)

Corps Area	D-Day		D+90	
	KM <sup>2</sup>	MD*	KM <sup>2</sup>	MD
A	79	6.3	14	2.6
B	38	4.4	34	4.1
C	109	7.4	104	7.2

\*Maximum distance to kitchen, equals  $(\text{Area}/2)^{1/2}$ .

**TABLE B-6**  
**COMMZ ANALYSIS**

	Forward	Rear
Total Troop Strength	40,700	81,600
No. Population Centers	33	12
No. Integrated Kitchens	55	85
Total Area, km <sup>2</sup>	12,000	4,200
No. Companies in Population Center	3-24	17-61
No. Companies/Integrated Kitchen	3-8	5-6
Area (km <sup>2</sup> )/Population Center	150-850	30-650
Area (km <sup>2</sup> )/Integrated Kitchen	120-400	10-75
Max Distance, km	6-11	2-5

and rear areas is, respectively, 120–400 km<sup>2</sup> and 10–75 km<sup>2</sup>. The maximum distance a unit is located from an integrated kitchen at the center of a circular area, ranged from 6–11 km, and averages 8 km, for the various forward population centers, and ranges from 2–5 km, averaging 4 km, for the rear area population centers. Average distances, assuming a uniform distribution of troops through the population centers, are two thirds of their respective maximum distance.

COMMZ units are located close enough together to facilitate establishing integrated kitchens, if required or desired. Even for the least dense population center in the forward area, the greatest distance which troops must be transported to a kitchen, or over which food must be transported to the troops, is only about 11 km.

## APPENDIX C

### FOODS, MENU-CYCLES, MENUS

1. **INTRODUCTION.** The amounts and kinds of sustenance essential to, or desirable in, the combat environment differs with respect to battle conditions, duration of commitment, mission objectives, and other circumstances of the conflict situation. In the Theater Level Scenario, combat units will be highly mobile and widely dispersed in a flux of changing combinations and deployments. However, for each crew and vehicle there will be a recurrent pattern of resupply, servicing and maintenance of vehicles, during which time meals or other sustenance might be provided, without degradation of the combat performance or effectiveness of these forces. The food service system, to be responsive under such conditions, must be simple, flexible and functional. Therefore, the food and equipment components of the system should be developed simultaneously to achieve the highest level of compatibility practicable, consistent with these requirements.

Foods of the best quality available, within military constraints, should be utilized in the field. These foods should be selected, insofar as possible, to provide meals which are most preferred by the troops and insure adequate nutrition at those levels specified by The Surgeon General. In the forward areas, particularly, the meals should require little or no preparation prior to consumption, and variety should be restricted to a workable minimum to expedite handling and issue, while maintaining consumption and nutritional goals. The package and packaging should be compact and sufficiently rugged to protect the contents under the anticipated conditions of shipping, handling and storage. The importance of packaging materials, heat transfer properties, structural characteristics, geometry and size relative to the volume of contents, and the composition of gas within the package, which may protect or degrade the quality of food, must be observed and considered. Finally, a margin of safety should be built into all food service systems for the support of military forces during hostilities, i.e., extended shelf-life should characterize these foods, for unforeseeable exigencies can impede or halt resupply or change prearranged plans substantially, and alternative sources of food may not exist.

Three general classes of menus and menu cycles are proposed. A fourteen day heat and serve menu cycle is designed to provide hot meals as frequently as possible in the combat zone. Another menu cycle is based on low-volume foods that may be required if logistic and supply operations are constrained. Finally, an A-ration menu cycle will be used, as soon as conditions permit, wherever possible. The respective rations, menus and meals are described in considerable detail in the following discussion.

2. **CANDIDATE FOODS.** Foods for inclusion in military field feeding systems should possess a considerable spectrum of desirable chemical and physical attributes, the important ones of which are noted below. It would be a rare food, if any, that would possess maximum or near maximum levels of all desirable traits. In practice, trade-offs are made depending on the relative significance of the several attributes and the uses intended for the commodity.

(1) **Nutritional Quality.** Potential of the foods to meet stipulated nutritional requirements.

(2) **Sensory Qualities.** Acceptability (hedonic rating); color; flavor; aroma; appearance; etc. Frequency of acceptance for prolonged periods of use.

(3) **Cost.** Ration costs relative to basic daily food allowance; manpower requirements for preparation and serving; etc.

(4) **Convenience.** Readiness for consumption; ease of preparation and use; and, high nutritional density.

(5) **Stability and Resistance to Spoilage.** Inherent compositional/physical/microbiological stability; prolonged shelf life; low susceptibility to destruction; resistance to food and container interactions; resistance to CBR contamination; and low susceptibility to quality drift in procurement.

(6) **Versatility/Variety.** Range of recipes, meals, and feeding conditions to which adaptable; and utility in changing battle/supply situations.

(7) **Logistic Requirements.** Weight and cube; ease of handling, transporting, and storing; and, degree of dependence on refrigeration or other critical equipment.

(8) **Compatibility.** Consistent with ration and menu, equipment and concept of operations.

(9) **Water Consumption.** Water required for preparation, sanitation, clean-up and other related uses.

(10) **Sanitation.** Ease of accomplishing sanitation and clean-up.

(11) **Availability.** Sufficient variety and adequacy of industrial base within relevant time frames.

a. **Thermally Stabilized Foods.** The common objectives of all food preservation methods are the destruction or inactivation of microorganisms which are capable of decomposing the foods; inactivation of the enzymes which cause deteriorative chemical changes; and, protection from mechanical damage, insect infestation and rodent contamination.

In thermally stabilized foods, exposure to high temperatures for a sufficient period of time destroys or inactivates the bacteria and enzymes. Physical and chemical changes also occur in the product itself, in response to the time and temperature of processing. Acid foods, those having hydrogen ion concentrations of pH 4.5 or less, can be safely processed at the temperature of boiling water. Foods less acid than this, in conventional processes, must be exposed to a temperature of 250°F for at least 2.5 minutes, or to other temperatures and times equally lethal to food-borne bacteria. To achieve a sufficiently high temperature at the coldest spot in the food mass, and to maintain it for the critical period, exposes the balance of the product to overcooking and deterioration of its quality. The sequence of come-up,

cooking and cooling times for a food product in a #10 cylindrical can may take in excess of three hours, although vibratory or agitating cookers or retorts can reduce this time significantly.

Recently developed technology in thermal stabilization utilizes a rigid, rectangular container, the size of a half steam table pan with the same volume as that of the #10 can, referred to as the tray pack. The improved geometry of the package design reduces the cooking time; in the case of the Kraft Company "Pasteurization Process", to approximately 30 minutes as compared to 240 minutes with the #10 can. This process consists of filling at near ambient temperatures, sealing the containers, and heating in an agitating cooker to a sterilizing temperature. The packaged product is then cooled and shipped to storage or sales.

The "Flash-1B" process, developed by Swift and Company, uses still other means to shorten cooking times. This process is carried out in an hyperbaric chamber, in which water boils at 250°F. The product is heated to that temperature and filled hot, with no cooling. The cover is then affixed, and the closed container is then held for a brief period while the residual heat of the product sterilizes the contents.

The same general principles characterize the "High IT" process of the FMC Corporation, except that no hyperbaric capsule is required. The product and container are sterilized separately. Filling is conducted at temperatures as high as 270° - 300°F, and the top is immediately double seamed to the container, which is then held briefly, to ensure sterilization, before being cooled.

Products developed using these newer technologies are now mostly in developmental and test marketing stages. Those consumer items, which ultimately may result from current industrial efforts, will likely differ in degree and kind from those required to meet more stringent military requirements. Even so, if successful, considerable knowledge and production capacity will have been developed, which may be exploited by the military, when needed.

Some indication of the quality potential of tray pack foods can be seen in the data of Table C-1. A comparison of these ratings with those of canned B ration entrees, Table C-2, is of interest. The data in these two tables are not directly comparable, since the products, their age, and other variables between the two, are dissimilar. Both sets of values, however, appear to be in the same general rating level. Also illustrated, are the effects of storage time and temperature on the quality of processed foods.

Canned heat-stabilized foods have been the backbone of military subsistence for many decades, and they remain important today. Canned foods are consistently safe; with but very rare exceptions, attractive; available in an ever expanding variety; and, if prepared properly, nutritionally adequate. Further, they can withstand storage, under less than desirable conditions, for considerable periods of time. The cans present a creditable barrier to physical and to many chemical abuses, exclude insects, and to an appreciable degree, defy rodents. Costs are moderate.

**TABLE C-1**  
**HEDONIC RATINGS FOR TRAY-PACKED FOODS**  
**PETERSON AIR FORCE BASE, AUGUST, 1978**

<b>Lunch 15 August, 1978</b>	<b>Hedonic Rating*</b>	<b>N</b>
Sliced Roast Pork/Gravy	5.70	43
Lasagna	6.62	71
Potatoes	7.82	73
Peas	7.30	50
Corn	7.25	89
Cherries in Sauce	6.94	33
<b>Dinner, 16 August, 1978</b>	<b>Hedonic Rating*</b>	<b>N</b>
Beef Burgundy	7.00	13
Stuffed Peppers	7.78	23
Beef Stroganoff	5.68	22
Barbecued Beef	5.73	48
Potatoes	6.75	73
Green Beans	6.64	67
Lima Beans	7.08	13
Apple Slices in Sauce	7.61	23
Blueberries in Sauce	7.57	14

\*Average ratings using the Peryam and Pilgrim 9 point scale.<sup>1</sup>

<sup>1</sup>Peryam, D. R. and Pilgrim, F. J. "Hedonic Scale Method of Measuring Food Preferences." *Food Technology*, Volume 11, 1957, p.9.

TABLE C-2  
 HEDONIC RATINGS FOR SELECTED B-RATION CANNED ENTREES<sup>1</sup>

Storage Temperature °F.	Commodity	0 Mo.	Hedonic Rating* 12 Mo.	36 Mo.	Statistical Significance
70	Beef Chunks/Gravy	7.0	6.4	6.6	
100					
70	Meat Balls/Beef Gravy	7.0	6.5	5.8	SIG.
100		7.0	6.5	5.7	SIG.
70	Corned Beef Hash	6.9	6.8	6.8	N.S.
100		6.9	5.9	4.8	SIG.
70	Luncheon Meat	6.3	6.9	5.8	
100		6.3	6.9	5.8	

\* Ratings by consumer panels, N = 36.

<sup>1</sup> US Army Natick R&D Command. Food Acceptance Laboratory and Experimental Kitchens. 7 Year B-Ration Storage Study. Draft: Natick, MA; January 1979.

To the attributes of canned foods already enumerated, there can now be added, the exploitation of new shapes. Such changes enhance the quality of canned foods, by reducing the heating cycle. Convenience is also increased by the changes in shape and processing. This added convenience will be reflected in the savings of required food service manpower. Preliminary tests have indicated savings to be very substantial.<sup>3</sup>

b. **Dehydrated, freeze-dried, compressed foods.** The logistic advantage of dehydrated foods has long been recognized by the US Armed Forces. During World War II, when shipping was scarce, an intensive national effort was initiated to preserve as many kinds of food as possible by drying. Product quality generally was very poor, and the state of the underlying technology was, for the most part, very primitive. During the course of the war, however, elite methods were developed for drying of antibiotics and blood plasma, one of which was freeze-drying. An intensive development of this process, for the preservation of military foods, was undertaken by the US Army during the middle 1950's. It has proven military utility and established industrial production capability. Freeze-drying produces light-weight convenience foods of excellent quality. The weight of foods is reduced in proportion to the amount of water inherently present. Typical savings in weight, in terms of logistics, may lie in the range of 50% to 75%.

Freeze-drying, however, does not reduce the volume of foods markedly, and volume reduction is essential to realize maximum logistical savings. Owing to the low specific gravity of foods, volume constraints will often limit load capacities before weight constraints. Compression has provided very impressive volume reductions of freeze dried foods in a wide array of vegetables, in some fruits, meats and meat products, seafoods of selected types, and prepared dishes, such as chili con carne. More than thirty food items have been compressed to date.

Certain dehydrated and freeze-dried foods, especially those which are compressed, are extremely viable candidates for inclusion in the field menus. The Navy is currently using a limited number of such foods to conserve storage space on vessels such as submarines, which are assigned protracted sea duty. Recurrent purchases and improved techniques in manufacturing have lowered their costs significantly. The industrial base for the production of dehydrated and freeze-dried, compressed foods currently is limited, but there is scarcely a major food processor or purveyor in the US or any other industrialized country, which does not have an expanding position in the dehydrate market. Initial items include freeze-dried coffee, soups, casserole type foods and the like. Industrial interest will be responsive to military needs, if and when these are clearly expressed, and there is evidence of continuing and reasonably sizeable procurement requirements.

c. **Frozen Foods.** Frozen foods are attractive for military use for many of the same reasons that have made them increasingly popular in the home and in institutional food service: high quality is attainable; they are convenient to prepare and serve; they save kitchen labor

<sup>3</sup>US Army Natick R&D Command. Operations Research and Systems Analysis Office. MSR USAF 9-1: Phase I. Presentation. 6 February 1979.

and reduce waste; they provide extended shelf life when properly stored, as compared to fresh foods; there is a wide variety of items and food styles; and, they are nutritious.

The principal disadvantage of frozen foods lies in their complete dependence on the maintenance of virtually invariable, low temperatures to assure product safety and quality. The long logistic trail of refrigerated storage, trucks and box cars are difficult to maintain. Susceptibility to destruction by malfunction limits the usefulness of frozen foods to those same areas in which the A-ration can be used. It is not practical to feed a complete frozen food ration during combat. The quality and nature of packaging used in the preservation of frozen foods is highly important to the retention of product quality. It is to be noted that most frozen foods are not sterile. There appear to be practical limitations on the size and geometry of frozen food units/package, owing to the need to thaw the product prior to its final preparation. Conditions prevailing during the thaw are critically important to conservation of the inherent product qualities.<sup>4</sup>

The potential quality of precooked frozen foods, such as might be used in military meals, is indicated in Table C-3. Hedonic ratings are shown for a number of entrees at the beginning of a storage test, and after twelve months of storage. The scores accorded the five entrees indicate very high quality, but not every food tested scored as high as shown for these entrees. The need for more effort in formulating attractive, convenient, labor saving pre-cooked frozen foods seems apparent.

The consumer market abounds with frozen foods of an extremely wide assortment. In a recent study by the US Department of Commerce,<sup>5</sup> it was found that a single US food chain stocked more than 500 different frozen foods. The rate of growth in volume of production between the years of 1965-1972 was 16.4 percent. Estimated total US production of frozen foods, by principal category, for the year 1985 is shown in Table C-4. Based on these data, production in 1985-1990 should be adequate to accommodate military requirements. Problems could arise in converting civilian plants to military item production, since foods, packaging and packing for military use will differ from those for commercial products in a number of essential characteristics. If a decision is made to use these kinds of foods, it will be desirable, in the interim, to engage in product formulation, packaging, storage and related research and development.

A recently completed survey of the literature relating to general subject of the nutritional content of frozen foods, i.e., levels of the several nutrients in frozen foods, losses during storage, nutrition levels compared to canned and fresh food counterparts, concluded:

<sup>4</sup>US Department of Commerce. **Frozen Foods for Military Troop Field Feeding: Economic Feasibility Report.** A Study for the US Army Natick Laboratories. Project Order No. AMXRED 73-190: June 1974.

<sup>5</sup>ibid.

TABLE C-3  
 HEDONIC RATINGS FOR PRECOOKED FROZEN ENTREES AT WALTER REED  
 ARMY MEDICAL CENTER, 1975 - 1976<sup>a,b</sup>.

Product <sup>c</sup>	Storage Time/Mo.	Color	Odor	Flavor	Texture	Appearance
BBQ Sliced Beef	Initial	6.9	7.1	6.9	6.7	7.0
	12 Mo.	7.1	6.7	6.1	6.3	7.0
Neapolitan Spaghetti	Initial	6.2	6.7	6.9	7.7	6.4
	12 Mo.	6.5	6.5	6.1	6.3	6.3
Tallierine (Chop Suey)	Initial	7.2	7.4	7.4	7.2	7.2
Seafood Au Gratin	Initial	7.2	7.3	6.9	7.1	7.3
	12 Mo.	6.6	6.8	6.0	5.8 <sup>d</sup>	6.5
Reuben Sandwich	Initial	7.2	7.2	7.0	6.8	7.3
	12 Mo.	6.5	6.3	5.8	6.1	6.5

**NOTES:**

<sup>a</sup>Darsch, G. Shaw, C., and Tuomy, J. Storage Study of Frozen Entree Items Developed for Walter Reed Army Medical Center. Technical Report TR 78/006. Natick, MA: US Army Natick R&D Command. April 197B.

<sup>b</sup>Ibid., p. 12-14

<sup>c</sup>Products contained in 1/2 steam table sized aluminum pans stored at -10° F (-23° C); reheated at 325° F (163° C) to 160° F (71° C) internal temperature.

<sup>d</sup>Texture of shrimp ingredient toughened; significant at 5% level.

**TABLE C-4**

**ESTIMATED FROZEN FOOD PRODUCTION IN 1985**

<b>Product Category</b>	<b>Volume Millions of Pounds</b>
Fruits	700
Meats	2,900
Juice Concentrates	2,600
Vegetables	14,400
Seafoods	3,800
Poultry	2,400
Prepared Foods	<u>22,200</u>
Total	<u>49,000</u>

"From the information available, it does not appear that the consumer will be any more nutritionally deprived from this feeding frozen food system than from any (other) system in use today."<sup>6</sup>

A 1974 US Department of Commerce study dealing with the use of precooked frozen foods in military menus estimated an average cost of \$3.24 per day for breakfast, dinner and supper. The meal components were assumed to be bulk packaged, and costed for a 28 day Master Menu cycle.<sup>7</sup>

d. **Irradiated Foods.** The technological development of irradiated meats, poultry, and selected seafoods is far advanced. Unfortunately, such foods are not available for use at this time. Later, when cleared for use by the responsible Federal Agencies, these foods should be evaluated for military applications.

3. **MENU CYCLES AND MENUS.** The initial menus were developed using a computerized mathematical program to produce a preference maximized non-selective menu.<sup>8,9</sup> The menu generated by the program is actually a list of generic recipe items and their frequency of use during a menu cycle, rather than a detailed schedule of items for each meal.

First, a fourteen day cycle of thermo-stabilized, tray pack foods, requiring only heating for serving, was developed by the computer, Table C-5. Several substitutions, such as barbecued pork instead of barbecued spare ribs, were effected for logistical and economic reasons. Canned fruits are indicated for use, since fruits, in general, are eaten cold or at ambient temperatures. Dehydrated juices, commercially available, of good quality, conserve weight and bulk. The cocoa, instant coffee, instant tea and other beverages are supplied in bulk dispensers to be mixed with hot or cold water, as appropriate. Bread for all menus will be supplied from the Automated Bakery System. This cycle, designated as the T ration, is planned especially for the combat zone, emphasizing ease of preparation and responsiveness to feeding the troops.

<sup>6</sup>White, Virginia M. *Nutritional Effects of Processing and Reheating Centrally Prepared Foods*. Manuscript. Natick, MA: US Army Natick R&D Command, 1978.

<sup>7</sup>Op. cit., US Department of Commerce.

<sup>8</sup>Balintfy, J., Ross, G., Sinha, P., and Zoltners, A. *A Mathematical Programming System for Preference-Maximized Nonselective Menu Planning and Scheduling, Part I: Models and Algorithms*. Research Report 3-75. Amherst, MA: University of Massachusetts, Food Management Science Laboratory. November 1975.

<sup>9</sup>Sinha, P., Balintfy, P., Ross, G., and Zoltners, A. *A Mathematical Programming System for Preference-Maximized Nonselective Menu Planning and Scheduling, Part II: Solution Procedures*. Research Report 3-75/2. Amherst, MA: University of Massachusetts, Food Management Science Laboratory, June 1976.

TABLE C-5

CONCEPT MENUS BY ITEM FREQUENCY

MENU CATEGORY	RATION CONCEPT		
	T RATION	MINIMUM VOLUME	A RATION
<b>Entrees — L/D</b>			
Roast Beef/Gravy	2 Tray (T)	1 Tray (T)	2 Froz (F)
Grilled Beefstaak	3 Tray (T)	3 Dehy (D)	3 Froz (F)
Beef Pot Roast/Gravy	1 Tray (T)	1 Tray (T)	1 Froz (F)
Peppersteaks	1 Tray (T)	-	-
Swiss Steak/Tom. Sauce	2 Tray (T)	1 Dehy (D)	1 Froz (F)
Meatloaf/Gravy	1 Tray (T)	1 Tray (T)	1 Froz (F)
Salisbury Steak/Gravy	1 Tray (T)	1 Tray (T)	1 Froz (F)
Swedish Meatballs	1 Tray (T)	-	1 Froz (F)
Ham	-	3 Canned (B)	1 Froz (F)
Roast Pork/Gravy	1 Tray (T)	-	-
Stuffed Pork Slices	-	-	1 Froz (F)
Italian Sausages	1 Tray (T)	1 Tray (T)	1 Froz (F)
BBQ Pork	1 Tray (T)	1 Tray (T)	1 Froz (F)
Roast Vaal/Gravy	1 Tray (T)	-	1 Froz (F)
Beef Stew	2 Tray (T)	2 Dahy (D)	2 Froz (F)
Lasagna	1 Tray (T)	2 Dry/Dehy (D)	2 Dry/Froz (F)
Spaghetti/Meatballs	1 Tray (T)	2 Dry/Dahy (D)	1 Dry/Froz (F)
Turkey Pot Pia	-	1 Dahy (D)	1 Dry/Froz (F)
Chile Con Carne w Beans	1 Tray (T)	2 Dehy (D)	1 Dry/Froz (F)
Fried Shrimp	2 Tray (T)	1 Dehy (D)	2 Froz (F)
Baked Golden Chicken	1 Tray (T)	1 Tray (T)	1 Froz (F)
Fried Chicken	2 Tray (T)	3 Tray (T)	3 Froz (F)
Roast Turkey/Gravy	1 Tray (T)	1 Tray (T)	1 Froz (F)
Shrimp Creole	1 Tray (T)	-	-
<b>Starch — L/D</b>			
Baked Potatoes	3 Tray (T)	2 Dehy/Fabr (D)	3 Fresh (F)
French Fried Potatoes	-	7 Dahy/Extr (D)	8 Dehy/Extr (D)
Hash Browns	4 Tray (T)	4 Dehy (D)	4 Dehy (D)
Scalloped Potatoes	1 Tray (T)	-	1 Dahy (D)
Mashed Potatoes	4 Tray (T)	Dehy (D)	4 Dehy (D)
Beans, Baked	1 Tray (T)	(D)	1 Dry (D)
Spanish Rice	1 Tray (T)	1 Dehy (D)	-
Macaroni/Cheese	2 Tray (T)	2 Dry (D)	2 Dry/Ref (D) (F)
Shoestring Potatoes	8 Canned (B)	-	-

TABLE C-5

CONCEPT MENUS BY ITEM FREQUENCY (Cont'd)

MENU CATEGORY	RATION CONCEPT		
	T RATION	MINIMUM VOLUME	A RATION
<b>Vegetables - L/D</b>			
Green Baans	4 Tray (T)	4 Dehy/C (DC)	4 Froz (F)
Peas	3 Tray (T)	3 Dehy/C (DC)	5 Froz (F)
Whole Kernel Corn	4 Tray (T)	4 Dehy/C (DC)	4 Froz (F)
Cream Styla Corn	3 Tray (T)	3 Dehy (D)	3 Can. (B)
Mixed Vegetables	3 Tray (T)	3 Dehy/C (DC)	3 Froz (F)
Waxbeans	2 Tray (T)	.	.
Peas and Carrots	2 Tray (T)	.	.
Broccoli	.	.	2 Froz (F)
Spinach	.	3 Dehy/Cmpd (DC)	.
Onion Rings, Franch Fried	4 Tray (T)	4 Dehy/Extr (D)	4 Dahy/Extr (D)
<b>Desserts - L/D</b>			
Ice Cream	.	.	10 Froz (F)
Asst Cakes/Frosting	4 Tray (T)	5 Dry Mix (D)	2 Dry (D)
Asst Pies	12 Tray (T)	13 Dry Mix/Dehy(D)	5 Dry Mix/Dehy/Froz(F)
Straw. Sundaes	.	.	4 Froz (F)
Asst Fruits	9 Canned (B)	8 Canned (B)	5 Fresh (F)
Straw. Shortcake	3 Tray (T)	2 Dry/Dehy (D)	2 Dry/Dehy (F)
<b>Salads - L/D</b>			
Asst'd. Veg Salads	20* Fresh (F)	20 Fresh (F)	20 Fresh (F)
Cole Slaw	3* Dehy/Comp(DC)	3 Dehy/Comp(DC)	4 Fresh (F)
Fruit Salad/Creamy Dressing	4* Dehy (D)	4 Dehy (D)	3 Fr/Froz (F)
Grapefruit/Orange Salad	1* Canned (B)	1 Canned (B)	1 Chilled (F)
<b>Soups - L/D</b>			
Asst'd. Soups	14* Dehy (D)	28 Dahy (D)	28 Canned (B)
	14* Canned (B)	.	.
<b>Beverages - L/D</b>			
Asst'd. Bev Base	28 Dry (D)	28 Dry (D)	.
Asst'd. Soda	.	.	28 Canned (B)
Cocoa	6 Dry (D)	6 Dry (D)	6 Dry (D)
Coffee	18 Dehy (D)	16 Canned (B)	17 Canned (B)
Tea	14 Dry (D)	12 Dry (D)	15 Dry (D)
Milk (White or Choc)	19 Dehy (D)	17 Dahy (D)	19 Fresh (F)

TABLE C-5

CONCEPT MENUS BY ITEM FREQUENCY (Cont'd)

MENU CATEGORY	RATION CONCEPT		
	T RATION	MINIMUM VOLUME	A RATION
<b>Breakfast</b>			
<b>Meat Entree - B</b>			
Canadian Bacon	3 Prefried Flax (T)	3 Prefried Flax (T)	3 Froz (F)
Bacon	5 Prefried Flax (T)	4 Prefried Flax (T)	5 Froz (F)
Ham Slices	2 Tray (T)	2 Tray (T)	2 Froz (F)
Sausage	4 Tray (T)	5 Tray (T)	4 Froz (F)
<b>Non Meat Entree - B</b>			
Eggs	6 Tray (T)	5 Dehy Mix (D)	6 Fresh (F)
Cheese Omelet	2 Tray (T)	1 Dehy Mix (D)	1 Fresh (F)
French Toast	2 Tray (T)	3 Mix/Bread (D)	3 Fresh/Bread(F)
Pancakes	4 Tray (T)	5 Mix (D)	4 Dry (F)
<b>Starch - B</b>			
Hominy Grits	2 Tray (T)	-	1 Dehy Mix (D)
Hash Browns	6 Tray (T)	6 Dehy (D)	6 Dehy (D)
<b>Juices/Fruits - B</b>			
Asst'd. Juices	9 Dehy (D)	7 Dehy (D)	-
Asst'd. Fruits	4 Canned (B)	6 Canned (B)	14 Fresh (F)
Applesauce	1 Canned (B)	1 Dehy (D)	-
<b>Pastry/Muffin - B</b>			
Danish Pastry	2 Tray (T)	-	2 Dry Mix (D)
Doughnuts	3 Tray (T)	3 Dry Mix (D)	3 Dry Mix (D)
English Muffins	1 Tray (T)	2 Dry Mix (D)	1 Dry Mix (D)
Blueberry Muffins	2 Tray (T)	1 Dry Mix (D)	1 Dry Mix (D)
<b>Cereals</b>			
Hot Cereal	7* Dry (D)	7 Dry (D)	7 Dry (D)
Cold Cereal	5* Dry (D)	5 Dry (D)	5 Dry (D)

\*Key to Symbols:

B = Canned, conventional process  
 C = Compressed  
 D = Dehydrated, freeze-dehydrated  
 Fabr = Fabricated  
 \*Augmentation

F = Fresh or frozen  
 T = Tray pack (thermostabilized)  
 Extr = Extruded  
 Ref = Refrigerated

A twenty-eight day cycle was then constructed, which included not only the T rations, but 14 days of shelf stable, minimum weight and volume foods, plus cereals, soups and salads, as shown in Table C-5. Although only a few salads consist of ingredients which are shelf stable, it is anticipated that fresh fruits and vegetables will eventually become available. This cycle, referred to as the minimum volume ration, was designed to increase the bulk density of subsistence and reduce the logistic burden by using dehydrated and compressed items. Tray pack, flex-packed and canned items are included when their dehydrated counterparts are not available, or, are not considered to be satisfactory.

A forty-two day cycle was finally developed by computer, including both the T ration and minimum volume ration, as well as an additional 14 days of A rations, which is also presented in Table C-5. The A ration consists of fresh and frozen foods and canned, dry and dehydrated foods whose quality is such as to make them suitable replacements for their fresh or frozen counterparts.

Since the T ration, minimum volume ration and A ration consist of 14 day increments of a 42 day cycle, the individual cycles were used to determine and compare their logistic requirements and relative costs.

**4. LOGISTICAL IMPACT OF RATION CONCEPTS.** The logistical requirements generated by each ration concept were obtained by selecting a representative sample of recipes or items from each menu category. Detailed logistical data, gross weight and cube per hundred servings, were then established for each item to estimate the average logistic load generated by each menu category.

Logistical data for most recipes and items, except for the tray pack, were readily available from the Federal Supply Catalog,<sup>10</sup> in conjunction with the military recipe file.<sup>11</sup> The recipe file detailed item requirements for each recipe, while the Federal Supply Catalog provided data on the gross weight, net weight, and cube. The tray pack is a somewhat new form of food packaging, and the number of items available is quite limited. Two approaches were used for estimating the weight and cube of the tray packs. For most recipes, military volumetric serving sizes were used to calculate recipe weight and cube. Using the filled volume of the tray to be 96 fluid ounces, the number of tray packs necessary to provide 100 volumetric servings was calculated, and the corresponding weight and cube determined. However, for items in gravy, such as Swiss Steak, this approach was not acceptable. In this case, the weight of meat required for 100 servings was calculated, and estimates were obtained of the amount of gravy per tray pack required for proper packaging. Then the number of trays required per 100 servings was calculated and converted to weight and cube measures. Table C-6 summarizes the estimated weight and volume of the three rations, in terms of pounds and cubic feet per 100 rations.

<sup>10</sup> Federal Supply Catalog Stock List: FSC Group 89, Subsistence. C8900-SL. 1 January 1978.

<sup>11</sup> Departments of the Army, the Navy, and the Air Force. Technical Manual 10-412, NAVSUP Publication 7, AFM 146-12, MCO P10110.16B: Government Printing Office, Washington D.C. February 1969.

TABLE C-6

ESTIMATED LOGISTICAL PARAMETER VALUES FOR RATION CONCEPTS<sup>a</sup>  
(PER 100 RATIONS)

	T-Ration		Minimum Volume Ration		A-Ration	
	lb	ft <sup>3</sup>	lb	ft <sup>3</sup>	lb	ft <sup>3</sup>
Basic Ration	p <sup>b</sup>	.	28.0	1.17	380.1	10.07
	NP	<u>485.6</u>	<u>316.9</u>	<u>11.32</u>	<u>219.4</u>	<u>6.97</u>
	T	<u>485.6</u>	<u>344.9</u>	<u>12.49</u>	<u>599.5</u>	<u>17.04</u>
Augmentation <sup>c</sup>	P	28.0	28.0	1.17	380.1	10.07
	NP	<u>68.5</u>	<u>316.9</u>	<u>11.32</u>	<u>219.4</u>	<u>6.97</u>
	T	<u>96.5</u>	<u>344.9</u>	<u>12.49</u>	<u>599.5</u>	<u>17.04</u>
Total Ration	P	28.0	28.0	1.17	380.1	10.07
	NP	<u>554.1</u>	<u>316.9</u>	<u>11.32</u>	<u>219.4</u>	<u>6.97</u>
	T	<u>582.1</u>	<u>344.9</u>	<u>12.49</u>	<u>599.5</u>	<u>17.04</u>

NOTES:

<sup>a</sup> A ration consists of three meals, breakfast, lunch, and dinner.

<sup>b</sup> P = Perishable; NP = Nonperishable; T = Total.

<sup>c</sup> Augmentation with cereals, soups and salads (latter fresh on an as available basis).

Similar data on the Standard B ration, the Meal, Combat, Individual and the Meal, Ready-to-Eat, Individual are recorded in Table C-7 for comparative purposes.

Detailed logistical data on an item/recipe basis within each menu category is presented in Table C-8, along with the menu category averages. The serving frequency of items within a given menu category, for each concept menu, and the resulting estimated logistical parameter values are tabulated in Table C-9.

5. **MENU COSTS.** The T ration, the minimum volume ration and the A ration menus were each costed, item by item, and the results summarized in Table C-10. Cost of the basic T ration is \$3.91 per day, with an additional \$0.50 per day for cereal, soup and salads in the augmented ration, for a total cost of \$4.41 per day. The minimum volume ration costs \$3.83 per day, and the A ration costs \$3.13 per day. All costs were calculated at current price levels.

The estimated cost of tray pack items was derived from costs supplied by the packers currently in the market. In a few instances, anomalous figures appeared in the data provided. The finished product cost in these cases was less than the estimated raw product costs. Such figures were deleted from the calculations. Trays were calculated to have a capacity of 8.2667 servings of French toast, waffles, pancakes, Danish pastry, doughnuts, English or blueberry muffins. Another \$2.53 per tray was added to the costs of the raw ingredients for these products for packaging (calculated as the cost of tray-packing apple cobblers). For desserts and French fried onion rings, \$2.504 per tray packaging costs were added to raw ingredient costs. Entrees and starch items were calculated to cost \$0.113/serving, 13 servings per tray, to package. Vegetables were estimated to cost \$0.04 more per pound to tray pack than to fill into #10 cans.

Canned fruits and dehydrated juices are served in both the T ration and minimum volume ration breakfasts, with the cost differential due to the items selected. Fruits used in the A ration are more costly because fresh assortments only are designated.

Costs of fresh, frozen, dehydrated and canned items, as presently procured by the military were obtained from the Federal Supply Catalog Price List.

6. **EVALUATION OF ALTERNATIVE RATION CONCEPTS.** Four alternative ration concepts were considered for combat feeding purposes. These ration concepts were selected and designed to satisfy specific system objectives, requirements, and constraints of an Army combat feeding system, thus include food items processed and preserved by several different techniques. The evaluation consisted of establishing the relative merits of the alternative ration concepts, with respect to these several factors, to determine the preferred alternatives for combat feeding applications.

a. **Ration Alternatives.**

(1) **A Ration.** The A ration, is the ration normally used in garrison food service operations. To large extent, the foods comprising this ration are fresh or frozen, and tend to be perishable in natura. For two reasons, it is not considered as being a particularly viable

TABLE C-7

ESTIMATED LOGISTICAL PARAMETERS  
(PER 100 RATIONS<sup>a</sup>)

	Standard B		MCI <sup>b</sup>		MRE <sup>b</sup>	
	lb	ft <sup>3</sup>	lb	ft <sup>3</sup>	lb	ft <sup>3</sup>
NP <sup>c</sup>	396.3	11.1	650.0	19.8	388.0	23.2

NOTES:

<sup>a</sup>A ration consists of three meals, breakfast, lunch, and dinner.

<sup>b</sup>MCI = Meal, Combat, Individual

MRE = Meal, Ready-to-Eat, Individual

<sup>c</sup>NP = Nonperishable

TABLE C-8

RECIPE/ITEM AND MENU CATEGORY LOGISTICAL DATA  
(PER 100 PORTIONS)

Menu Category	Recipe/Item	Fresh/Frozen		Thermo-Processed		Dehydrated/Dehydrated/Compressed		Tray Pack	
		Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>
Entree-Roast	Roast Beef, Gravy	44.8	0.726	2.4	0.049	-	-	87.8	2.013
	Roast Turkey, Gravy	45.8	1.063	2.2	0.045	-	-	-	-
	Baked Chicken	56.8	1.592	2.7	0.061	-	-	-	-
	Roast Ham, Gravy	45.0	1.055	2.6	0.054	-	-	69.4	1.589
	Smoky Pork	-	-	-	-	-	-	78.8	1.801
	Average	48.1	1.109	2.5	0.053	-	-	-	-
Entrees-Steak	Grilled Steak	47.4	1.058	-	-	22.0	1.678	69.4	2.013 <sup>a</sup>
	Swiss Steak	48.7	1.225	19.0	0.456	31.6	1.983	87.8	2.013
	Pork Slices	33.9	0.800	0.3	0.004	18.9	1.472	-	-
	Average	43.4	1.028	6.4	0.153	24.2	1.711	78.6	2.013
Entree-Fried	Fried Chicken	54.2	1.542	4.6	0.089	-	-	75.5	3.02
	Fried Shrimp	24.6	1.055	3.0	0.060	12.6	0.981	-	-
	Average	39.4	1.299	3.8	0.075	12.6	0.981	75.5	3.020

TABLE C-8

RECIPE/ITEM AND MENU CATEGORY LOGISTICAL DATA (Cont'd)  
(PER 100 PORTIONS)

Menu Category	Recipe/Item	Fresh/Frozen		Thermo-Processed		Dehydrated/Compressed		Tray Pack	
		Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>
Entree-Casserole	Spaghetti/Meatballs	41.6	0.975	57.0	1.690	44.4	2.122	131.8	3.020
	Beef Stew	65.4	1.589	9.5	0.224	19.5	0.674	82.4	1.887
	Lasagna	42.1	1.403	32.5	1.199	27.2	1.649	81.5	1.868
	Chicken A La King	62.5	2.004	5.2	0.125	24.4	0.771	65.9	1.509
	Chile Con Carne	28.4	0.641	20.7	0.558	29.5	1.557	82.4	1.887
	Average	48.0	1.322	25.0	0.759	29.0	1.355	88.8	2.034
Starch	Mashed Potatoes	49.7	1.342	1.2	0.033	9.2	0.242	41.9	1.009
	French Fried Potatoes	51.7	1.532 <sup>b</sup>	-	-	12.3	0.732 <sup>c</sup>	-	-
	Hashed Brown Potatoes	35.3	1.051 <sup>b</sup>	-	-	12.0	0.544	-	-
	Shoestring Potatoes	-	-	-	12.3	0.878	-	-	-
	Average	45.6	1.308	0.4	0.011	12.3	0.878	41.9	1.009
Vegetables	Corn	20.3	0.795	-	-	31.3	0.734	31.6	0.725
	Peas	20.3	0.795	-	-	30.3	0.740	31.6	0.725
	Beans	18.0	0.706	-	-	29.2	0.731	31.6	0.725
	Carrots	22.5	0.492	-	-	30.2	0.722	-	-
	Spinach	20.3	0.795	-	-	28.5	0.728	-	-
	Average	20.3	0.717	-	-	29.9	0.731	31.6	0.725
		6.6	0.650	4.0	0.132				

TABLE C-8

RECIPE/ITEM AND MENU CATEGORY LOGISTICAL DATA (Cont'd)  
(PER 100 PORTIONS)

Menu Category	Recipe/Item	Fresh/Frozen		Thermo-Processed		Dehydrated/Compressed		Tray Pack	
		Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>
Soups	Chicken Noodle	-	-	28.9	0.684	5.5	0.130	-	-
	Pea	-	-	28.9	0.684	10.0	0.347	-	-
	Tomato-Vegetable	-	-	28.9	0.684	5.3	0.193	-	-
	Average	-	-	28.9	0.684	6.9	0.223	-	-
Salad	Cole Slaw	17.0	0.186	6.9	0.899	3.4	0.102	-	-
	Lettuce	12.3	0.682	12.4	0.352	-	-	-	-
	Tossed Vegetable	25.7	1.218	12.4	0.352	-	-	-	-
	Spring	23.4	1.189	12.4	0.352	-	-	-	-
	Fruit Salad	-	-	31.3	0.750	10.8	1.429	-	-
Average	9.6	0.819	11.0	0.489	31.3	0.750	10.8	1.429 <sup>d</sup>	
Dessert	Pudding	1.2	0.019	10.4	0.304	-	-	34.2	0.755
	Brownies	-	-	20.1	0.639	-	-	-	-
	Cookies	-	-	-	-	14.5	0.430	-	-
	Apple Crisp	2.6	0.047	34.6	0.835	15.9	0.483	65.9	1.510
	Cake	0.6	0.009	18.4	0.578	17.0	0.550	20.5	1.390
Average	1.5	0.025	20.9	0.589	-	-	15.8	0.488	

TABLE C-8  
 RECIPE/ITEM AND MENU CATEGORY LOGISTICAL DATA (Cont'd)  
 (PER 100 PORTIONS)

Menu Category	Recipe/Item	Fresh/Frozen		Thermo-Processed		Dehydrated/Dehydrated/Compressed		Tray Pack	
		Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>
Fruit	Peaches	38.8	1.431	-	31.0	0.724	-	31.6	0.725
	Pears	36.9	1.099	-	30.5	0.729	-	31.6	0.725
	Apples	39.6	0.912	-	31.0	0.724	6.3 <sup>e</sup>	31.6	0.725
	Average	38.4	1.148	-	30.8	0.726	6.3	31.6	0.725
Juices	Grapefruit	11.0	0.223	-	38.0	1.040	5.4	0.243	-
	Orange	11.0	0.223	-	38.0	1.040	5.4	0.243	-
	Average	11.0	0.223	-	38.0	1.040	5.4	0.243	-
Miscellaneous	Ice Cream	19.3	0.525	-	-	-	-	-	-
	Coffee	-	-	-	2.9	0.094	0.8	0.060	-
	Milk	55.8	0.879	-	-	-	6.3	0.229	-
	Beverage Base, Assorted	-	-	-	-	-	7.5	0.250	-
	Soda, Assorted	-	-	-	-	-	-	-	-
	Carbonated	-	-	-	12.9	0.293	-	-	-
Breakfast Meats	Sausage	21.7	0.557	-	-	-	-	21.1	0.492
	Ham	-	-	-	-	-	-	23.0	0.527
	Bacon	13.3	0.313	-	-	-	-	5.6	0.120
	Average	17.5	0.435	-	-	-	-	16.6	0.380

TABLE C-8

RECIPE/ITEM AND MENU CATEGORY LOGISTICAL DATA (Cont'd)

(PER 100 PORTIONS)

Menu Category	Recipe/Item	Fresh/Frozen		Thermo-Processed		Dehydrated/Compressed		Tray Pack	
		Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>	Perishable Lb	Non Perishable Ft <sup>3</sup>
Eggs	Eggs	27.1	1.529	-	-	-	-	-	-
	Omelets	28.1	1.549	5.2	0.231	-	-	30.8	0.755
	Average	27.6	1.539	2.6	0.116	-	-	30.8	0.755
Pancakes	Pancakes	2.6	0.041	30.0	0.798	-	-	15.75	0.508
Muffins	Blueberry Muffin	8.3	0.362	21.9	0.483	-	-	28.4	0.844
Cereals	Hot	27.9	0.429	7.5	0.145	-	-	10.3	0.347
	Ready to Eat	55.8	0.879	10.0	1.190	16.3	1.419	-	-
	Average	41.9	0.659	8.8	0.668	16.3	1.419	10.3	0.347

NOTES:

<sup>a</sup>Irradiated form

<sup>b</sup>Average for fresh/frozen

<sup>c</sup>French fried potato mix

<sup>d</sup>For dehydrated form first row represents dehydrated form, second row represents dehydrated compressed.

<sup>e</sup>Applesauce

TABLE C-9

LOGISTICAL PARAMETER ESTIMATES FOR CONCEPT MENU CYCLES  
(100 RATIONS PER DAY FOR 14 DAYS)

Menu Category	Form	T Ration			Minimum Volume			Garrison "A" Ration				
		Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving		
Entree-Roast	T	78.6	1.801	8	628.8	14.408	8	828.8	14.408	.	.	.
	F-P	48.1/	1.109/	.	.	.	.	.	.	8	384.8/	8.872
	-NP	2.5	0.053	.	.	.	.	.	.	.	20.0	0.424
Entree-Steak	T	78.6	2.013	7	550.2	14.091	1	78.6	2.013	.	.	.
	D	24.2	1.711	.	.	.	4	96.8	6.844	.	.	.
	F-P	43.4/	1.028	.	.	.	.	.	.	6	260.4	6.168
Entree-Fried	-NP	6.4	0.153	.	.	.	.	.	.	.	38.4	0.918
	T	75.5	3.020	4	302.0	12.080	3	226.5	9.060	.	.	.
	D	12.6	0.981	.	.	.	1	12.6	0.981	.	.	.
Entree-Casserole	F-P	394/	1.299/	.	.	.	.	.	.	5	197.0/	6.495/
	-NP	3.8	0.075	.	.	.	.	.	.	.	19.0	0.375
	T	88.8	2.034	9	799.2	18.306	2	177.6	4.068	.	.	.
Entree-Total	D	29.0	1.355	.	.	.	9	261.0	12.195	.	.	.
	F-P	48.0/	1.322/	.	.	.	.	.	.	9	432.0/	11.898/
	-NP	25.0	0.759	.	.	.	.	.	.	.	225.0	6.831
Entree-Total					2280.2	58.885		1481.9	49.569		1274.2/	33.433/
											302.4	8.548

- T = Tray Pack
- F = Fresh or frozen recipe
- P = Perishable
- NP = Nonperishable
- B = Canned
- D = Dehydrated
- DC = Dehydrated-compressed
- A = Augmented

TABLE C-9

LOGISTICAL PARAMETER ESTIMATES FOR CONCEPT MENU CYCLES (Cont'd)  
 (100 RATIONS PER DAY FOR 14 DAYS)

Menu Category	Form	T Ration			Minimum Volume			Garrison "A" Ration				
		Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving		
Starch	T	41.9	1.009	16	670.4	16.144	-	-	-	-	-	-
	B	12.3	0.878	8	98.4	7.024	-	-	-	-	-	-
	D	11.2	0.506	-	-	-	21	235.2	10.626	20	224.0	10.120
	F-P	45.6	1.308/	-	-	-	-	-	-	3	136.8/	3.924/
	-NP	0.4	0.011	-	768.8	23.168	-	-	-	1.2	0.033	-
Starch-Total					768.8	23.168		235.2	10.626		136.8/	3.924/
											225.2	10.153
Vegetables	T	31.6	0.725	25	790.0	18.125	-	-	-	-	-	-
	D	6.6	0.650	-	-	-	7	46.2	4.550	4	26.4	2.600
	DC	4.0	0.132	-	-	-	17	68.0	2.244	-	-	-
	B	29.9	0.731	-	-	-	-	-	-	3	89.7	2.193
	F-P	20.3/	0.717/	-	-	-	-	-	-	18	365.4/	12.906/
Vegetable-Total					790.0	18.125		114.2	8.794		365.4/	12.906/
											116.1	4.793
Soups	D	6.9	0.223	14A	96.6A	3.122A	28	193.2	6.244	-	-	-
	B	28.9	0.684	14A	404.6A	9.576A	-	-	-	28	808.2	19.152
Soup-Total					501.2A	12.698A		193.2	6.244		808.2	19.152
Salads	B	31.3	0.750	1A	31.3A	0.750A	1	31.3	0.750	-	-	-
	D	10.8	1.428	4A	43.2A	5.716A	4	43.2	5.716	-	-	-
	DC	3.4	0.102	3A	10.2A	0.306A	3	10.2	0.306	-	-	-
	F-P	19.6/	0.819/	20A	392.0A	16.380A	20	392.0/	16.380/	28	548.8/	22.93
	-NP	11.0	0.489		220.0A	9.780A		220.0	9.780		308.0	13.69
Salad Total					392.0A/	16.380A		392.0	16.380/		548.8/	22.93
					304.7A	16.552A		304.7	16.522		308.0	13.69

TABLE C-9

LOGISTICAL PARAMETER ESTIMATES FOR CONCEPT MENU CYCLES (Cont'd)  
 (100 RATIONS PER DAY FOR 14 DAYS)

Menu Category	Form	T Ration			Minimum Volume			Garrison "A" Ration			
		Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	
<b>Desserts</b>											
Cake, Pie, Pudding	T	40.2	1.218	19	763.8	23.142	-	-	-	-	-
	D	15.8	0.488	-	-	-	20	316.0	9.760	-	-
	F-P	1.5/	0.025/	-	-	-	-	-	-	9	13.5/
	-NP	20.9	0.589	-	-	-	-	-	-	-	188.1
Fruits	8	30.8	0.726	9	277.2	6.534	8	246.4	5.808	-	-
	F-P	38.4/	1.148/	-	-	-	-	-	-	5	192.0
Ice Cream	F-P	19.3/	0.525/	-	-	-	-	-	-	14	270.2
<b>Dessert-Total</b>					1041.0	29.676		562.4	15.568		475.7/
											188.1
											13.315/
											5.303
<b>Beverages</b>											
Powdered Beverages	D	7.5	0.250	48	360.0	12.000	46	345.0	11.500	21	157.5
	B	12.9	0.293	-	-	-	-	-	-	28	361.2
Carbonated Soda	D	0.8	0.060	18	14.4	1.080	-	-	-	-	8.204
Coffee	8	2.9	0.094	-	-	-	16	46.4	1.504	17	49.3
	D	6.3	0.229	19	119.7	4.351	17	107.1	3.893	-	1.598
Milk	F-P	55.8	0.879	-	-	-	-	-	-	19	1060.2
					494.1	17.431		498.5	16.897		16.701
<b>Beverage-Total</b>											1060.2/
											568.0
											16.701/
											15.052

TABLE C-9

LOGISTICAL PARAMETER ESTIMATES FOR CONCEPT MENU CYCLES (Cont'd)  
 (100 RATIONS PER DAY FOR 14 DAYS)

Menu Category	T Ration			Minimum Volume			Garrison "A" Ration		
	Form	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>
Breakfast									
Meats	T	16.6	0.380	14	232.4	5.320	14	232.4	5.320
	F-P	17.5/	0.435/	-	-	-	-	245.0/	6.090/
Eggs	T	30.8	0.755	8	246.4	6.040	-	-	-
	D	9.6	0.437	-	-	-	6	57.6	2.622
	F	27.6/	1.539/	-	-	-	-	193.2/	10.733/
Pancakes	T	40.5	3.624	6	243.0	21.744	-	-	-
	D	15.8	0.508	-	-	-	8	126.0	4.064
	F-P	2.6/	0.041/	-	-	-	-	18.2/	0.287/
	-NP	30.0	0.798	-	-	-	-	210.0	5.586
Entree-Total				721.8	33.104		416.0	12.006	
Starch	T	41.9	1.009	8	335.2	8.072	-	-	-
	D	11.2	0.506	-	-	-	6	67.2	3.036
Starch-Total				335.2	8.072		67.2	3.036	

TABLE C-9

LOGISTICAL PARAMETER ESTIMATES FOR CONCEPT MENU CYCLES (Cont'd)  
(100 RATIONS PER DAY FOR 14 DAYS)

Menu Category	T Ration			Minimum Volume			Garrison "A" Ration		
	Form	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>	Frequency of Serving	Lb	Ft <sup>3</sup>
Juice/Fruit									
Juice	D	5.4	0.243	9	48.6	2.187	7	37.8	1.701
Fruits	B	30.8	0.726	5	154.0	3.630	6	184.8	4.356
	D	6.3	0.179	1	-	-	1	6.3	0.179
	F-P	31.6	0.72E	-	-	-	-	442.4	10.150
Juice/Fruit - Total					202.6	5.817		228.9	6.236
Pastry/Muffins	T	20.5	1.390*	8	164.0	11.120	-	-	-
	D	28.4	0.844	-	-	-	6	170.4	5.064
	F-P	8.3/	0.362/	-	-	-	-	58.1/	2.534/
	-NP	21.9	0.483	-	-	-	7	153.3	3.381
Pastry/Muffins - Total					164.0	11.120		170.4	5.064
Cereals									
Assorted Cereals	D	10.3	0.347	7A	72.1A	2.492A	8	82.4	2.776
	B	16.3	1.419	5A	81.5A	7.095A	5	81.5	7.095
	F-P	41.9/	0.659/	-	-	-	-	502.8/	7.908/
	-NP	8.8	0.668	-	-	-	12	105.6	8.016
Cereals - Total					153.6A	9.524A		16.39	9.871

\*Same as Cake.

**TABLE C-10**  
**RATION COSTS**

Component	T Ration	Minimum Volume Ration	A Ration
<b>Breakfast</b>			
Fruit or Juice	\$ 1.080	\$ 0.942	\$ 1.615
Eggs, Potatoes, Pastry or Pancakes	9.754	3.195	2.895
Breakfast Meats	3.760	3.843	2.880
Cereal	1.422 <sup>1</sup>	1.422	1.464
<b>Lunch/Dinner</b>			
Entree	22.002	23.857	17.303
Vegetable	1.826	4.117	2.171
Starch	3.501	1.972	2.092
Dessert	6.341	3.410	3.551
Bread <sup>2</sup>			
Hot/Cold Beverages and Milk	6.480	5.288	4.674
Salad	3.731 <sup>1</sup>	3.731	2.869
Soup	1.913 <sup>1</sup>	1.913	2.282
Totals Per Person for 14 Day Cycle	\$54.744 \$ 7.066	\$53.690	\$43.796
<b>\$/Ration</b>	<b>\$ 3.91</b> <b>.50<sup>1</sup></b>	<b>\$ 3.83</b>	<b>\$ 3.13</b>

**NOTES:**

<sup>1</sup> Augmentation costs.

<sup>2</sup> To be provided by Automated Bakery System.

alternative for combat feeding operations. First, such a ration would necessitate a reliable refrigerated transport and storage capability from the initial source to the ultimate point of consumption, which would be extremely difficult, if not impossible, to establish and maintain under active combat conditions. Secondly, the A ration, because of the relatively short shelf life of the food items involved, cannot be effectively stockpiled as war readiness reserves. However, this does not mean that the A ration cannot eventually be employed as a bulk operational ration in the theater, where the situation permits and when it can be adequately supported.

(2) B Ration. The current B ration is a non-perishable, bulk operational ration, planned for a ten day menu cycle. It consists largely of dehydrated, dehydrated compressed, thermally processed items, thereby reducing the logistic requirements and allowing for reasonably long storage periods.

(3) Minimum Volume Ration. The minimum volume ration concept was developed for those situations where transportation resources may be limited, and therefore constrain the scope of combat feeding operations. Transportation requirements are determined primarily as a function of product weight and cube, but because of their low density, transportation of subsistence supplies are generally cube dependant rather than weight limited. Thus, the reasons for designing a minimum cube ration, rather than trying to minimize weight. This ration concept includes predominantly dehydrated compressed vegetables, starches, soups, etc. Since dehydration reduces cube only marginally and many of the meal components other than the antree cannot be acceptably compressed, they were selected in other preserved forms that provide for higher troop acceptance and reduced preparation labor requirements, without significantly exceeding the volume of similar dehydrated items. This kind of ration would compare favorably to the B ration in terms of storage and logistical implications.

(4) T Ration. The motivation underlying the T ration design was to achieve flexibility and maximum responsiveness. Flexibility is considered primarily in terms of the adaptability of the ration to a broad range of combat conditions and operational requirements, and its compatibility with the remainder of the Army food service program.

By responsiveness is meant the total elapsed time required to react to planned and unplanned requirements to prepare, deliver, and serve hot meals, to troops under a variety of conditions. This attribute of combat food service is critically important where forces will be highly mechanized and widely dispersed, and the forward areas of the combat will be characterized by the fluid, rapidly changing battle lines, and by the intensity of combat. Meal opportunities will be somewhat irregular, at best, and the troops will be largely dependent on individual combat rations, such as the Meal-Ready-to-Eat, for subsistence. A high response ration concept can reduce this dependency on individual rations, and materially increase the likelihood and frequency of hot meals being available on short notice to troops in combat.

Food items selected for this ration concept should consist largely of totally prepared items. In general, such foods may be frozen, irradiated, dehydrated/compressed, or thermally processed. Frozen foods were eliminated from consideration because of the refrigerated storage and transport requirements. Irradiated foods are not expected to be available in sufficient

quantity in the 1990 time frame to be seriously considered as the basis for a military ration. For the kinds and variety of foods that can be successfully dehydrated and compressed, some degree of skill is required for reconstitution and a significant amount of time and labor is needed to prepare them for serving. Also, in general, they cannot obtain the same high degree of acceptance by the consumer as foods processed and prepared in other forms. Therefore, the high response ration concept is currently envisioned as consisting of fully prepared, thermally processed items, requiring only heating prior to serving.

b. **Evaluation Factors.** The total elapsed time from notification to prepare a meal, until it is delivered and ready for serving, either onsite or at a remote location, determines responsiveness. The T ration clearly is the most responsive for onsite feeding. For remote site feeding, a ration concept which facilitates preparation, heating and/or cooking on the move will be most responsive. Since the T ration requires only heating prior to serving, and the necessary equipment can be developed with present technology which allows for heating in transit with no food service worker involvement, it is also most responsive for this application.

All of the other alternatives require some food service worker labor and additional time for the preparation and/or rehydration stages, and possibly for heating and cooking, either prior to transport or at the final destination. The A and B rations are about equal in terms of responsiveness, depending upon the exact menu items. For example, dehydrated pork chops (B ration) would take a longer time to prepare than fresh pork chops (A ration), but on the other hand, canned beef stew (B ration), takes less time than preparing beef stew from all of its ingredients (A ration). However, on the average, these rations do not differ appreciably in this respect. The entree portion of a meal typically requires the longest lead time from start of preparation to serving. Since the minimum volume ration contains a large proportion of T ration type entrees, it is generally more responsive than the A or B type rations.

Many variables affect the acceptance of a ration as served to the individual soldier. These include preference, initial quality, preparation and handling, holding time and serving temperature as well as less tangible considerations.

Preference pertains to the menu design rather than to the operating system effectiveness. Regardless of the ration concept finally selected, the resulting menu should be developed to maximize preference, which will promote consumption and enhance nutritional maintenance of the troops.

A major condition of acceptance is the quality of the food as served. The initial quality of the ration can only be reduced, even under optimum conditions, through the preparation, handling, cooking/heating, holding and serving cycle of combat feeding. Generally, the initial quality of the A ration, which includes a large proportion of fresh and frozen products, is higher than for the remaining ration concepts, which are comprised of processed and preserved items. Even so, this does not necessarily imply that the A ration will sustain the highest quality until served, which is certainly the more important criterion for troop acceptance. The ration that maximizes final quality, given the constraints, conditions, and parameters of the field environment under which the combat feeding system must operate, should determine the preferred concept.

This final quality is determined, in part, by the length of time for which the rations are held between cooking, heating and serving. Ideally, the rations should be served immediately after cooking, with no holding period. In practice, however, the unsettled nature of the combat environment may require that rations be prepared and then held for indeterminate periods of time, because of uncertainty as to when a unit will be able to subsist, or as a result of unexpected changes in conditions which prohibit the troops from subsisting at the scheduled time. Thus, a combat ration should be such that excessive holding times are eliminated, or that it suffers little degradation of quality, if it is necessary to hold it for any length of time. The T ration appears to be best suited to this requirement, since it may be heated enroute, or within a short time after arrival at the point of service; it can be maintained at fairly low temperatures for reasonable periods, with no further substantial loss in quality; and, within limits, can even be withdrawn from the heating process and used at another time, provided the package remains unopened.

Another important relationship to the final quality of the ration is the serving temperature of the food. The distance between the field kitchen and a remote site, and unexpected troop movements, which make it difficult to locate units being subsisted, contribute to the length of time before prepared foods can be served. This time may be considerable, up to 3-4 hours, or more. Therefore, food has to be delivered in either insulated or heated containers; otherwise it becomes cold, and unacceptable. Although heated containers are not practical at the present time, they may become feasible in the future. If insulated containers are filled with food that is hot enough, or food is held in heated containers at temperatures high enough, to avoid this problem, the residual heat continues the cooking process during the time while in transport, and the food becomes overcooked and less acceptable. In terms of minimizing this source of degradation to food quality, the T ration is superior to the other alternatives.

Food service personnel are probably the most important variable affecting the final quality of the food serviced. Their level of training, experience, skills, ability, motivation, etc. vary tremendously. Identical rations, prepared on the same equipment, in the same environment, and under the same conditions, may vary considerably in acceptance, when served, because of differences in the characteristics of the responsible food service personnel. A ration concept which does not rely on a high degree of skill or training in food preparation, and employs simple, easily operated equipment, decreases the possibility of producing poor quality food. The T ration requires the least labor and skills, and uses the simplest equipment, as compared to the other ration concepts.

The A and B ration concepts, based upon extensive field observations, require high levels of food service worker effort. In peacetime, these food service workers are normally in a garrison, where A rations are utilized, and only occasionally are they in the field where they gain any experience with B rations. Besides being somewhat demanding and labor intensive, both rations need a well equipped field kitchen for preparation. The minimum volume ration contains a reasonably large number of the same kind of entrees as the B Ration, so it rates higher in this regard than either the A or B ration.

Except for food, labor is the largest cost of combat feeding operations. With the T ration, all preparation labor has already been added, and it requires only heating prior to serving.

In effect, nearly all preparation labor in the field is eliminated, and the heat and serve functions can be performed by lower skilled, less costly personnel. However, it is important to note that preparation is only one component of the total labor requirement. Based upon extensive work measurement data in the field exercises,<sup>1,2</sup> the productive man hours expended on pot and pan sanitation can even exceed that expended on ration preparation. Thus, further reductions in labor can be obtained if the T ration is packaged to heat and serve directly from a container which is disposable.

Two possible packaging forms for the T ration have been identified, the tray pack and the flex-pack. The tray pack is rigid container, while the flex-pack is a non-rigid pillow type container. In either case, the contents can be heated and served directly from the package. However, the non-rigidity of the flexible package either requires an additional container be provided, into which to transfer the contents of the package prior to serving, or a frame from which to suspend the package for serving purposes. Both approaches are unnecessarily complicated and more costly than the tray pack. Labor requirements may also be higher because of the additional transfer and handling required, and if the container or frame are not disposable, by the additional sanitation requirements. Therefore, in terms of minimizing labor, the tray pack would appear to be a better option than the flex-pack for the T ration concept.

The A and B rations are both much more labor intensive, and about equal in total labor requirements. The minimum volume ration, which makes extensive use of the same entrees as in the T ration, lies somewhere between these extremes. Another aspect of personnel costs to be considered are those incurred in peacetime to maintain combat readiness for mobilization purposes. If the combat staffing exceeds the peacetime garrison requirement, the excess cooks must nevertheless be maintained in the peacetime environment, which represents a major cost penalty with the current system.

**7. CONCLUSIONS.** Foods and menus to be served in the combat zone to infantry and crews, and other small units are described. It has been adequately demonstrated that the T ration is the preferred alternative with respect to maximum responsiveness, high troop acceptance, and other relevant characteristics, and should be adopted as the bulk combat ration. The only disadvantage of the T ration compared to the other ration concepts is its higher weight and cube. If logistical constraints on food service operations become important, then the minimum volume ration is preferred to the B ration.

During combat, at least one hot meal per day, if conditions permit, consisting of thermally-stabilized, convenience types of foods in tray packs, that is, the T ration, will be delivered to the troops. Initially, the ration will be employed in the support and reserve areas. Certain other fresh foods (milk, salads, etc.) will be made available as soon as practicable. Three hot meals per day will be served in all areas of the theatre as soon as it is reasonable to do so. The menus for these meals will continue to add further fresh and frozen items, so that eventually an A ration menu will thus be available.

<sup>1,2</sup> Baritz, S., et. al. *The Camp Pendleton Experiment in Battalion Level Field Feeding*. Technical Report 7T-4-OR/SA. Natick, MA: US Army Natick R&D Command, July 1976.

When the conflict ceases, the total force will eventually convert to three hot meals per day based on the A ration menu.

## APPENDIX D

### FOOD SERVICE EQUIPMENT

1. **INTRODUCTION.** The food service equipment requirements of the Army in the field in the 1990 time frame are identified. In general, the equipment must be compatible with the anticipated menu, food packaging techniques, food preservation methods and other factors. Further such equipment concepts must reflect the need for reduced labor requirements, be capable of providing at least one hot meal per day to combat personnel, insure consistent cooking and heating results, be able to prepare food from the raw state, efficiently use available energy sources, be easy to maintain and, provide effective sanitation to reduce the likelihood of food borne illness to a minimum.

In accordance with these objectives and requirements, such factors as heat transfer, energy options, equipment design philosophy, shelters, mobility, habitability, sanitation and waste disposal are discussed and evaluated. Specific equipment and kitchen concepts are recommended for further development.

2. **ENERGY CONSIDERATIONS.** The primary energy source used today by the Army in the field is gasoline, but a shift to diesel fuels will occur in the future.<sup>1</sup> Aside from these, other energy sources which may reasonably be considered for long range food service applications include liquid petroleum gas, electricity and hydrogen gas.

The major variables to be considered in the selection of energy sources are responsiveness, availability, cost, logistics, labor and safety. Responsiveness refers to those factors which affect the length of time to heat or cook foods, such as the time it takes to make a cooking device operational and the efficiency of the device. Labor relates to the level of effort required for operating and maintaining a cooking device, as well as the skills required to carry out these functions. Safety pertains to any hazards associated with the use of cooking devices because of the type of energy source selected. Availability, cost and logistics are self explanatory.

a. **Gasoline and Diesel Fuel.** Within the existing field feeding systems, both the M-2 burner unit, used with the M-1950 Field Range, and the immersion heater, used to heat water in G. I. cans for sanitation purposes, are gasoline fired. In a typical company sized field kitchen, during a peak period of activity, the fuel consumption amounts to about 6.5 gallons per hour, which would be about the same with diesel fuel. However, there is a tendency to leave burner units running, once they have started, so that the actual daily fuel consumption per kitchen is much more than actually required. Also, there is no question that burner units available today are inefficient, putting more heat into the kitchen than into the food being cooked, but technologically, an improvement in efficiency of 50% or more is a distinct possibility. Such efficiencies would also affect labor requirements, because burner units normally are refueled from five gallon fuel cans and lighted off some distance from the point of use, for safety reasons and then carried to the kitchen and placed in the cooking equipment.

<sup>1</sup>US Army Quartermaster School. **Fuel Type for Field Kitchen Use, Time Frame 1980-1990.** Letter Ft. Lee, Virginia: 18 November 1975.

Therefore, improvements in fuel usage efficiency will reduce both labor requirements and the logistics burden.

Perhaps the most obvious disadvantages of gasoline is the inherent danger of the fire and explosion hazard, although diesel is a less volatile fuel. One approach to reducing this risk, which is now under development, is to distribute the fuel from a remote source, and to install improved ignition and control mechanisms on the burner equipment.

b. **Liquid Petroleum Gases (LPG).** This type fuel was used in modified M-2 burner units, on a limited basis, during the Viet Nam conflict. Although some of the problems of operating gasoline-fired equipment were eliminated, e.g., maintenance, refueling, start-up, replacement of generators, experience indicated the LPG just is not practical for general use in the field, because it requires another completely separate fuel handling system. This added dimension to logistics operations cannot be entirely justified for the benefits realized. Consequently, it is recommended that LPG not be considered for food service in a combat theater.<sup>2</sup>

c. **Electricity.** In terms of electrically operated equipment, there are several factors to consider. First of all, because electricity may not be available, or if it is, the current characteristics of the electrical systems may not be compatible with the equipment being used, it will be necessary for the military to rely exclusively on its own fuel driven generating equipment. A large family of standard, gasoline and diesel engine driven generators is available for a variety of uses, as indicated in Table D-1. Such equipment requires skilled maintenance personnel and a ready supply of spare parts, and even then, back-up generating units are usually necessary in case of power failure. In addition, many of these generators are massive and heavy, requiring either dedicated transporters or materials handling equipment for loading and unloading them from their carriers.

The power demand of electrical kitchen equipment is substantial, Table D-2, requiring more than 30 kw just to operate a single oven and griddle. Although the fuel requirement for a 60 kw diesel generator, needed to service a company field kitchen, is only 6 gallons/hour the generator must be operated for as long as any electrical equipment is being used; often as much as 24 hours/day, which would require up to 144 gallons of fuel per day. A comparable kitchen, using fuel fired equipment, would require no more than 40 gallons of fuel per day. It could even be provided with a small 3 kw generator, which uses about 0.8 gallons per hour, to operate powered burner units, slicers, choppers, pumps, etc., at a penalty of only a few additional gallons of fuel per day.

All factors considered, the possible advantages of electrical energy may not warrant the added costs that would be incurred as compared to diesel operations.

d. **Hydrogen.** Hydrogen as a potential energy source for combat food service, cannot be totally ignored. Electrolysis is probably the most achievable method of producing hydrogen in the field. Currently, one of the largest electrolysis plants ever to be built, producing about

<sup>2</sup>Op. cit., US Army Quartermaster School.

TABLE D-1

CHARACTERISTICS OF ELECTRICAL POWER SOURCES<sup>3</sup>

Rating, kw	Engine Type	Weight, lbs	Fuel Consumption gallons/hr
5	Diesel	900	0.57
5	Gasoline	488	1.4
10	Gasoline	850	2.4
10	Diesel	1,100	1.09
15	Diesel	3,000	1.5
30	Diesel	3,500	3.0
60	Diesel	5,000	6.0
100	Diesel	7,000	8.5
200	Diesel	10,500	10.0

<sup>3</sup>Lanza, R.J. Evaluation of Energy Requirements for Field Kitchens Using the Bare Base Kitchen as a Baseline. Internal Memorandum. Natick, MA.: US Army Natick R&D Command. Food Engineering Laboratory, October 1978.

**TABLE D-2**

**POWER CONSUMPTION OF VARIOUS KITCHEN EQUIPMENT<sup>4</sup>**

Griddle	14 kw
Tilt Fryer	15 kw
Oven	16 kw
Steam System	75 kw
Toaster	4-6 kw
Ice Machine	4-6 kw
Ice Cream Maker	4-6 kw

<sup>4</sup>Op. cit., Lanza, R.

3 tons/hour, will require about 150,000 kw of electrical power for this process.<sup>5</sup> At this rate, 25 kw/lb, it would not be practical to produce hydrogen by utilizing conventional electric generating equipment. Presently, there is a major development effort to improve the efficiency of this process, thereby reducing the energy requirements. If this technology can achieve significant advances in the near future, then the advantages of hydrogen as a field fuel could become a reality, possibly even as early as the 1990 decade.

Aside from the obvious logistical advantages of being able to provide fuel near the point of consumption, other benefits of hydrogen in a field kitchen operation include instant ignition of burner units, nonpolluting by-products of heat and water, and improved safety, by eliminating the explosion hazard since the hydrogen is absorbed on a solid substrate in the hydride form.

e. **Conclusions.** Of the various energy sources examined, the Army plans to eventually convert from gasoline to diesel fuel operations, and liquid petroleum gas and hydrogen are not feasible contenders. Thus, diesel fuel and diesel engine generated electricity are the most viable energy options on which to base future equipment developments.

3. **HEAT TRANSFER CONSIDERATIONS.** Heat transfer can be achieved by conduction, convection, radiation, or a combination of these methods. The heating media, which determines the rate of heating, may be water, steam, liquid fats, air or electromagnetic waves, i.e., infrared or microwaves. The rate of heating depends upon a temperature gradient between the surface and center of food mass. The larger the temperature gradient, the more rapid the heating, within the constraints of the maximum temperature which the food can tolerate without adversely affecting the quality of the food product. In general, microwave and infrared radiation heating is faster than conduction or convection heating because the energy penetrates the surface of the food. Steam heating is more rapid than contact heating because of the much greater amount of heat transferred by the steam condensing on the food surface. For fluid media, e.g., water or air, the heating rate can be improved by forced circulation. But each of these methods have their limitations, and must also be considered from the point of view of cost, complexity and equipment requirements.

a. **Contact Heating.** This process involves heat being conducted directly to food or food containers directly in contact with a surface heated by electricity, flame, steam, or some other transfer medium, for example, frying. Where heat can be applied at several points of contact at the same time, the heating time is significantly reduced. This method might be used to heat food packaged in containers. Some means would have to be provided to insure good contact of the heat source with top and bottom or sides of the container, which may require some controlled pressure mechanism. In the case of the tray pack, it might be difficult to employ, since the container is embossed on the top and bottom to increase its strength, and this could preclude obtaining effective contact. In addition, unless the container is completely full, there will be voids or air gaps, which would also prevent the intimate contact required of this process.

<sup>5</sup>Braun, M. 1978. *Water Electrolysis - Its future role in the production of hydrogen*. Brown, Boveri & Cie. Ltd., Baden/Switzerland.

With a food container of satisfactory design, double-sided contact heating could be accomplished in the manner shown in Figure D-1. The shelves or platens may be heated electrically, or by an internal heat transfer fluid flow system. The connecting fluid lines would need to be sufficiently flexible to permit pressure to be applied to the platens to enable good contact with the containers. Such equipment would be relatively complex, fairly costly, and would likely require some degree of skill to operate. And, of course, such a device would have little use for any other kitchen application.

b. **Immersion Heating.** Foods may be heated by immersion in water, liquid fat (e.g., deep fat frying) or, possibly some other fluid media. Likewise, food packaged in containers can be heated by immersion to bring the contents up to serving temperature. When water is used, the maximum temperature is limited to the boiling point of water, so that overheating is virtually eliminated and the skill levels required are minimal. Operating with heated oil or other fluids, at higher temperatures to obtain faster heating rates, would demand greater awareness and competence on the part of the cook personnel to prevent overheating and damage to the food. Further, if oil is used with an open flame burner, there is the danger of fire or other burn hazard.

Water could be heated by electrical resistance elements inserted in the water, direct flame or electrical heating at the base of the unit, steam injection heating, circulation of water through a heat exchanger, or through the use of heat pipe technology.

Immersion heating of packaged foods is readily adaptable to combat feeding requirements. The equipment can be designed, so that hot meals delivered to the forward division area can be heated enroute, using a device powered by the vehicle electrical system, storage batteries, or a self-contained fuel-burning heater. When the package reaches serving temperature, the hot water provides a convenient holding medium to keep the food warm until served. Alternatively, the packages may be heated in an insulated container, which is then drained and used as a transporter to deliver the food. A simple design for this approach is shown in Figure D-2.

An important advantage of this method is that heated food, if not opened, can be cooled and heated again at another meal, thereby minimizing food loss and waste. Obviously, this cannot be carried to extremes, because food quality and nutritive value will be degraded by repeated heating. Also, the availability of a hot water supply after heating the food is accomplished, although not potable, can possibly be used for other purposes.

c. **Steam Heating.** Steam heating is one of the more efficient heating methods known. Swift, et. al.,<sup>6</sup> reported that a low pressure steamer consumed only 41% of the energy used by a conventional gas oven, and 31.5% of the energy required by an electric convection oven, to heat precooked, frozen food products in half-size steam table pans, which are similar to the tray pack containers. Another important result of this study, Table D-3, was that wide variations in heating time occurred between containers of food in hot air ovens, while low pressure steamers gave the most uniform heating results.

<sup>6</sup>Swift, J., Conca, S., and Tuomy, J. **Efficiency and Cost Factors in Re-thermalizing Frozen Foods in Typical Dining Hall Equipment.** Technical Report TR-78/014. Natick, MA: US Army Natick R&D Command, 1978.

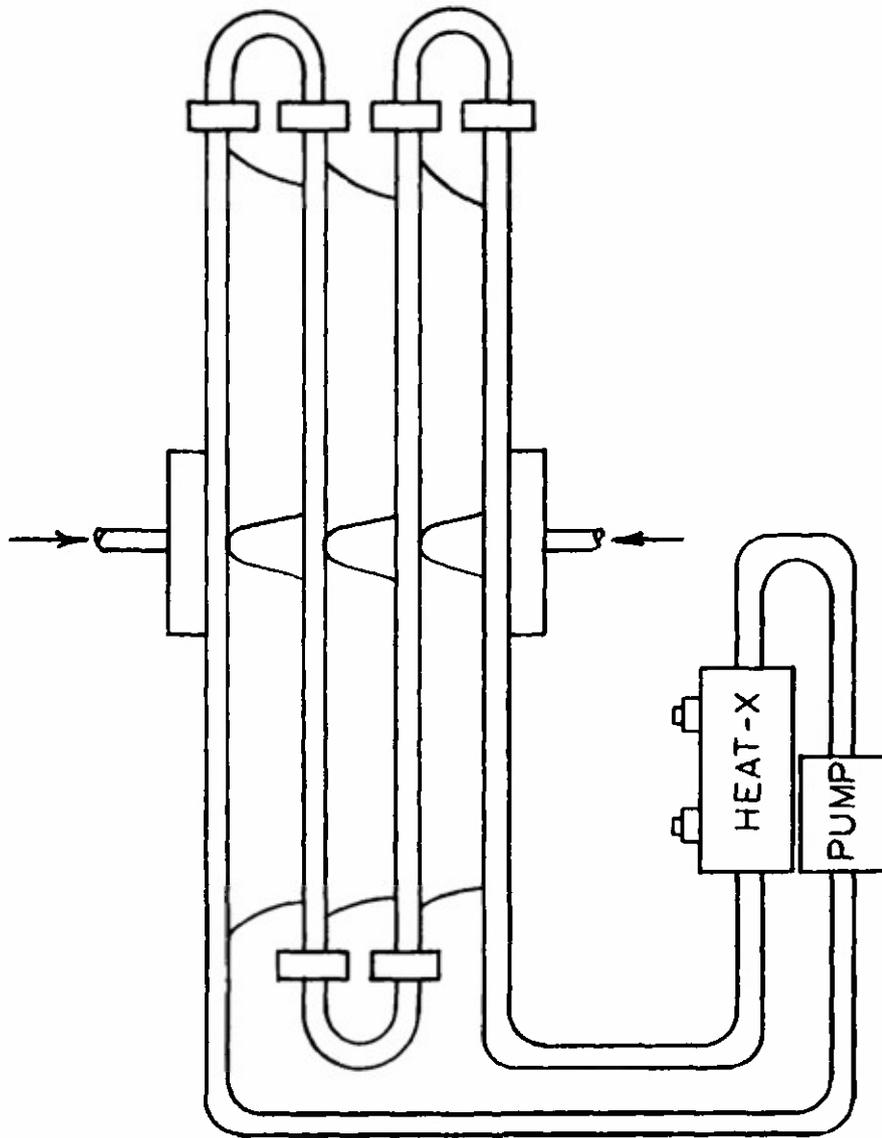


Figure D-1 Double-Sided Contact Heating of Tray Pack Containers

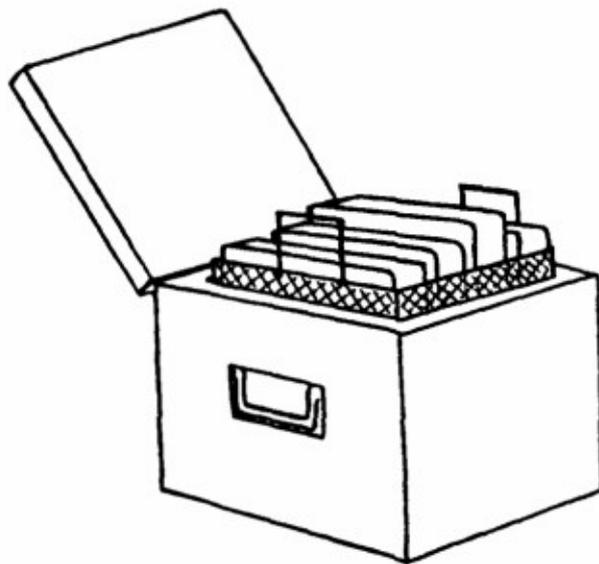


FIGURE D-2. WATER IMMERSION HEATER FOR TRAY PACK CONTAINERS.

**TABLE D-3**

**THE TIME LAG FOR HEATING MULTIPLE CONTAINERS OF FROZEN FOODS  
USING DIFFERENT ITEMS OF EQUIPMENT\***

<b>Equipment</b>	<b>Set Point °F.</b>	<b>Time Lag hrs</b>
Conventional gas oven	350	0.78
Convection gas oven	300	0.42
Convection electric oven	300	0.65
5-psig steamer	227	0.35
15-psig steamer	250	0.41

\*Adapted from Swift, et. al.<sup>6</sup>

Steam heating requires the use of a closed cabinet, an electric or fuel-fired steam generator, and somewhat sophisticated controls. Further, the skill levels demanded of food service personnel, in this case, are significantly higher than for either immersion or contact heating methods.

d. **Hot Air Heating.** Natural or forced air ovens are typically heated electrically or by flame. A blower is added in forced hot air ovens to accelerate heat transfer, so that the heating times are substantially less than for natural convection ovens. Swift<sup>7</sup> noted that forced convection was about twice as fast as natural convection when heating frozen foods in one-half size steam table pans, even though the natural convection oven was operated at higher temperatures.

Similar results were obtained in other unpublished studies using tray pack foods and a variety of different heating methods, as shown in Table D-4. It appears that the times for forced convection heating of tray pack containers does not differ significantly from that obtained with water immersion heating. But, substantial temperature variations do occur with the forced convection oven, and the slowest heating containers may not actually reach serving temperature until twenty minutes or more after the fastest heating containers. These differences are a result of the air flow patterns in the ovens, and distortion of the pattern by the presence of several containers in the oven. Oven manufacturers have not had much success in coping with this problem, except to recommend rotating the product from hot areas to cooler areas, and vice-versa, during the heating process. Because of the variations in heating rate in these ovens, operational difficulties are increased. The additional time that would have to be allowed, to insure that all containers are at proper serving temperatures, reduces the responsiveness of this method.

Another important consideration of oven heating is that the containers must be opened before heating, to prevent expansion and possibly bursting at the seams from internal pressure generated during heating operation. Thus, once such foods are heated, they either must be consumed or discarded. Further, with the lids removed from the containers, there is some evaporation loss of the product during heating.

Hot air heating requires sizable equipment, to provide adequate space for air circulation. The heat source can be electrical resistance or flame, and an electric blower would be required. A prototype field oven, heated by an M-2 burner unit, has been developed and tested at NARADCOM. Heating times for a load of twelve tray packs in this oven averaged about 60 minutes. This oven could be modified to provide additional capacity, if needed.

e. **Infrared Heating.** Both short or long wave infrared have been used in food preparation equipment. Short wave infrared is produced by electrically powered quartz tube elements, which heat very rapidly and, therefore, provide for essentially instant start-up of operations. However, the quartz elements are somewhat fragile and easily broken, thus do not appear to be appropriate for combat feeding applications. Long wave infrared is generated by electrical resistance or calrod elements, which are very durable, have high heat capacity, but are slower to reach operating temperatures. Also, long wave infrared is less efficient in

<sup>7</sup>Op. cit., Swift, J.

**TABLE D-4**

**EFFECT OF HEATING METHODS ON TIME TO HEAT SHELF STABLE FOODS  
(75°F) TO SERVING TEMPERATURE (165°F)**

<b>Heating Method</b>	<b>Temperature (° F.) Heating Media</b>	<b>Time (min)</b>
Forced Convection Oven	275	42
Forced Convection Oven	309	36
Forced Convection Oven	348	25
Water Immersion Device	180	35
Steam Jacketed Kettle	212	20
Stock Pot with M-2 Burner	212	20
Conventional Oven with M-2	400	60

directly heating the product. But, if infrared heating is to be employed, it must be long wave radiation equipment, to provide the necessary ruggedness for reliable field operations.

The size of such equipment would need to be somewhat larger than for other methods of heating, because the product or container must be exposed directly to the radiant sources, and a greater distance between the source and the container is needed to obtain uniform heating of the product. Although the heating times appear to be quite competitive with alternative methods of heating,<sup>8</sup> the size of the equipment, and power requirements necessary to provide sufficient capacity to meet combat feeding requirements, would mitigate against this concept.

f. **Microwave Heating.** Microwave heating, the most sophisticated of all of the heating methods, has previously been evaluated for field feeding applications.<sup>9</sup> A major factor in considering the use of microwave heating is the electrical power required. The power required depends, in part, on how rapidly the foods are to be heated; though increasing the power will not reduce the heating time proportionately, but rather, can cause more intensive surface heating which could damage the product. In addition, food in tray packs requires comparatively more time and power to heat, because of the relatively poor penetration of microwave energy into food over the temperature range 0°F to 160°F, and because the product is in a metal container, so that heating time occurs only from the top of the open package. With transparent containers, the heating times could be reduced by at least one half.

It is estimated that two 4 kw microwave ovens would be needed to provide the minimal capacity required for combat feeding requirements, with a resulting line power requirement of about 20 kw at 208 volts. An extensive equipment design effort would be required to insure adequate reliability and minimal maintenance, but it is conceivable that by 1990, an entirely solid state microwave oven could be available which would function under the most severe field conditions.

g. **Discussion.** The evaluation matrix approach employed by Pilger<sup>10</sup> was applied to the six heat transfer methods discussed, i.e., water contact, immersion, steam, hot air, infrared, and microwave, the results of which is shown in Table D-5. Comments on the ratings follow:

<sup>8</sup>Bernazzani, R., Blais, R., Bows, P., and Kornuta, K. **Evaluation of an Electric Radiant Heat, Quartz Oven.** Technical Report 74-8-GP. Natick MA: US Army Natick R&D Command, 1973.

<sup>9</sup>Fox, M. and Dungan, A. L. **The SPEED Field Feeding System.** Technical Report 70-11-GP. Natick, MA: US Army Natick R&D Command, 1969.

<sup>10</sup>Pilger, R. E. **Development of a Concept for a Field Kitchen Reconstitution System.** Technical Report 75-12-OR/SA. Natick, MA: US Army Natick R&D Command, 1974.

TABLE D-5

CONCEPT EVALUATION MATRIX HEAT TRANSFER METHODS

Criteria Effectiveness	Rating Range	Water Immersion	Contact Heating	Forced Hot Air	Infrared	Microwave	Steam
<b>Operational Requirements</b>							
1. Percent of Menu	8	8	8	8	8	8	8
2. Quality of Foods	10	10	7	7	5	8	8
3. Throughput	8	8	8	8	8	8	8
4. Emergency Cooking	8	8	2	4	4	5	5
5. Ease of Operation	8	8	4	6	4	4	4
6. Packaging Flexibility	3	3	1	2	2	2	2
7. Safety	8	7	6	6	4	8	4
8. Mobility	8	8	2	2	2	2	2
9. Reliability	16	16	10	14	8	10	12
10. Maintainability	8	7	6	6	5	4	5
11. Survivability	3	3	3	3	2	1	2
12. Environmental Suitability	4	4	3	3	3	3	3
13. Development Risks	8	8	7	7	5	5	5
Subtotal	100	97	67	79	60	68	68

TABLE D-5  
 CONCEPT EVALUATION MATRIX HEAT TRANSFER METHODS (Cont'd)

Effectiveness	Rating Range	Water Immersion	Contact Heating	Forced Hot Air	Infrared	Microwave	Steam
<b>Resource Requirements</b>							
1. Manpower	25	20	12	22	12	15	15
2. Development Costs	25	15	15	25	20	10	15
3. Production Costs	25	25	18	14	16	12	18
4. Operating Costs	<u>25</u>	<u>25</u>	<u>22</u>	<u>20</u>	<u>15</u>	<u>12</u>	<u>20</u>
Subtotal	100	85	67	81	63	49	68
Totals	200	182	134	160	123	117	136

(1) Effectiveness Criteria.

(a) Percent of Menu. All shelf-stable tray pack foods can be prepared by each of these methods.

(b) Quality of Foods. Water immersion heating, because of the maximum temperature limitation of the media, will least affect quality. Infrared could result in overcooking and scorching the product. Hot air heating is less risky in this regard, but produces some evaporative losses.

(c) Throughput. All methods can be operated to maintain a desired serving rate of five persons per minute for a group of 200 troops.

(d) Emergency Cooking. An immersion heating system is a kettle operation, hence can be used to cook raw foods on an emergency basis. All other methods need some kind of additional container to heat or cook raw foods.

(e) Ease of Operation. Water immersion heating is essentially self-controlling; the product temperature cannot exceed the boiling point of water. Contact heating equipment is likely to be the most difficult to load and adjust. Infrared, microwave and steam are small batch operations, and therefore require constant attention.

(f) Packaging Flexibility. Most container sizes can be heated by water immersion. Contact heating would have the greatest limitations, in that equipment adjustments would have to be made for different package sizes.

(g) Safety. There is little danger associated with the use of immersion heating, whereas steam and infrared pose serious burn hazards.

(h) Mobility. The number, size and weight of the equipment, for all methods but water immersion, imposes significant restraints on mobility. Infrared and microwave units would be most sensitive to damage during transit in a combat environment.

(i) Reliability. There are few opportunities for failure with water immersion equipment, while infrared and microwave equipment reliability could be seriously degraded under field conditions.

(j) Maintainability. Microwave heaters would require the most spare parts and technical service support. Infrared equipment maintenance would be mainly replacing infrared elements. A plumber would be required for the steam system.

(k) Survivability. Microwave equipment could present some problems in suppressing the electromagnetic signals, and both microwave and infrared equipment might be subject to damage from nearby explosions.

(l) Environmental Suitability. Extreme cold would present the greatest problem to water immersion heating. However, a good grade ethylene glycol could be used

as anti-freeze, which would permit operation even under arctic conditions. Most other equipment can be modified to operate in very cold weather.

(m) Development Risks. The greatest risks would be in the development of microwave and infrared equipment, because of the need for greater component reliability under the adverse conditions likely to be encountered.

(2) Resource Requirements.

(a) Manpower.

One person can operate the water immersion and hot air heating systems. The major problem with the water and contact heating methods is the opening of the hot containers. All other methods involve opening the containers before heating. Steam, infrared and microwave methods require greater effort, because of the more frequent loading and unloading of these ovens.

(b) Development Costs.

These ratings are based on the estimated development costs to build a working prototype. The major cost for development of a water immersion heating prototype is the compact water heater. Based on the present status of the Raytheon Company Heat Transfer Module, and the results obtained with a prototype heater developed for another application, these costs should be in the \$50,000 to \$100,000 range.

A contact heating device would be primarily a mechanical engineering effort, and would utilize a hot water heat exchanger. Development costs should be of the same order magnitude as for the water immersion system i.e., \$50,000-\$100,000.

Forced hot air ovens would require less development effort, probably little more than modifying and improving on a commercial design, which should cost about \$25-\$50,000. Similarly, the infrared system would probably be no more than a ruggedized version of the commercial model, which would involve approximately \$50-\$75,000 additional development costs.

A microwave oven would have to be higher powered than commercially available items, and modified for easier servicing, through use of plug-in components. The related cost of development would be on the order of \$75-\$125,000.

A steam heater could be developed from a commercial model, with its own integral steam generating system, hence, could probably be accomplished at relatively low cost of \$25-\$50,000.

(c) Production Costs.

Estimates of the production costs of the developed items are as follows:

Water Immersion	\$ 400
Contact Heating	1,000
Forced Hot Air	3,000
Infrared	3,000
Microwave	6,000
Steam	1,000

(d) Operating Costs.

Operating costs are estimated in terms of labor, fuel and water expended per day. The infrared and microwave system, for example, would consume significant amounts of electrical power, and therefore, substantial amounts of diesel fuel for the electric generators. A steam system would use large amounts of water. Water immersion, contact and hot air heating would be the least costly to operate.

(e) Conclusions.

Heat transfer methods were discussed to identify approaches to the design of efficient cooking and heating equipment. An efficient, simple, essentially fool-proof method of heating tray pack rations in the field is required, but other cooking processes such as frying, oven baking, and roasting also need to be optimized.

On the basis of this evaluation, water immersion heating is the clear choice for use in combat. Other heating studies also support this conclusion, therefore, a water immersion heating system for shelf stable foods is recommended.

Forced convection hot air heating would appear to be the method of choice for baking and roasting operations, though improved air flow techniques to insure more uniform results are needed. Some additional heating capability would also be desirable, in the event electrical power to operate the air blowers is not available. Direct burner heating is a viable alternative for this purpose.

#### 4. EQUIPMENT DESIGN PHILOSOPHY.

a. Commonality. Food service equipment should be designed to have as much commonality with garrison equipment as possible, so that food service personnel will be able to operate field food service equipment with minimal additional training. The ideal would be to have field equipment identical with garrison equipment, in appearance and operation,

as well as in performance. This, at least, should be the goal of the development effort. The field equipment should be simple to operate and maintain, durable, and efficient, in terms of energy consumption as well as operation.

b. **Flexibility.** Food service equipment for the field should be designed so that it is capable of being responsive to unexpected changes in the feeding situation. The prospects for energy supplies in the future suggests that one begin to consider the possibilities of designing equipment which can operate from more than one energy source. In Viet Nam, the M-2 burner unit was modified to operate from liquid petroleum gas (LPG), because it was easier to ignite and control, there were no start-up problems, handling was simplified, less frequent refueling was required, and the fire and explosion hazards, were reduced. An LPG system, however, imposes logistic constraints for a combat food service which precludes its further consideration.<sup>11</sup>

Kitchen systems, other than those used in the forward combat and combat support areas, which of necessity must operate under the most adverse environmental conditions, should reflect garrison food service operations as much as possible, so that food service personnel will be able to operate field equipment with only minimal additional training. In addition, if the equipment were designed for both fuel-fired and electrical operations, either through a built-in dual energy capability, or by means of interchangeable heating units, the transition from combat to peacetime food service operations could be facilitated.

There are relatively few options open when designing multi-energy capability into food service equipment. The heavy dependence on electrical power throughout the world strongly suggests that electricity must be one of the alternatives considered. It is realized the overseas electrical systems may have different voltage and frequency characteristics, so that some means of adapting to different electrical sources must be designed into the equipment. A second alternative should be the primary energy source used by the military in the field. At least during the next decade, this is likely to be diesel fuel and other petroleum derivatives used to power field vehicles. It is not a difficult matter to design a fuel-fired oven or griddle, to which electrical heating elements could be added or built-in at little additional cost.

The M-2 Burner unit, the current standard field heating device, is known to be inefficient, and requires a considerable amount of routine maintenance, which interferes with the primary responsibility of food service personnel, i.e., food preparation. In addition, these burner units generate more heat into the work space than is used for cooking or heating food, hence field kitchens, except in cold weather, tend to become uncomfortably hot. With the exception of a hand valve to lower or raise the heat output and a control for air adjustment, which must be simultaneously regulated to obtain good fuel burning results, there is no feedback control of the burner unit, such as a thermostat. A serious effort should be made to develop a more efficient, controllable heat source.

One approach to burner unit operation which needs to be explored, is the use of a remote pressurized fuel tank to reduce the explosion hazard associated with the present design, in

<sup>11</sup>Op. Cit., US Army Quartermaster School.

which the fuel tank is an integral part of the burner unit. This would also result in a significant labor reduction, since it would no longer be necessary to refuel and maintain individual burner units on each piece of equipment. A blow torch preheater device, like that depicted in Figure D-3, could be used to reduce the start up time of the M-2 burner unit using gasoline. Another approach would be needed with diesel fuel. There is currently an ongoing contract effort directed toward the solution of this problem (Contract No. DAAK60-78-C-0045, Investigation of ignition, vapor generation and burner design for a diesel fueled stove).

c. **The Heat Pipe Concept.** The heat pipe is a development which found practical application in the solution of heat transfer problems in space flight. A heat pipe is a hermetically sealed pipe containing a heat transfer fluid selected for the temperature range of interest. A wicking material is bonded to the inside of the pipe. When one end of the pipe is heated, the fluid vaporizes and condenses at the cold end, transferring the heat of condensation. The condensed liquid then moves back to the hot end of the pipe, by capillary action in the wicking material, to be heated, vaporized, condensed, etc. The concept has already been applied to the design of food service equipment. Specifically, heat pipe griddles have been built for both electrical or gas fired operations. A heat pipe griddle, designed and built by Hughes Aircraft Company, using a modified M-2 burner unit as the heat source, is shown in Figure D-4.<sup>12</sup> The heat pipe principle has also been applied to the design of a deep fat fryer.<sup>13</sup>

The advantages of a heat pipe cooking device are the rapid come-up to operating temperature, and fast recovery to operating temperature when a load is placed on the device. Heat pipe griddles reach operating temperature in about five minutes, as compared to 15-20 minutes for conventional griddles. A heat pipe griddle has an unusually uniform temperature over the griddle surface, which can be described as essentially isothermal, whereas the temperatures can fluctuate widely over the surface of a conventionally heated griddle. Because of this feature, only a single burner unit, with sufficient output, is needed with the heat pipe griddle. This not only means some reduction in fuel consumption, but more important, it is highly responsive to use demand, since the griddle can be shut down, then put back in operation in only minutes. The fuel economy feature also contributes less to the heating of the work area, and therefore results in a lower discomfort level in the usually confined kitchen areas.

The heat pipe concept could be the key to an effective, multi-energy capability equipment design. Resistance heating elements can be either built into the heat pipe or attached to the underside. The latter approach is the least attractive alternative, because of the undesirable effect of expansion and contraction on the heating elements when a flame heat source is applied. When the elements are built into the unit, heat transfer is somewhat more efficient, the elements are not subject to the same heat stresses, and fabrication of the unit should be simplified.

<sup>12</sup> Hughes Aircraft Company. Griddle with a Heat Pipe Surface and a Liquid Fuel Burner. USANARADCOM Contract DAAG-17-73-C-0171. 1973.

<sup>13</sup> Lazaridis, L., Searight, E., and Shetsiek, D. Deep Fat Fryer. U.S. Patent No. 4,091,801: 1978.

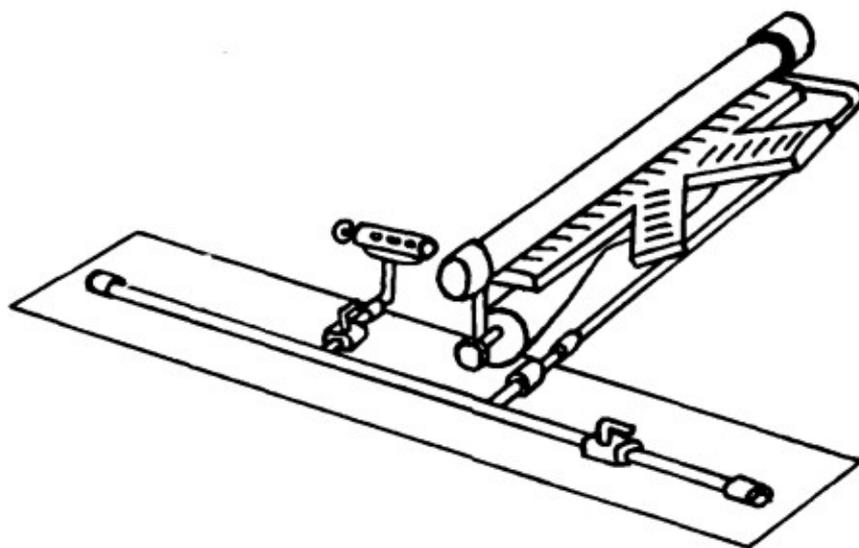


FIGURE D-3. MODIFIED BURNER UNIT WITH BLOW TORCH PREHEATER.



Figure D-4 Heat Pipe Griddle for Use in Field Feeding

## 5. CREW FEEDING.

a. **Specific Requirements.** The force structure analysis, Appendix B, indicates that about 45% of the division strength will consist of crews assigned to or associated with combat vehicles. The major objective of the food service system is to deliver at least one hot meal per day, to these crews and all other combat personnel. Otherwise, meals will be provided in the form of individual operational rations, which may also be heated and served as a substitute for hot meals, if demanded by the situation. Therefore, a means is required for heating operational rations onboard the vehicles.

b. **Evaluation of Alternatives.** Among the alternatives considered for heating operational rations is a soft fabric envelope containing electrical resistance heating strips, into which the Meal Ready to Eat (MRE) pouch can be inserted and heated.<sup>14</sup> These heaters are small enough to be issued to, and retained by, the individual crew members, or if a part of the vehicle equipment, they can be stowed in collapsed form to minimize space demands, which are critical in these vehicles. In either case, electrical outlets will have to be provided within the vehicles to power the heaters. A single device will draw only about 5 amps for a five minute heating period. If necessary, the heating time can be extended to reduce the power requirements; and, an appropriate discipline can be established when several heating devices are operated at the same time to minimize the total vehicle power demands, these two characteristics, minimum space and power requirements, together with demonstrated capabilities of prototype evaluations of this concept, support recommendations for further development and evaluation.

A second alternative is the British Cooking Vessel, Figure D-5, which has been evaluated by the US Army Armor and Engineer Board, Fort Knox, Kentucky,<sup>15</sup> and a draft LR has been issued by the Armor Board<sup>16</sup> for a vehicle ration heater. This device has been used to boil water, heat rations, and even to fry certain foods. The dimensions (8½" x 9½" x 9") are such that the space claim is not particularly large, but the power demands for this item, currently about 45 amps, may be excessive.

A German hot plate, also intended this purpose, was rejected because of its lack of versatility. It cannot be used while the vehicle is in motion, and an additional container is required in which to heat food or boil water.

<sup>14</sup>Murphy, A. Personal Communication. Natick, MA: US Army Natick R&D Command, 1979.

<sup>15</sup>Miller, J. B. Ration Heating Elements for Combat Vehicles Operational Feasibility Test. Final Report 7C96CEP02508. Fort Knox, Kentucky: US Armor & Engineer Board, 1977.

<sup>16</sup>US Army Armor Center. ATEK-CD-TE. Draft LR for Combat Vehicle Ration Heater. Letter. Fort Knox, Kentucky: 14 August 1978.

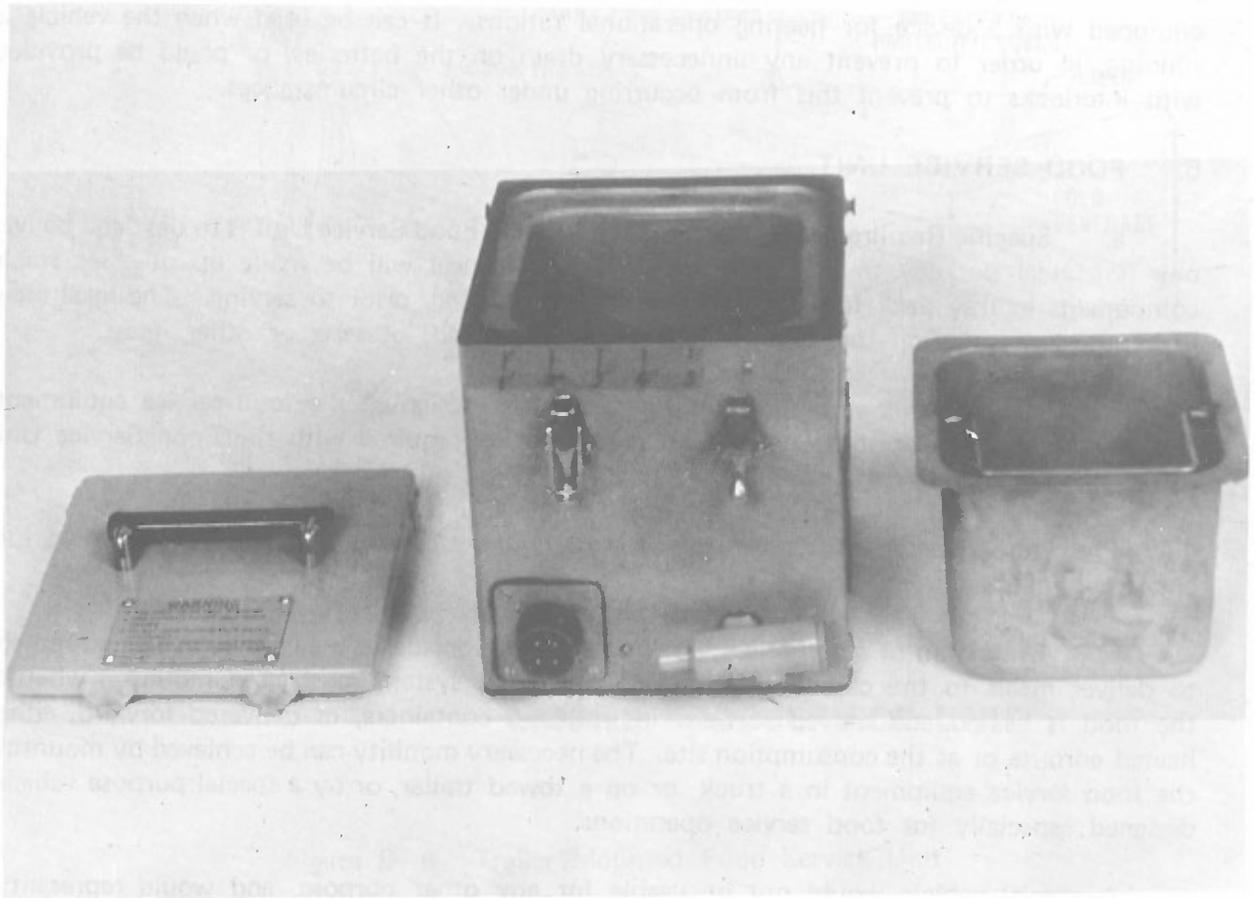


Figure D-5 British Cooking Vessel

c. **Concept of Operations.** The Food Service Unit, described in the following section, will, whenever possible, rendezvous with combat vehicles to deliver hot meals, and can also carry operational rations for resupply of combat crews. Otherwise, combat vehicles will be equipped with a device for heating operational rations. It can be used when the vehicle is running, in order to prevent any unnecessary drain on the batteries, or could be provided with interlocks to prevent this from occurring under other circumstances.

## 6. FOOD SERVICE UNIT.

a. **Specific Requirements.** The function of the Food Service Unit is to heat and deliver one hot meal per day to combat troops. The hot meal will be made up of shelf stable components in tray pack form, which require only heating, prior to serving. The meal may, as circumstances permit, be augmented with salads, bread, desserts or other items.

Food service skills will be minimized by proper design of the food service equipment. Generally, only two or three persons, at most, will be required with the Food Service Unit for company sized operations.

The Food Service Unit must have a cross country capability, and supply its own fuel and water needs.

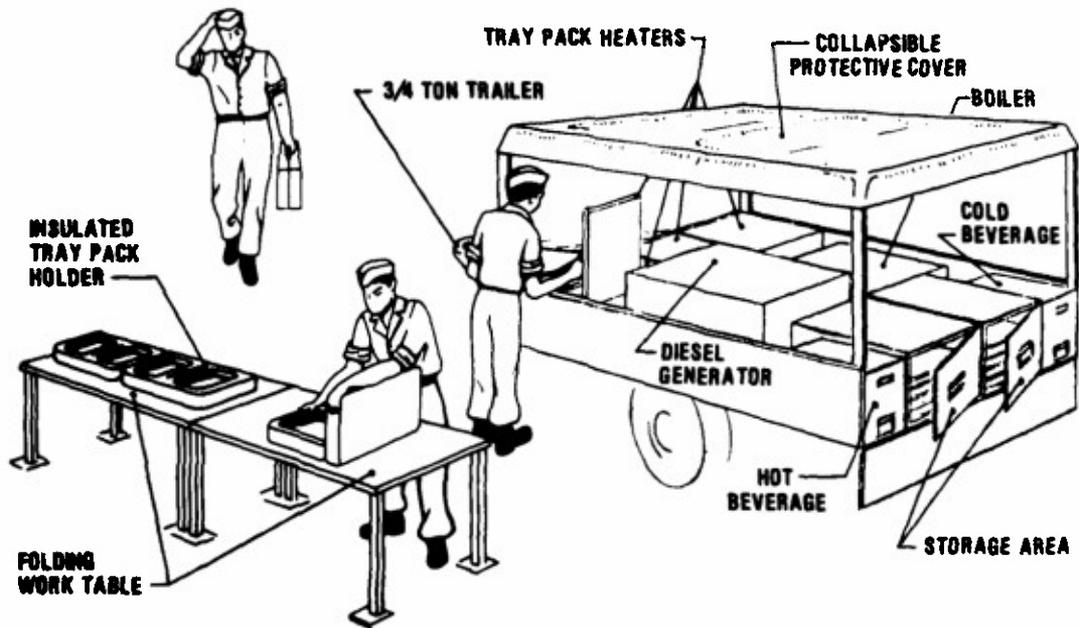
b. **Evaluation of Alternatives.** All alternatives considered are based on the requirement to deliver meals to the combat personnel. Thus, the system must have mobility, whether the food is heated and moved forward in insulated containers, or delivered forward, either heated enroute or at the consumption site. The necessary mobility can be achieved by mounting the food service equipment in a truck, or on a towed trailer, or by a special purpose vehicle, designed especially for food service operations.

A special vehicle would not be usable for any other purpose, and would represent a major development effort, therefore, is not considered a preferred alternative. Similarly, the use of the truck for the Food Service Unit would take up scarce cargo space and reduce the general utility of the vehicle. A trailer mounted Food Service Unit, with simple food service equipment, appears to be the least costly alternative with the highest probability of success. One concept is illustrated in Figure D-6, for which the schematic is provided as Figure D-7.

### c. Equipment Options.

(1) **Trailer.** The M116A1, 3/4 ton trailer is an example of an existing trailer which might be used as the base for a Food Service Unit.

(2) **Tray Pack Heater.** A sketch of a circulating hot water heater for the tray pack containers is shown in Figure D-2. The heater should have a capacity of eight containers, sufficient to support a serving rate of five persons per minute each thirty minute heating cycle. The heaters can be insulated for greater heating efficiency, and fitted with latching, gasketed covers to prevent spilling water during cross country transit. Another approach would be to design a unit for direct heating, which could then also be used for certain cooking operations, such as the preparation of soups, stews or vegetables under emergency circumstances, where only raw food is available.



### MOBILE FOODSERVICE UNIT

Figure D-6 Trailer Mounted Food Service Unit

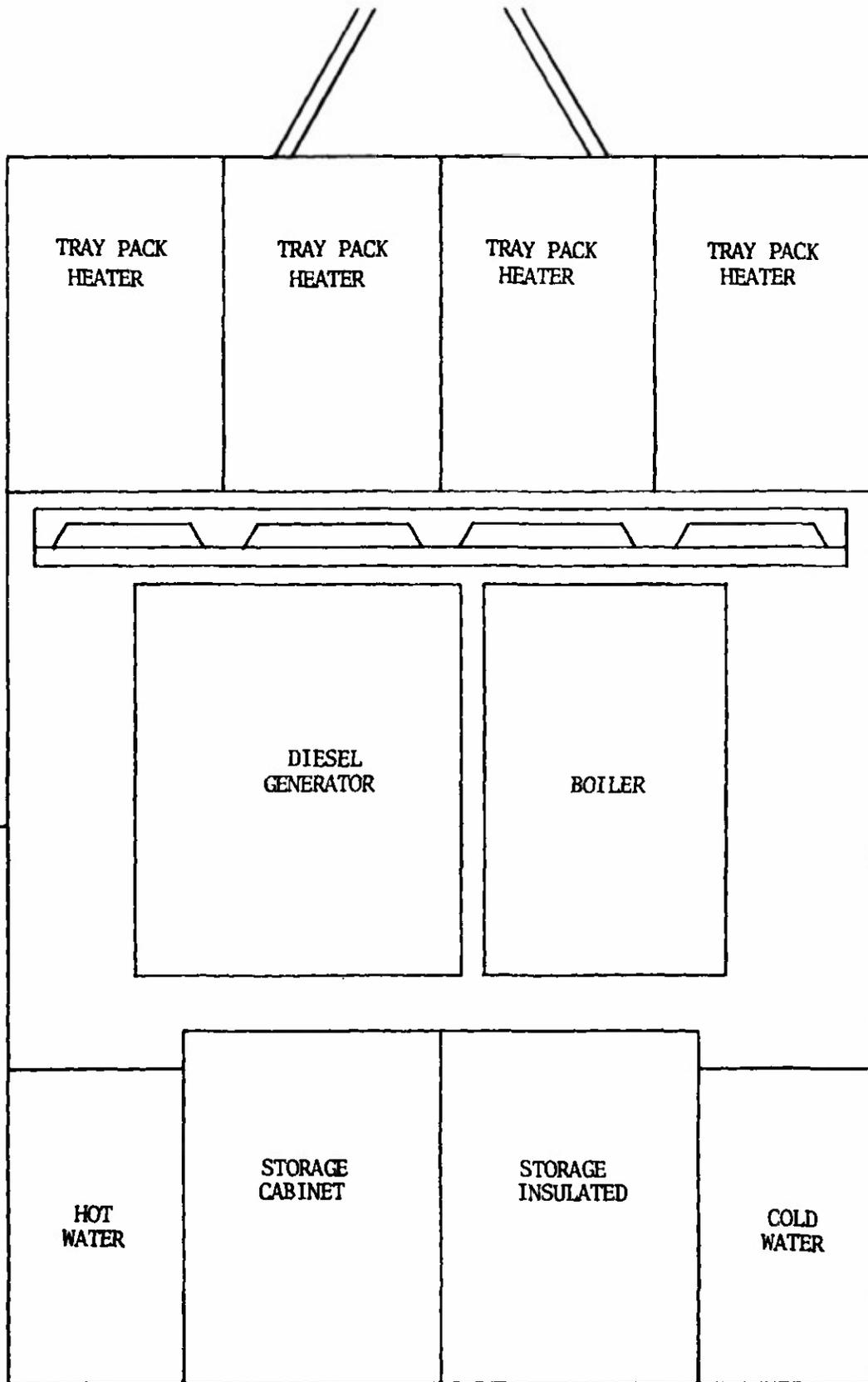


Figure D-7 Layout of Equipment on Trailer Mounted Food Service Unit

(3) Boiler. A closed, powered burner, water heater, similar to that shown in Figure D-8, which has been adapted to field sanitation operations, would be used for the tray pack heater. An example is a small, but efficient, water heater of novel design by Raytheon Company, procured and tested at NARADCOM several years ago.<sup>17</sup> The more desirable features of this unit were that it was light weight (about 75 lbs); compact (1' x 1' x 4'); had a relatively high heat output (175,000 Btu/hr) which could be attained in less than three minutes from start-up.

(4) Diesel Engine Generator. A small military standard generator set, about 1 kw, is needed to operate the pumping system and to provide power to the burner unit. Although a diesel electric generator is suggested as a component of the food service unit, the energy requirements could also be provided by a 24 volt DC battery, by an alternator off the engine of the prime mover, or, at some point in the future, perhaps by a high energy fuel cell power source of the type being developed by the Mobility Equipment R&D Command, Ft. Belvoir, Virginia. The diesel generator is presently indicated, because the power source is essential if the prime mover is separated from the trailer.

(5) Hot Water Dispenser. Hot water for beverages is provided by indirect heating using the boiler.

(6) Cold Water Dispenser. An insulated container with tap is used for cold water. Although no special provision for cooling water is provided, developments in thermoelectric cooling could lead to a powered water cooling system.

(7) Storage Cabinets. Insulated storage cabinets for bread, pastry, salad and other items are illustrated in Figure D-9.

(8) Insulated Carrier. Tray pack foods remain in the unopened container during and after heating until actually required. It is not necessary to open the tray packs and transfer their contents to insulated containers. In fact, this would be undesirable, because the insulated container would have to be cleaned and sanitized after each use, whereas the tray pack container itself is disposable. One example of a tray pack carrier configuration, that also allows the carrier to function as a serving line component, is shown in Figure D-10. The four pan capacity gives an appropriate distribution of two entrees, and one each vegetable and starch, necessary to serve one meal to twenty troops. The carrier itself can be protected from spillage by spreading a thin plastic film over it before the tray packs are inserted. It can be carried like a suitcase or backpacked.

d. Concept of Operations. Food service personnel assigned to each company would load the ration heaters with tray packs; place additional tray packs, operational rations disposables, water and fuel in the prime mover; and depart for the rendezvous. Heating of the tray packs could begin before departure, so that they would be ready to serve on arrival, or at the rendezvous point if sufficient time is available.

<sup>17</sup>Haggood, W. **Lightweight, Compact Space Heating/Water Heating System**. Technical Report 72-58-GP Natick, MA: US Army Natick R&D Command. 1972.

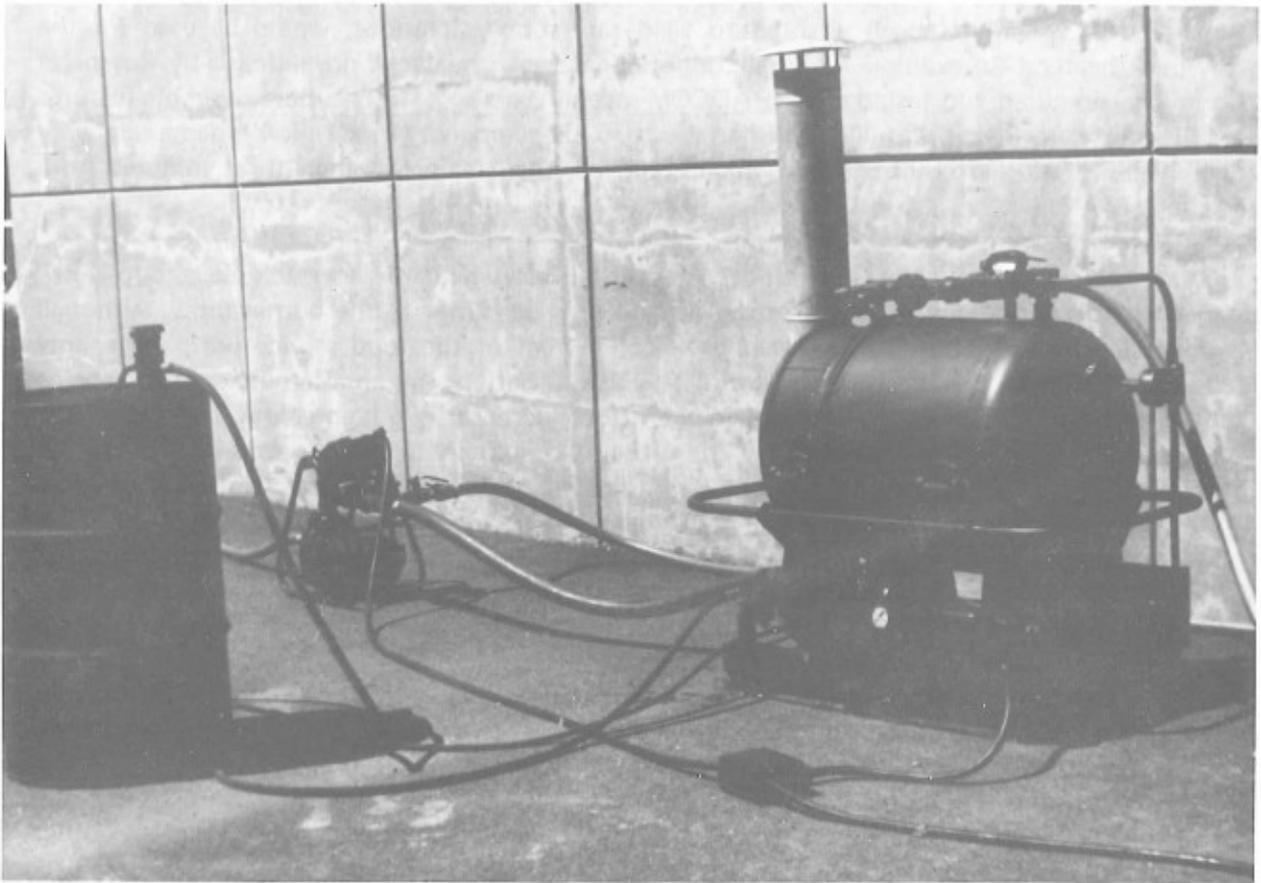


Figure D-8 Water Heater for Field Shower Unit

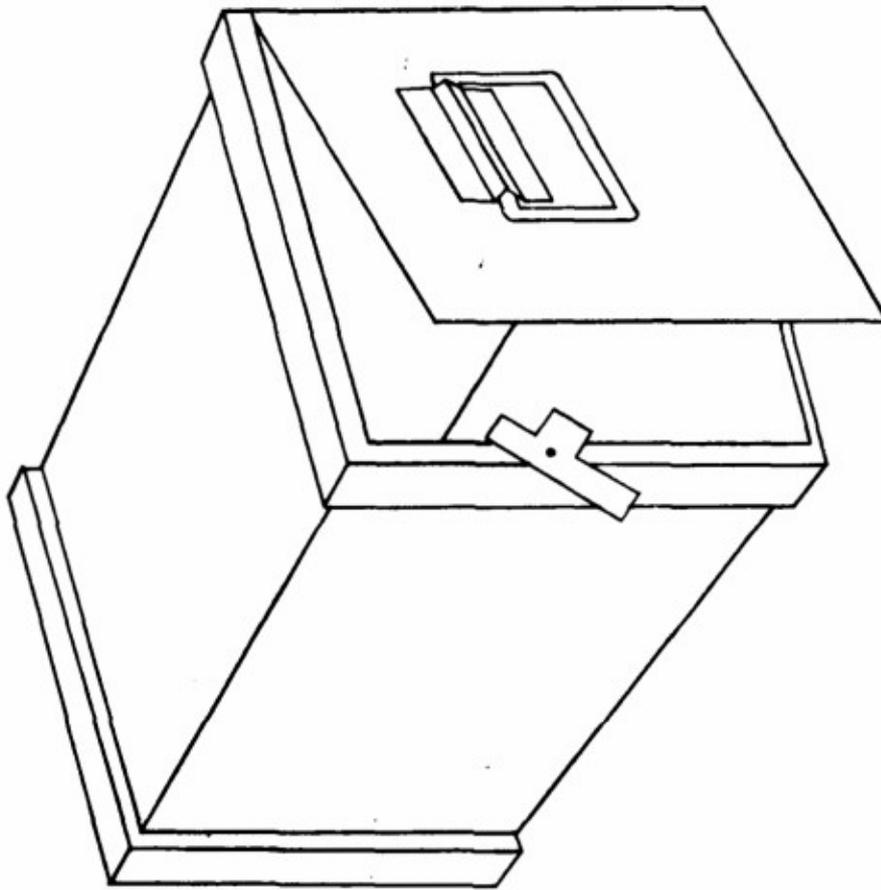
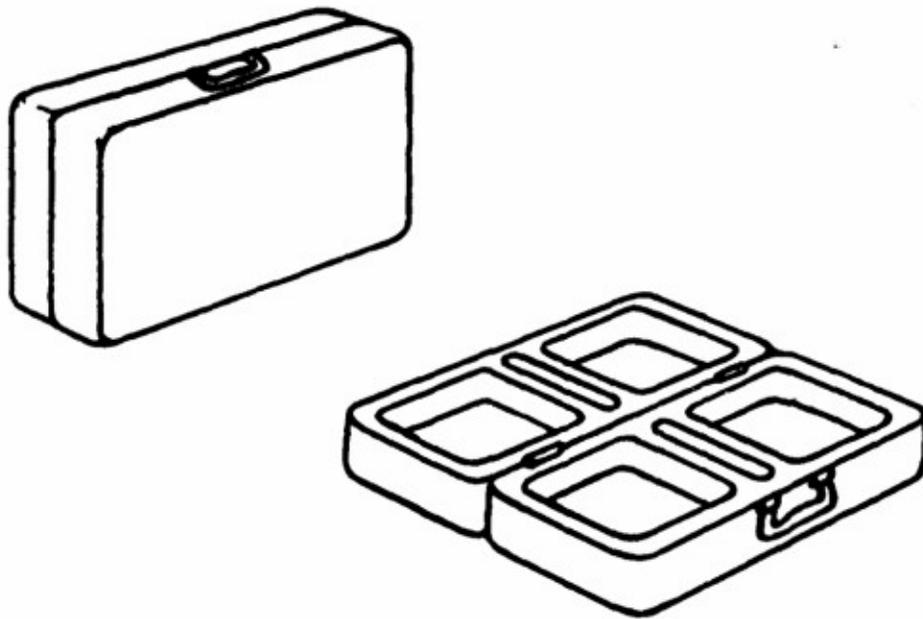


Figure D-9 Insulated Storage Cabinet



D-10. INSULATED TRAY PACK CARRIER.

On arrival, the trailer would be situated, the work tables erected as the serving line, insulated tray pack holders set out on the table along with disposables and other items, and the first tray packs opened and placed in the insulated holders. One person would serve the meal, while another would be occupied with opening tray packs, and heating additional tray packs as needed to keep the line stocked. Hot and cold beverages, and other items that may be available, would be on a self-serve basis. Plastic bags would be used to collect trash and waste. High rates of service, or serving large groups, could require the assistance of an additional person.

Closing down the Food Service Unit operation would involve returning trays and pans to the cabinets; wiping off the tables and insulated tray pack holders, possibly using pre-wetted, disposable, sanitizing wash cloths; stowing the work tables; and loading bags of trash and waste on the prime mover.

On return, the storage cabinets and tables would be offloaded and cleaned; tray pack heaters drained and cleaned; disposables restocked; and, general maintenance carried out.

The Food Service Unit could be operated in battalion rear or brigade with a company kitchen to permit preparation of a T or limited A ration menu, when available. This kitchen would be housed in a soft shelter, as shown in Figure D-11. The additional equipment includes a field oven, griddle, pot cradle, steam table, work tables, and field sinks with drain rack for pot and pan washing.

Under some circumstances, such as a battalion moving into reserve, or after ceasefire, the company Food Service Units can be integrated into a battalion level kitchen, as depicted in Figure D-12. In this example, the trailer units are shown backed into the shelter, so that much of the equipment can be retained on the trailers to facilitate redeployment, as necessary. Other food service equipment and a sanitation center are provided, capable of serving a limited A-ration menu and expanded meal service to the whole battalion.

The use of permanent dinnerware, instead of disposables, would depend on the status of the combat situation.

**7. UNIT KITCHENS.** Elsewhere in the combat zone, kitchens will normally be operated at company level or less, with T rations, to provide one, or perhaps, even two hot meals per day. Under other than combat conditions, or in secure areas, they can be complexed or combined into larger kitchen operations to provide either A or T type rations. Therefore, unit kitchens need to provide a complete food service equipment capability at company level and, at the same time, be the modules from which to effectively assemble larger consolidated or integrated area kitchens.

Three existing alternative field kitchen concepts are considered for this purpose -- a Mobile Kitchen Trailer (MKT), the Modular Field Kitchen and the ISO Container Kitchen -- one which is trailer mounted, another housed in a soft shelter, and the third in a rigid shelter. Each alternative is evaluated in terms of the specific operational requirements for future combat, and is not limited to the current design or configuration which typifies a given alternative.

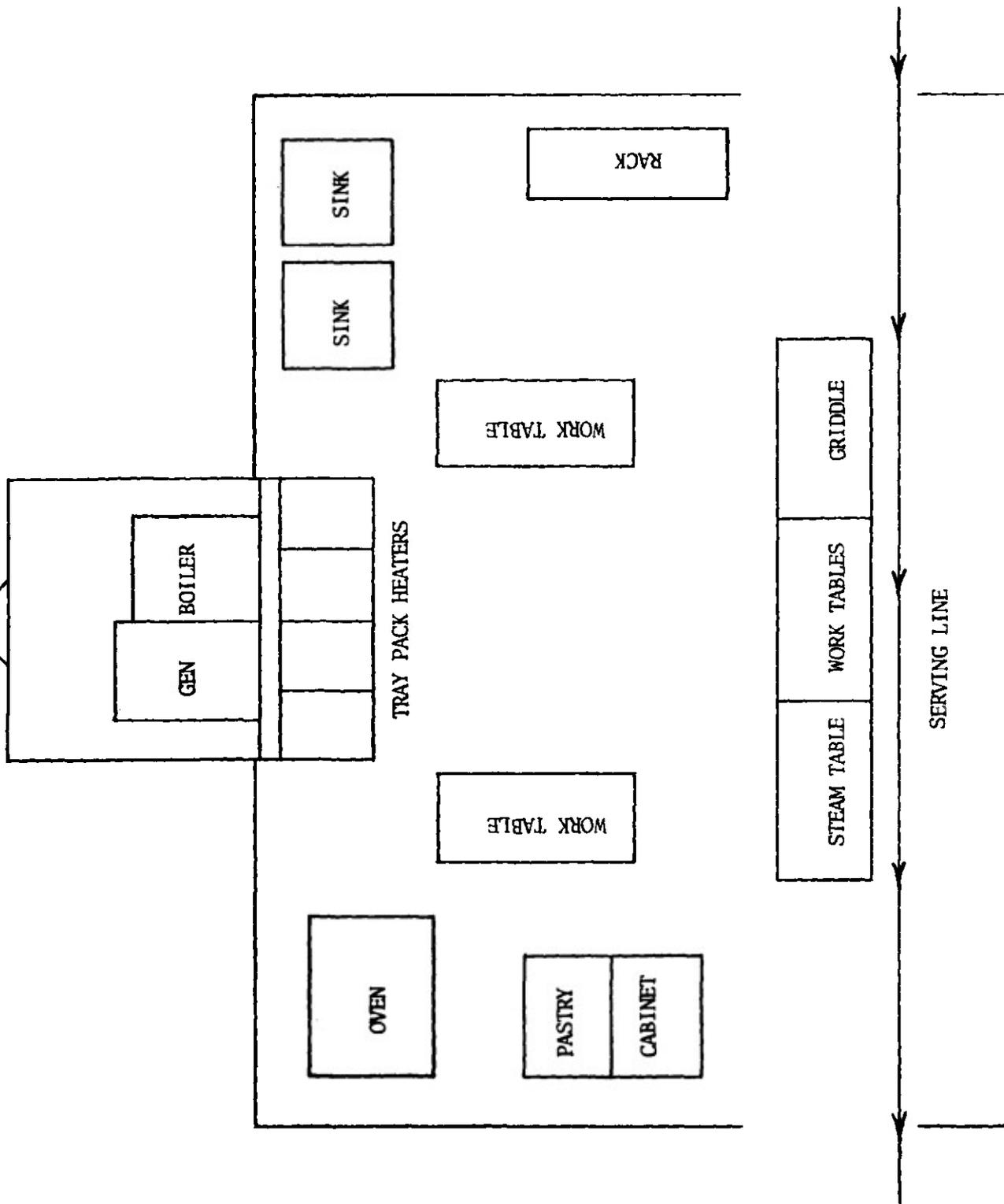


Figure D-11 Food Service Unit with Company Kitchen



a. **Description of Alternatives.** The MKT is an expandable, self-contained, trailer mounted field kitchen, towable by a 2½ ton truck. The MKT was originally designed and type classified for company level operations with A and B rations. However, it can be easily reconfigured to provide an A or T ration capability at company level, for example, as shown in Figure D-13.

The Modular Field Kitchen is housed in a frame supported shelter, and can be readily expanded and adapted to food service operations at all levels, including units up to 1000-1500 in strength.<sup>18</sup> The Modular Field Kitchen with an A or T ration capability, is depicted in Figure D-14.

An ISO Container Kitchen in a rigid wall shelter, which was designed to be compatible with air and sea transport systems, is illustrated in Figure D-15, as it may be fitted out to provide an A or T ration capability.

b. **Equipment Options.** The equipment listed in Table D-6 for unit kitchens is definitive only to the extent of showing examples of equipment for preparing A or T rations. All kitchen concepts would use the same basic equipment, though there would be some variations in design necessary to accommodate to differences in the size and space of the shelters. For example, modifications would have to be made to provide work surface covers on the griddles or steam tables, or fold-up and attachable work surfaces wherever possible in the trailers.

(1) **Tray Pack Heater.** This item would be fitted with a hinged cover to reduce evaporation loss, and with wire baskets to facilitate tray pack handling. The heater will be filled with hot water from the boiler and maintained at 180° F or higher by means of a circulating hot water system. The side walls should be insulated to reduce heat losses. The water could also be heated by a fuel fired burner placed beneath the heater, if the situation required it.

(2) **Forced Convection Oven.** The oven is for roasting, baking or heating, as determined by the menu being served. A powered burner is recommended, so that it can be operated in the same manner as a commercial oven, but it should be designed to function as a natural convection oven if electrical power is not available.

(3) **Griddle.** A heat pipe griddle offers greater fuel economy, however, a regular type griddle may also be utilized. The heat pipe griddle surface is easier to maintain.

(4) **Steam Table.** The steam table can be heated directly, by a burner unit below, although like the griddle and oven, may also be operated electrically, if adequate power were available.

<sup>18</sup>Baritz, S., Bustead, R., Kirejczyk, H., Kulinski, M., Meiselman, H., Silverman, G., Smith, R., Stefaniw, I., and Symington, L. **The Camp Pendleton Experiment in Battalion Level Field Feeding.** Technical Report 7T-4-OR/SA. Netick, MA: US Army Netick R&D Command, July 1976.

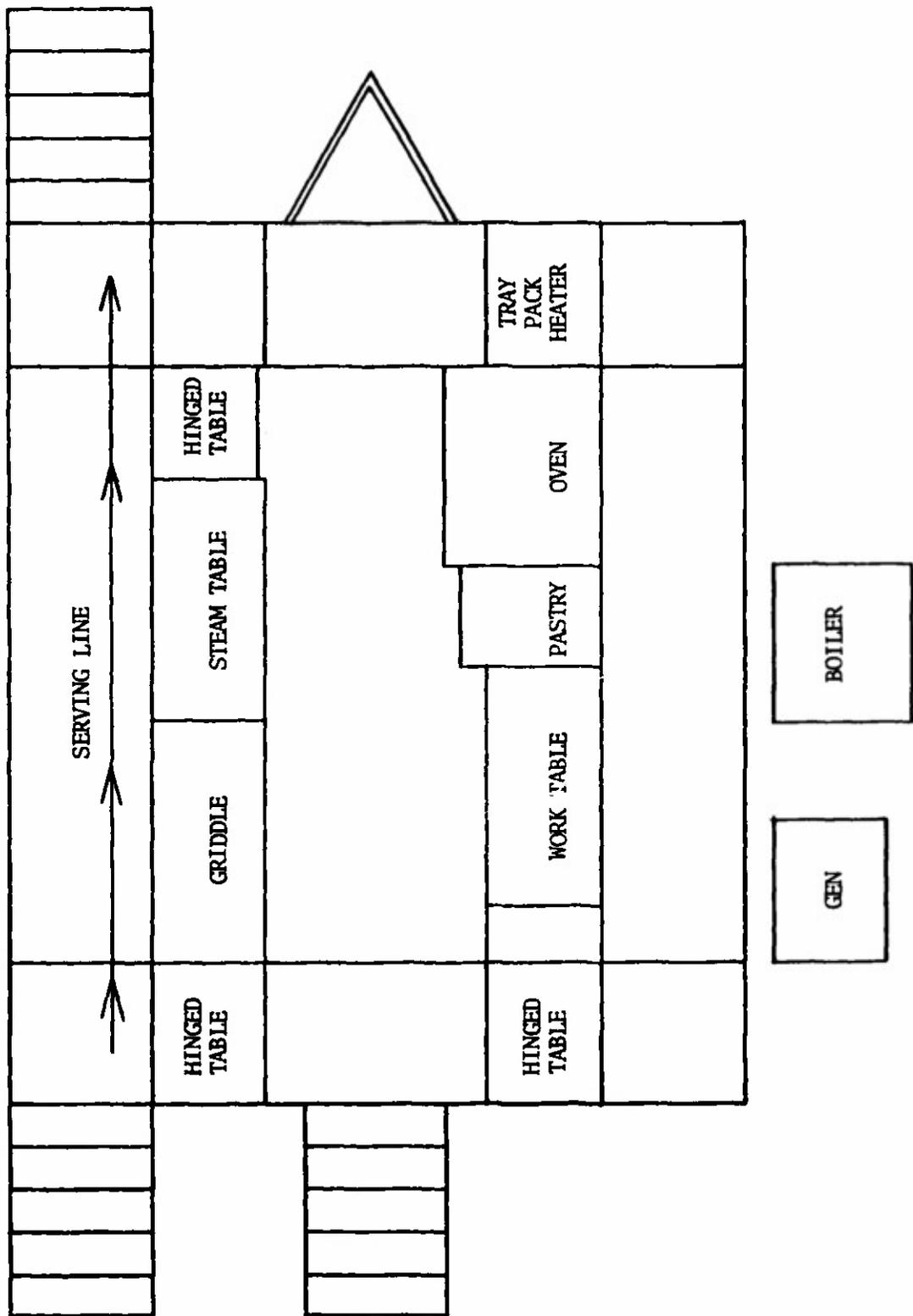


Figure D-13 Mobile Kitchen Trailer (MKT-75)

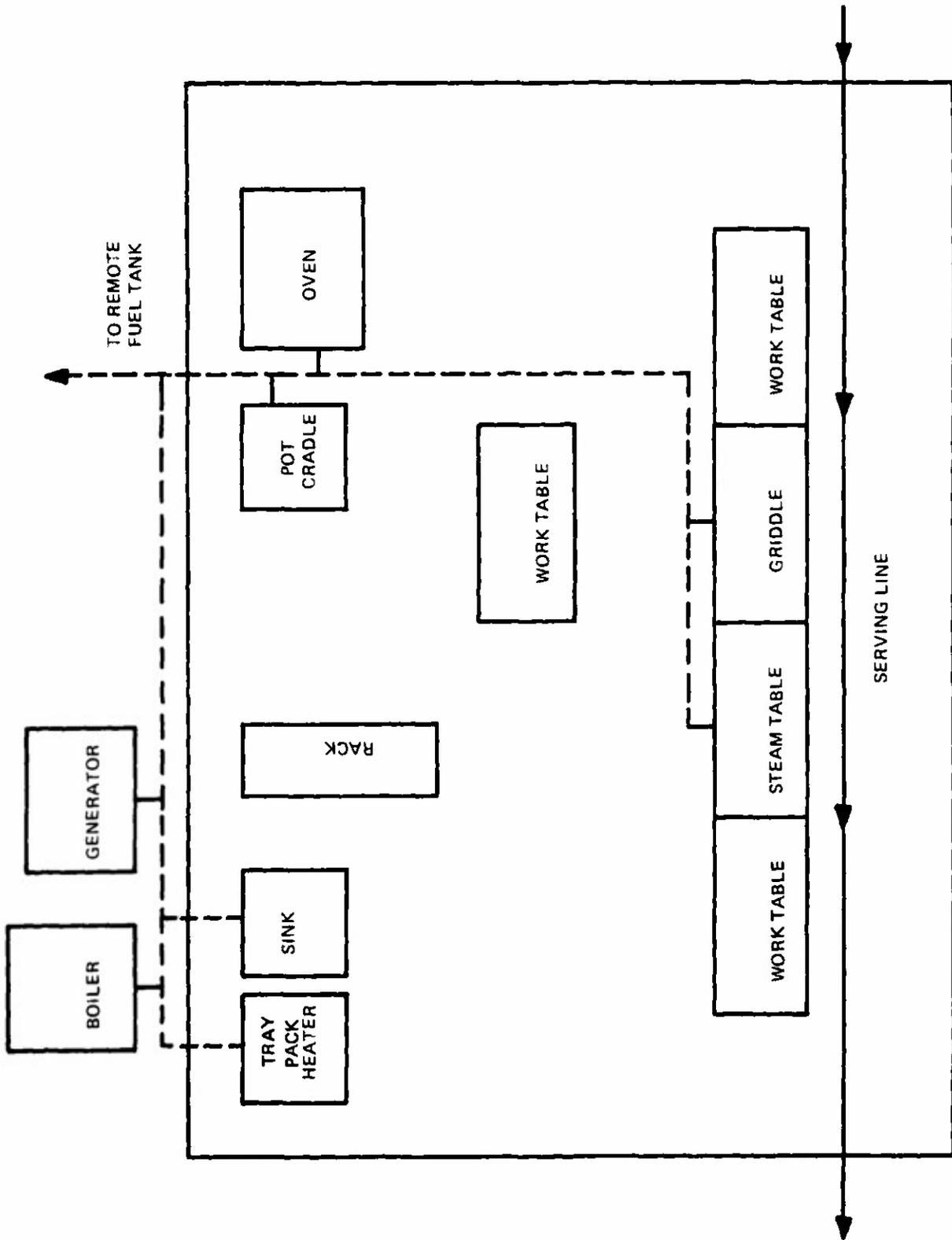


FIGURE D-14. MODULAR FIELD KITCHEN (XM-75)

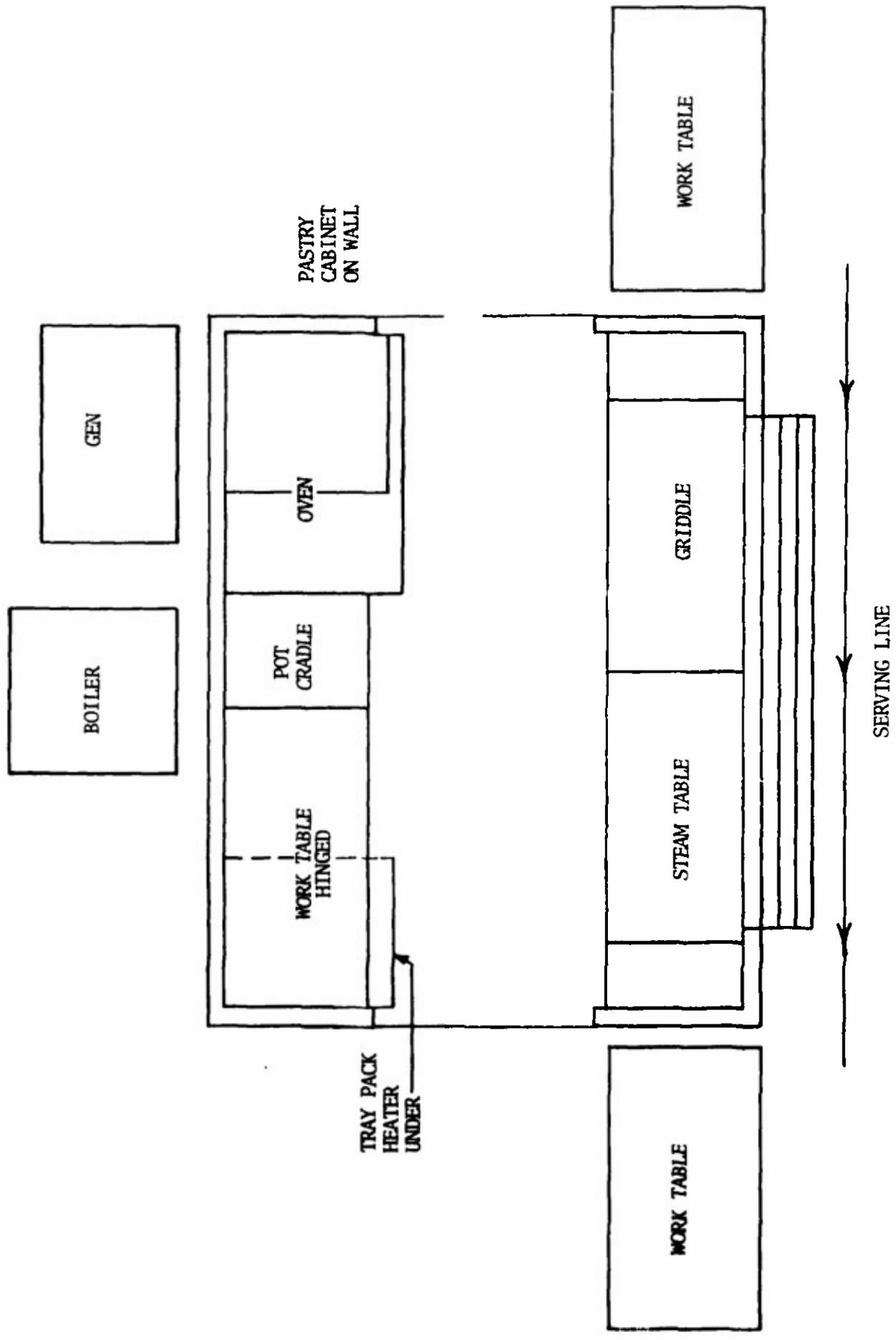


Figure D-15 ISO Container Kitchen

**TABLE D-6**  
**BASIC EQUIPMENT ITEMS**

<b>Item</b>	<b>Dimensions</b>	<b>Area (ft<sup>2</sup>)</b>
Tray Pack Heater	26" x 26"	4.7
Griddle	24" x 48"	8.0
Steam Table	24" x 48"	8.0
Work Table	24" x 48"	8.0
Oven	30" x 39"	8.1
Pot Cradle	21.5" x 23"	3.4
Pastry Cabinet	28" x 20"	3.9
Insulated Cabinet	28" x 20"	3.9
Generator, 3 kW	35" x 24"	5.8
Boiler	30" x 22"	5.6
Sink	26" x 26"	4.7
Rack	18" x 48"	6.0

(5) Pot Cradle. A pot cradle is included to cook vegetables and other foods. The heat source would be a non-powered burner unit, though a hot plate could be substituted if adequate power were available. Pots should have food contact surfaces that can be easily cleaned.

c. **Evaluation of Alternatives.** Of primary concern is whether or not the kitchen concept can be operated effectively at company level or less, given the constraints and conditions of the combat environment. Certainly, none of these kitchens are expected to be employed forward of the brigade area during active combat. Division elements operating in these areas would be supported by a trailer mounted Food Service Unit. Typically, then, unit kitchens would be located in the division rear, though removed from immediate combat, may frequently be threatened by enemy action, so that mobility is important.

The ISO Container Kitchen Concept is quite small, with little usable floor space, Table D-7. Experience has shown that a trained food service team can prepare and serve hot meals from such a kitchen.<sup>19,20</sup> But, to support a large company, say 200-350 troops, three hot meals per day, on a continuous basis, would require either one 20' or two 10' ISO Container Kitchen to provide adequate work space. The amount of transportation and materials handling equipment needed to move this sort of complex about, seems to mitigate against serious consideration of this concept as a unit kitchen.

Only one MKT or Modular Field Kitchen would be required per company. The Modular Field Kitchen has more than twice the space of an MKT providing sufficient room for storage and sanitation functions. Separate additional storage and sanitation space would have to be added to the MKT. Either of these two kitchens need a prime mover, a 2½ ton truck, for transport. Other mobility factors that have to be considered are the times necessary to strike and stow the kitchen when being readied for movement, and subsequently to unload and erect the kitchen at the new location; and, the possible effects of the load on the speed and maneuverability of the transporting vehicle. Even though much of the equipment on the MKT is fixed in place, the remainder must be positioned according to a fairly exact loading plan when preparing for a move, because of space limitations. Then, certain components of the trailer must be disassembled, the trailer unit buttoned up, and hitched to the towing vehicle; all of which is time consuming. The Modular Field Kitchen shelter and equipment, on the other hand, needs to be disassembled, packed and loaded onto the truck, although considerable flexibility is allowed in the loading arrangement. It has been demonstrated that this can be

<sup>19</sup>Decareau, R. V. "Electrically powered Field Kitchens." *Cornell Hotel and Restaurant Administration Quarterly*, May 1971.

<sup>20</sup>McCormack, M. E. "Distillage Fuel-Fired Kitchens." *Cornell Hotel and Restaurant Administration Quarterly*, May 1971.

TABLE D-7

SPACE ALLOCATIONS FOR ALTERNATIVE KITCHEN CONCEPTS

Module	Dimensions (L x W)	Area (ft <sup>2</sup> )	Equipment <sup>1</sup> (ft <sup>2</sup> )*	Work Space (ft <sup>2</sup> )
Modular Field Kitchen	16' x 22'	352	75	277
MKT-75	15' x 12.75'	191	64	127
ISO-Container-Container	7.5' x 9.5'	71	39	32

NOTES:

<sup>1</sup> Does not include generator and boiler, which would be located outside the kitchen.

accomplished in a fairly orderly manner, by untrained personnel, within approximately thirty minutes,<sup>21</sup> which is comparable to what is expected with the MKT.

The Modular Field Kitchen offers other benefits not obtained with the MKT. A loaded truck is generally faster and more maneuverable than one which is towing a trailer behind it. On arriving at a new location, the time required to completely erect the kitchens for operation is about the same, in either case. With the Modular Field Kitchen, it is possible to begin operations immediately after offloading only a few selected equipment items, whereas the MKT is not quite as flexible. Under some circumstances, where only a limited, temporary food service capacity is adequate, this ability may be highly advantageous. Based on this comparison, it appears that the Modular Field Kitchen concept is equally as mobile, as a Mobile Kitchen Trailer concept.

The unit kitchen, to be compatible with the overall system concept, must be able to be assembled together into larger efficient kitchens, and to the extent possible, utilize equipment common with the remainder of the system, specifically the trailer mounted Food Service Unit. The Food Service Unit provides only a T ration capability, and is intended primarily as a high response system for division elements actively engaged in combat. However, an A ration capability also needs to be maintained at battalion level for eventual consolidation of food service operations, or in the event of a contingency wherein the T ration cannot be supplied. It is recognized that certain of the division units cannot consolidate on this basis, and must maintain an independent A ration capability. In either case, some additional equipment will have to be issued which can be combined with equipment components from the Food Service Unit to yield a complete unit kitchen for A ration operations. Regardless of the level at which the unit kitchen is established, the Mobile Kitchen Trailer concept needs additional prime movers for towing, while the Modular Field Kitchen concept would not, as it could be loaded onto either of the vehicles which are towing the water trailer or trailer mounted Food Service Unit.

The ability to form a larger kitchen is not simply a question of whether the unit kitchen can be combined and operated as a single kitchen, but one of the efficiency and effectiveness of the resulting operation as well. The number of unit kitchens adjoined may vary considerably, depending on a variety of conditions, but could range upward to six, or possibly even more, to support as many as 1000 troops. The Modular Field Kitchen shelter and equipment readily facilitates the configuration of a kitchen shelter arranged to a layout for the most effective and efficient operation. With the Mobile Kitchen Trailer Concept, the equipment is essentially fixed in place on the trailer, which makes rearrangement of the equipment and space to achieve operational efficiency difficult, if not impossible. Just the siting, colocation, and leveling of

<sup>21</sup> Kirejczyk, H. and Bonczyk, T. Evaluation of Alternative Field Feeding Systems for Army Field Medical Units. Draft Technical Report. Natick, MA: US Army Natick R&D Command, July 1978.

several adjacent kitchen trailers, with or without interconnecting platforms, can present considerable difficulties, as compared to simply erecting and connecting the frame supported tents, which are less sensitive to minor variations in their terrain. Past field evaluations indicate that larger field kitchen facilities housed in modular shelters are preferred by food service personnel to operating out of a multiple MKT complex.<sup>22,23</sup> Finally, when the Modular Field Kitchen units are consolidated in number, there is sufficient equipment and tentage, not only to set up a complete large size kitchen, but to provide for a sanitation center and a storage shelter, if desired. With the Mobile Kitchen Trailer, additional shelters would have to be issued for this purpose.

In summary, the ISO Container Kitchen does not appear to be a feasible alternative for Army combat food service. Comparing the Mobile Kitchen Trailer concept to the Modular Field Kitchen concept, the latter seems to be more flexible and better suited to combat requirements, offers a higher degree of compatibility with the total food service system concept, is no less mobile, and is easily adapted to large scale food service operations.

**8. CONSOLIDATED/AREA KITCHENS.** Most companies would merge their unit kitchens into consolidated area kitchens whenever the situation permits doing so. Depending on availability, A or T rations could be prepared. The pooling of authorized food service personnel would possibly equal, or may even exceed, the staffing requirements for A ration meal service at the larger, more efficient level of operation.

a. **Equipment Options.** Almost all of the equipment contained in the unit kitchens would also be operable in the consolidated area kitchens, but depending on the unit kitchen design, other equipment items may have to be added.

In this mode, however, having the equipment to operate from a remote pressurized fuel system would be most efficient and economical. A remote tank, with a fuel line manifolded to the various heating units, i.e., the ovens, griddles, and other fuel-burning equipment, provides a promising approach to significantly reduce labor, improve operations and reduce the danger associated with operating burner units. Integral tanks with burner units are subject to increasing pressure conditions, because of the proximity of the fuel tank to the heat source, and it is not unusual to see the tank pressure rise to danger levels. The remote tank can be pressurized, with suitable reducing valves to maintain a modest pressure level for fuel flow to the burners. Also, it is much easier to install a relief valve in the remote fuel system than directly in a burner unit. Appropriate valving and disconnects in the manifold would allow burner units to be removed for repair and maintenance, without shutting down the entire cooking operation.

A fail safe valving and disconnect system is extremely important with a manifold system, to avoid spraying fuel around the kitchen when a burner unit is removed. Dirt can easily

<sup>22</sup> Ibid.

<sup>23</sup> Op. cit., Baritz, S. et. al.

get into these connections, if they are not handled carefully, resulting in delays, fuel spillage, and down time for repairs. In addition, the manifold and fuel line design must permit the line to be separated, so that any equipment item can be detached and function completely alone.

b. **Sanitation.** Field sanitation now consists mainly of the mess kit laundry line. The use of disposable mess gear would eliminate the need for this setup, except for pot and pan washing and general equipment cleanup. However, a backup system, in the event of a break in the supply of disposables, must also be considered. Another alternative is to use permanent trays and utensils. Some means of cleaning these trays, which is not labor intensive, would then be required. A number of possibilities can be suggested.

(1) A manually, operated tray cleaner, in which the tray is inserted. Brushes and high pressure water spray remove the soil, after which the tray may be placed in a rack, and put through a sanitizing rinse or water bath to sanitize the trays. The trays could then be hung from a rod or placed in another rack to dry.

(2) A plastic film can be applied by dipping the trays into a prepared solution. After use, the film is stripped from the tray and discarded. A new layer of film is applied for each meal.

(3) The tray might be placed in a plastic film bag, and the open end closed or sealed in some manner. Food would then be served on, and eaten off, the film cover. After use, the bag would be removed and discarded, and the tray retained for use at the next meal.

Each of the possibilities will require some development effort to perfect. Plastic coatings or bags would both have to demonstrate resistance to cutlery use, and meet acceptable standards of food contact surfaces.

The effectiveness of a high pressure water spray system for soil removal has been already demonstrated.<sup>24</sup> During the test, trays were coated with a special food mixture and allowed to dry for 20 hours. The trays were then passed over an arrangement of water nozzles and exposed to a high pressure water spray. Soil removal was complete in tray movement rates of 3 to 7 inches per minute. These test conditions were far more severe than would normally be expected in actual operation.

c. **Evaluation of Alternatives.** Based upon the evaluation of unit kitchens, the most viable concept that could be utilized at company level in a combat environment, from which larger consolidated kitchens can be effectively assembled, and, that is also otherwise compatible with the total food service system, was the Modular Field Kitchen. As few as five companies could pool their food service assets to obtain a consolidated kitchen, Figure D-16, which would be sufficient to support up to 1000 troops, with a sanitation center for pot, pan and

<sup>24</sup>FMC Corporation. **Development of Concepts; Automated Scullery.** Central Engineering Report No. R-1914A. Santa Clara, California: 1963.

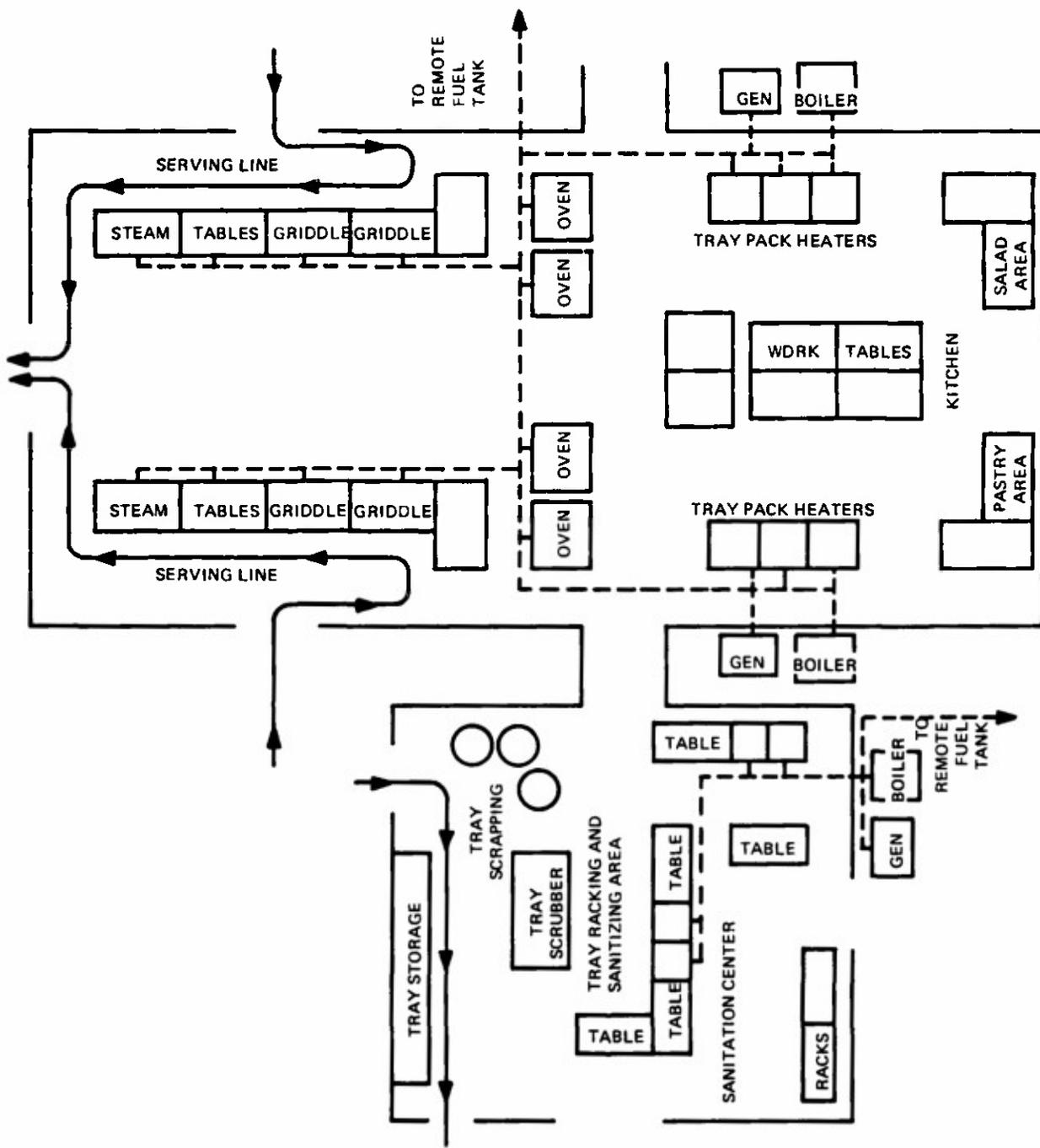


Figure D-16 Consolidated Field Kitchen with Sanitation Center

tray washing, and still have adequate shelter space remaining for storage of non-perishable rations. The only item of equipment which would have to be added is a manual tray scrubber, if it were decided to use permanent trays in lieu of individual messgear or disposables.

9. **CONCLUSIONS.** Food service equipment for future combat food service systems must reflect the efficiencies made possible by the introduction of improved shelf stable foods. To this end, equipment must not add to the labor burden, but rather, require the least effort to operate and maintain by the food service personnel.

The most likely energy source for cooking and heating purposes will be diesel fuel, since it will generally be used for military vehicles, and therefore most abundant in the theater. Efforts to develop an efficient and economical diesel burner systems for food service equipment should be initiated at an early date. It should also be possible to provide some electrical power through diesel electric generators to field food service operations, permitting them to use certain labor saving items of food service equipment, such as slicers, can openers, etc., as well as to use powered burner systems and convection oven blowers.

Water immersion is clearly the simplest and most reliable method for heating shelf stable foods to serving temperature, and has the least deleterious effect on the quality of those foods. Water also provides an excellent medium for holding unopened containers of food at serving temperature until needed. Unused containers can simply be cooled and retained for use at a later time.

Food service support to combat forces must be able to keep pace with those forces in order to provide them with at least one hot meal per day. This can best be accomplished with a high response, food service unit, with the means for heating food enroute, so that serving can begin shortly after arrival at the rendezvous. The equipment should be simple enough to be manned by a food service staff of two or three men.

The company level food service operations in the combat zone should be provided with additional items of equipment, so that certain other foods can be prepared to supplement the menu, if possible. This kitchen should also have some sanitation capability.

The preponderance of vehicle mounted personnel suggests that an onboard means of heating individual operational rations is desirable. A lightweight, fabric heater which uses vehicle power provides an answer to this problem.

Units operating elsewhere in this theater, typically do not require the same high response food service capability. Rather, what is needed is a kitchen that can be operated at company level or less, and also be the basis for establishing consolidated area kitchens. The apparent choice among the alternatives considered is the Modular Field Kitchen.

Sometimes, area kitchens will be located near sources of electrical power. Food service equipment for the field should be designed to take advantage of this resource, but should also have the capacity to operate from non-powered fuel burning energy sources. At least, the kitchen should be equipped with a small diesel electric generator which will permit the

use of labor saving devices, such as slicers and can openers, as well as to power the fuel burning equipment.

Refueling of self-contained burner units is labor intensive, hazardous and time consuming. A remote, pressurized fuel source with a fuel line manifold to the individual burners is within the state-of-the-art. Such a system would free personnel for their primary task of food preparation and, be much less hazardous than at the present, by essentially eliminating the danger of explosive fires in the kitchen.

Other heat transfer techniques appear to offer opportunities to improve field food service from a functional point of view. Heat pipe technology, for example, has been applied to the design of improved griddles and deep fat frying. Field versions of these two items are also within the state-of-the-art.

In combat, the food service system can no longer support the use of traditional messkits and the associated sanitation requirements. It is for this reason, that the use of disposables, at least in the active combat area, and possibly elsewhere, is recommended. The volume of waste generated by disposables is potentially a problem, so some means of reducing the volume of waste, perhaps by compaction or shredding, needs to be investigated. Where practicable, a reuseable tray, maintained at the kitchen site, is an alternative to disposables, and it is possible to provide tray cleaning and sanitizing facilities for field use that are not labor intensive. Within current technology, food service ware, such as trays, pots and pans, and kitchen utensils, with soil rejection surfaces can be designed so that sanitation can be accomplished by simply immersion in a high temperature water bath, or a low temperature, chlorinated water bath.

## APPENDIX E

### STAFFING ANALYSIS

1. **INTRODUCTION.** One of the most significant costs of the combat food service system are food service personnel, thus it was essential to develop plausible estimates of the staffing requirements for the various system concepts and situations proposed for cost analysis. Ideally, the design of future combat food service systems should consider the total spectrum of possible conflict situations in which it can reasonably be expected that it will be required to operate. Additionally, it has to be recognized that these conflicts may occur virtually anywhere in the world, under all types of geographic and climatic conditions. Thus, any new system concept recommended must be capable of being deployed, and operated efficiently and effectively, in a wide variety of such circumstances. However, because of limitations and constraints on available project resources, a detailed assessment of all of these factors simply was not possible at this time. Rather the agreed approach was to formulate and evaluate alternative system concepts for those requirements which derived from a combined analysis of the TRADOC standard Theater Level Scenario (TLS) (1977-78) and the FY 84 Program Force, the best available information, reflecting the 1990 force structure. Similarly, currently evolving organizational changes, specifically that might result from the Division Restructuring Evaluation (DRE), that could significantly impact on the future Army force structure were included in the staffing analysis.

2. **METHOD OF ANALYSIS.** The alternative systems concepts considered are based upon combinations of level of feeding, i.e., single or multiple units in an individual or consolidated mode of operation with A, B or T rations. Unfortunately, the data available on any one of the three different forces, that is, the FY 84 Program Force, the Theater Level Scenario Army force, and the planned DRE force structure, were inadequate for purposes of developing complete staffing requirements relative to each of these various concepts. The necessary assumptions and techniques for extending these data to all the situations of interest are briefly described in the following discussion.

a. **Force Projections.** Both the Theater Level Scenario and FY 84 Program Forces are based upon the H-series Division Tables of Organization and Equipment (TOE). However, there are substantial differences in the types and mix of units, and other variations between the two forces, so that a common basis had to be defined from which to project the future Army force structure. The division equivalent was selected for this purpose. Since the largest proportion of combat divisions will be mechanized by 1990, an Armored Division (SRC 17000H020) consisting of five Mechanized Infantry Battalions and five tank Battalions were established as the H-series division equivalent (H-DE). In actuality, there is no standard Armored or Mechanized Infantry Division, but the division base is essentially the same in any case; the only important differences are the numbers of Mechanized Infantry and Tank Battalions comprising each division. In any event, the total strengths, and therefore, the food service requirements, do not vary significantly. Information provided in the TOE Master File dated December 1977 indicates that the assumed H-series division equivalent consists of a total of 17,019 troops, of which there are 617 assigned food service personnel to operate company level field kitchens. The DRE force is organized around a hypothetical T-series Division TOE,

for which presently only one exists (SRC 1700T700), hence it is designated as the T-series division equivalent. Again, according to the TOE Master File, there is a total of 18,138 troops, including 415 food service personnel, assigned to this division. Fewer food service personnel are need in this instance, because combat feeding operations are expected to be performed on a consolidated basis. The projected divisional force structure for the Theater Level Scenario was obtained by translating total division troop strengths into division equivalents, either H-series or T-series, as shown in Table E-1.

The type, number and mix of non-divisional units are much more varied and less well defined. Unlike a division, which is generally committed entirely, as a single element, non-divisional units are assigned and deployed separately, according to a variety of factors, e.g., level of combat activity, area of operations, number of troops supported, ton-miles of supplies to be moved, expected casualties, etc., thus tend to vary considerably by scenario. For the purposes of analysis, the composition and disposition of non-divisional units in the Theater Level Scenario were assumed to be directly proportional to the equivalent component of the FY 84 Program Force. All non-divisional units in the 84 Force were classified into one of four groups — medical or non-medical, and by location, CORPS areas or COMMZ — and ratios calculated describing the distribution of troop and food service personnel strengths in each group. These results were then applied to the known troop strengths in each corresponding area of the Theater Level Scenario, establishing the projected force structure characteristics given in Table E-1.

b. **Food Service Personnel Requirements.** Presently, Army combat units are equipped and staffed by TOE to deliver three standard B ration meals daily. Extensive work measurement analyses, undertaken during recent field feeding system evaluations at Camp Pendleton and Fort Sam Houston, clearly demonstrated that the workload associated with the preparation and service of A ration type meals in the field were no different than for the B ration, therefore the staffing requirements are assumed to be identical. Then, wherever applicable, actual TOE authorizations are used to determine food service staffing levels. Otherwise, the guidelines promulgated in AR 570-2, C8 are utilized to establish the appropriate staffing for the A/B ration, except for a large scale, consolidated kitchen (operating two twelve hour shifts per day, seven days per week, and serving approximately 1000 persons) which required a total of twenty food service personnel, according to AR 570-7, C8. Also, KP personnel are authorized at the rate of two for the first fifty rations served, plus one for each additional fifty rations or major fraction thereof.

As now conceived, the T ration components will require virtually no preparation other than heating and serving, and since they are packaged in their own serving containers, can substantially reduce or even completely eliminate the need for pot and pan sanitation. Consequently, far less food service personnel may be required than when serving the A/B ration. Although experience with use of T ration items in the field is still very limited, the preliminary results of work measurement analyses indicate that meal preparation labor is reduced by as much as 73%. Conservatively, then, it is estimated that food service personnel requirements with the T ration are 50-60% less, which allows for a reasonable degree of uncertainty in these initial results, and ensures that there is still sufficient personnel authorized to perform those functions not directly related to the type of ration utilized, a.g., pick up and delivery of rations, POL and water. This permits for a simple, direct conversion of the above food

**TABLE E-1**  
**1990 FORCE PROJECTIONS**  
**THEATER LEVEL SCENARIO (D+90)**

	Total Strength	% Food Service Personnel	Projected Force Structure Food Service Personnel	Projected Force Structure Non-Food Service Personnel
<b>Division<sup>1</sup></b>				
H-Series	431,558	3.625	15,646	415,912
T-Series	431,558	2.288	9,874	421,684
<b>Corps<sup>2</sup></b>				
Non-medical	437,915	3.108	13,610	424,305
Medical	34,671	4.507	1,562	33,109
<b>Commz<sup>2</sup></b>				
Non-medical	121,302	3.230	3,920	117,382
Medical	38,997	6.184	2,411	36,586
<b>Total</b>				
H-Series	1,064,443	3.490	37,149	1,027,294
T-Series	1,064,443	2.948	31,377	1,033,066

**NOTES:**

<sup>1</sup> Based on analysis by division equivalents.

<sup>2</sup> Based on analysis of comparable FY 84 Program Force Structure.

service personnel and KP authorizations for the A/B ration to a staffing guide for the T-ration, Table E-2. In general, units authorized just one or two food service personnel with the A/B ration do not operate a separate field kitchen, but they are provided for the purpose of augmenting the food service staff of the host unit to which the unit is attached. With the T ration, these personnel are no longer required, for the additional burden on the host unit is minimal and, at most, may require simply extending the serving period of a meal to accommodate the larger customer load. All other units are staffed at a minimum of two food service personnel, or at about half of their TOE authorizations, with correspondingly reduced numbers of KP personnel.

c. **Division Staffing.** Five different feasible concepts of combat division food service operations were examined in detail. The results are presented in Tables E-3 and E-4.

(1) **Unit A/B Rations.** Because H-series divisions are now organized for this type of operation, staffing requirements follow from the H-series division equivalent TOE personnel authorizations. The T-series divisions, on the other hand, are intended to conduct consolidated A/B ration operations, so that staffing of the T-series division equivalent had to be determined from AR 570-2, CB. The KP allowance is derived from the standard planning factor of two for the first fifty, plus one for each additional fifty, rations served.

(2) **Consolidated A/B Rations.** Food service operations in a division are consolidated wherever possible, and serve the A/B ration. In this case, the proposed T-series division equivalent TOE staffing is appropriate, but the H-series division equivalent staffing had to be obtained from AR 570-2, CB. Two levels of KP requirements were considered. The first assumes conventional field sanitation practices, with standard KP staffing, and the second is based on employing improved sanitation procedures and equipment, e.g., XM-75 sanitation center, thereby reducing staffing requirements to two for the first seventy-five, plus one for each additional seventy-five, rations served.

(3) **Unit T Rations.** This concept is essentially the same as the present mode of operation, described first, except that the T ration is used exclusively, instead of the A/B ration. Therefore, food service personnel and KP staffing were defined by converting the above requirements for operations with A/B rations at unit level in accordance with the T ration staffing guide given in Table E-2.

(4) **Unit T Rations/Consolidated A/B Rations.** Another alternative is to consider a combination of the two preceding options. Initially, food service operations are conducted by each unit with the T-ration; then, as conditions permit, will subsequently transition to consolidated operations with the A/B ration. Staffing requirements differ for some division units with each operation; typically, more food service personnel being needed in the latter stage. Consequently, staffing would have to be augmented at the time the transition was implemented. Generally, it is expected that consolidated operations would be of a temporary nature, as during base development, and that as the situation stabilizes, headcounts would eventually decrease to the point that the added personnel could be released. The KP requirements are as before, and assume that improved sanitation methods are available in the consolidated operations.

TABLE E-2

T RATION STAFFING GUIDE

TOE Authorizations (A/B Rations)	Proposed Staffing (T Ration)	
FSP	FSP	KP
0-2	0	0
3	2	0
4	2	1
5	3	1
6	3	1
7	4	2
8	4	4
9	5	4
10	6	5
11	7	6
12	7	6
13	8	7
14	8	7
15	8	7

TABLE E-3  
STAFFING REQUIREMENTS - II-DIVISION EQUIVALENT

UNIT DESIGNATION	DIVISION ELEMENT				UNIT OPERATIONS								CONSOLIDATED OPERATIONS						
	NFS STR/UNIT	NO./DIV	NFS STR/DIV	HOST UNIT	REQ/UNIT		REQ/DIVISION		HOST UNIT	REQ/UNIT		REQ/DIVISION		NFS STR	REQ. (AVAIL./) UNIT		REQ/DIVISION		
					A/B RATION FSP	T RATION KP	A/B RATION FSP	T RATION KP		A/B RATION FSP	T RATION KP	A/B RATION FSP	T RATION KP		A/B RATION FSP	T RATION KP	A/B RATION FSP	T RATION KP	
1 HHC	173	1	173	1/15	13	9	8	7	13	9	8	7	387	10(8)	9	6	10	9	6
2 MP Co	195	1	195		4	3	2	1	4	3	2	1							
3 HHC, CAB	80	1	80		5	5	3	1	5	5	3	1							
4 Avn Co, CAB	188	1	188		6	6	3	1	12	12	6	2							
5 Atk Hel Co, CAB	233	2	466		6	5	3	1	6	5	3	1							
6 Tank Co, CAB	195	1	195		5	4	3	1	5	4	3	1							
7 CS Avn Co, CAB	152	1	152		9	7	5	4	9	7	5	4							
8 Sig Bn	98	1	98	9	7	4	3	1	7	4	3	1							
9 HHC, Sig Bn	194	1	194		7	4	4	2	7	4	4	2							
10 Cnd Op Co, Sig Bn	165	1	165		6	4	3	1	6	4	3	1							
11 Fed Com Co, Sig Bn	146	1	146		6	5	3	1	6	5	3	1							
12 Sig Spt Op Co, Sig Bn	184	1	184		6	4	3	1	6	4	3	1							
13 HHC, Eng Bn	146	4	584		6	4	3	1	24	16	12	4							
14 Cbt Eng, Eng Bn	156	1	156		6	4	3	1	6	4	3	1							
15 Bridge Co, Eng Bn	102	3	306		6	5	3	1	18	15	9	3							
16 HHC, Brig	172	1	172		6	4	3	1	6	4	3	1							
17 Arm Cav Sq	154	3	462		5	4	3	1	15	12	9	3							
18 INF, ACS	198	1	198		6	5	3	1	6	5	3	1							
19 Arm Cav Tp, ACS	203	1	203		9	8	5	4	9	8	5	4							
20 Air Cav Tp, ACS	158	1	158	19	6	5	3	1	6	5	3	1							
21 HHC, Div Arty	211	3	633		6	5	3	1	18	15	9	3							
22 TAB	93	9	837		5	3	2	1	45	27	27	9							
23 FA Bn 155	64	3	192		4	2	2	1	12	6	6	3							
24 155 BTRY, 155 Bn	193	1	193		6	5	3	1	6	5	3	1							
25 Svc BTRY, 155 Bn	89	3	267		4	3	2	1	12	9	6	3							
26 FA Bn 8"	74	1	74		4	3	2	1	4	3	2	1							
27 18B, 8" Bn	217	1	217	1/15	6	5	3	1	6	5	3	1							
28 8" BTRY, 8" Bn					4	3	2	1	4	3	2	1							
29 Svc BTRY, 8" Bn					4	3	2	1	4	3	2	1							
30 Cbt Int Co					4	3	2	1	4	3	2	1							
31 AIA Bn C/V					4	3	2	1	4	3	2	1							

\*Availability - staffing level obtained by consolidation of unit level T ration staffings. System 4 requirement is the larger of the requirement/availability.

STAFFING REQUIREMENTS - II-DIVISION EQUIVALENT (CONT'D)

DIVISION ELEMENT			UNIT OPERATIONS						CONSOLIDATED OPERATIONS								
UNIT DESIGNATION	NFS STR/UNIT	NO./DIV	NFS STR/DIV	REQ/UNIT		T RATION		REQ/DIVISION		HOST UNIT	NFS STR	A/B RATION		REQ (AVAIL)/UNIT		REQ/DIVISION	
				A/B RATION FSP	RP	FSP	RP	FSP	RP			FSP	RP	FSP	RP	FSP	RP
28 ADA Bn C/V	129	1	129	4	3	1	1	5	4	3	1	5	4	3	5	4	3
29 HHC, C/V Bn	102	2	204	3	3	1	1	10	6	6	2	10	6	4	2	10	4
30 Vnl Btry, C/V Bn	115	2	230	3	3	1	1	10	6	6	2	10	6	3	10	6	6
31 Chmp Btry, C/V Bn	106	1	106	6	4	2	2	7	6	4	2	7	6	9	10	9	6
32 HEC, Spt Cnd	273	1	273	7	4	2	2	7	8	4	2	7	8	8	8	8	6
33 Ag Co	88	1	88	4	4	2	2	4	4	4	2	4	4	6	6	6	6
34 Flm Co	142	1	142	4	4	2	2	7	4	4	2	7	4	4	7	4	3
35 Hq + Spt Co, Med Bn	75	3	225	3	3	1	1	18	9	9	3	18	9	3	7	4	3
36 Med Co, Med Bn	36	1	36	8	5	4	4	9	8	5	4	9	8	7	8	7	5
37 HHC, S+T Bn	127	1	127	3	3	1	1	36/40	36	36	1	36/40	36	36	36	36	36
38 S+S Co, S+T Bn	201	1	201	3	3	1	1	3	3	3	1	3	3	7	5	8	7
39 TMT Co, S+T Bn	110	1	110	3	3	1	1	5	3	3	1	5	3	7	5	8	7
40 Hq + Lt M Co, Mnt Bn	182	3	546	5	3	1	1	18	15	9	3	18	15	10	7	9	10
41 Pvd Spt Co, Mnt Bn	239	1	239	6	4	2	2	7	6	4	2	7	6	5	30	21	15
42 Hvy Mnt Co, Mnt Bn	114	1	114	3	3	1	1	5	3	3	1	5	3	7	5	30	21
43 Mle Spt Co, Mnt Bn	134	1	134	3	3	1	1	5	3	3	1	5	3	9	10	10	7
44 Div MHC	108	1	108	3	3	1	1	5	3	3	1	5	3	7	5	30	21
45 NBC Def Co	143	5	715	4	3	1	1	25	20	15	5	25	20	13	15	17	12
46 MU Bn	166	15	2490	4	3	1	1	90	60	45	15	90	60	13	15	17	12
47 HHC, MI Bn	148	5	740	4	3	1	1	30	20	15	5	30	20	65	85	60	60
48 Rifle Co, MI Bn	156	5	780	4	3	1	1	25	20	15	5	25	20	50	55	40	40
49 Ght Spt Co, MI Bn	88	15	1320	3	2	1	1	60	45	30	15	60	45	8	8	50	55
50 Tank Co, Tank Bn	91	5	455	3	2	1	1	25	15	15	5	25	15	10	12	11	8
51 Chc Spt Co, Tank Bn	156	5	780	4	3	1	1	25	20	15	5	25	20	375	372	262	262
TOTALS	6402		6402	617	445	332	133	617	445	332	133	617	445	375	372	262	262



STAFFING REQUIREMENTS - T-DIVISION EQUIVALENT (CONT'D)

UNIT DESIGNATION	DIVISION ELEMENT			UNIT OPERATIONS						CONSOLIDATED OPERATIONS							
	NFS STR/UNIT	NO./DIV	NFS STR/DIV	REQ/UNIT		T RATION		A/B RATION		RBO/DIVISION		HOST UNIT	NFS STR	REQ. (AVAIL)/UNIT		REQ/DIVISION	
				A/8 FSP	KP	FSP	KP	FSP	KP	FSP	KP			FSP	KP	FSP	KP
29 PA Bn 8"	93	1	93	4	3	2	1	4	3	2	1						
30 IIB, 8" Bn	64	3	192	4	2	2	1	12	6	6	3	31					
31 8" Btry, 8" Bn	79	1	79	4	3	2	1	4	3	2	1	31	437	10(12)	10	7	10
32 Svc Btry, 8" Bn	73	1	73	4	3	2	1	4	3	2	1	31					
33 Mt Btry, 8" Bn	108	1	108	9	6	5	4	9	6	5	4	34	249	8(5)	6	4	8
34 IIC, Spt Cnd	273	1	273	8	8	4	4	8	8	4	4	34	361	7(4)	8	6	7
35 Ag Co	88	1	88														
36 Fin Co																	
37 Mt Co																	
38 Hq + Lt Mt Co, Mt Bn	145	1	145	5	4	3	1	5	4	3	1		710	11(13)	15	11	11
39 Pvd Spt Co, Mt Bn	136	3	408	6	4	3	1	18	12	9	3		156	6(3)	4	3	18
40 Iby Mt Co, Mt Bn	213	1	213	6	5	3	1	6	5	3	1	36					
41 Mt Co, Mt Bn	103	1	103	4	3	2	1	4	3	2	1	36					
42 Ms/Spt Co, Mt Bn	101	1	101	4	3	2	1	4	3	2	1	36					
43 TAW Co, Mt Bn	148	1	148	5	4	3	1	5	4	3	1	36					
44 Med Bn																	
45 IHC, Med Bn	70	1	70	7	4	4	2	7	4	4	2		137	10(4)	5	4	20
46 Med Co (Hdld)	61	1	61									42					
47 Med Co (Trlage)	84	1	84									42/19					
48 Med Co (Amb)	69	1	69									42/19					
49 S+T Bn																	
50 IIB, S+T Bn	36	1	36	8	9	4	4	8	9	4	4		329	8(4)	8	5	8
51 S+S Co, S+T Bn	137	1	137									46/37					
52 TME Co, S+T Bn	157	1	157									46					
53 Mt + Co, S+T Bn	59	1	59									46					
54 Div HMC	141	1	141									33					
55 IHD, Div ADA	51	1	51									1					
56 ADA Bn V/R																	
57 IEB, V/R Bn	82	1	82	4	3	2	1	4	3	2	1		131	5(4)	4	3	5
58 VUL Btry, V/R Bn	45	3	135	3	2	2	0	9	6	6	0		78	5(3)	3	2	15
59 Rvd Btry, V/R Bn	99	1	99	4	3	2	1	4	3	2	1	53					
60 Mt Btry, V/R Bn	69	1	69	4	2	2	1	4	2	2	1	52					
61 ADA Bn, C/R																	
62 IIB, C/R Bn	75	1	75	4	3	2	1	4	3	2	1		146	6(4)	4	3	6

STAFFING REQUIREMENTS - T-DIVISION EQUIVALENT (CONT'D)

UNIT DESIGNATION	DIVISION ELEMENT			UNIT OPERATIONS												CONSOLIDATED OPERATIONS					
	NFS STR/ UNIT	NO./ DIV	NFS STR/ DIV	REQ/UNIT			T RATION			A/B RATION			REQ/DIVISION			HOST UNIT	NFS STR	REQ. (AVAIL)/UNIT		REQ/DIVISION	
				A/B RATION FSP	T RATION FSP	T RATION KP	A/B RATION FSP	T RATION FSP	T RATION KP	A/B RATION FSP	T RATION FSP	T RATION KP	A/B RATION FSP	T RATION FSP	T RATION KP			A/B RATION FSP	T RATION FSP	T RATION KP	A/B RATION FSP
57	74	2	148	4	3	2	1	8	6	4	2	1	108	62	108	6(3)	3	12	6	6	
58	67	1	67	4	2	2	1	4	2	2	1	57	62	57							
59	71	1	71	4	3	2	1	4	3	2	1	56	62	56							
60	74	6	444	4	3	2	1	24	18	12	6	62	62	62							
61	103	18	1854	4	3	2	1	72	54	36	18	62	62	597	11(14)	13	9	66	78	54	
62	84	6	504	4	3	2	1	24	18	12	6	62	62	62							
63	53	6	318	3	2	2	0	18	12	12	0	62	62	62							
64	77	6	462	4	3	2	1	24	18	12	6	62	62	62							
65	84	7	588	4	3	2	1	28	21	14	7	69	69	69							
66	93	1	93	4	3	2	1	4	3	2	1	69	69	69							
67	96	1	96	4	3	2	1	4	3	2	1	69	69	69							
68	51	27	2377	3	2	2	0	81	54	54	0	467	467	467	10(14)	11	7	90	99	63	
69	84	9	756	4	3	2	1	36	27	18	9	69	69	69							
70	53	9	477	3	2	2	0	29	18	18	0	69	69	69							
71	91	9	819	4	3	2	1	36	27	18	9	69	69	69							
TOTALS			7723					755	554	409	163							415	411	287	

(5) Unit T Rations/Consolidated A/B Rations with Reassignment of Personnel. This approach is exactly the same as the previous one, except that in those units where the transition resulted in excess food service personnel from the first to the second stage, these personnel would be reassigned to other units under strength for consolidated operations. Thus, fewer numbers of additional personnel would be required for augmentation purposes. This would necessitate substantial changes in present policies and doctrine with regard to the management of food service resources in the division, so that such transfers could be effectively accomplished.

A summary of the total staffing requirements under the various alternatives, for each type of division, is provided in Table E-5, and for the Theater Level Scenario division force in Table E-6.

d. **Non-divisional Unit Staffing.** Three alternatives were analysed for non-divisional food service operations, as shown in Table E-7.

(1) Unit A/B Rations. This situation was discussed previously, and the staffing requirements are presented in Table E-7. The associated KP requirements were estimated for two different conditions; first, using the standard planning factor for all the units, and then assuming that only the medical hospital units are provided with the improved sanitation methods, with the consequent lower number of KP personnel needed.

(2) Unit T Rations. Staffing requirements for this alternative were determined by means of the T Ration Staffing Guide, Table E-2, to convert food service personnel authorizations to this type of operation.

(3) Unit T Rations/Consolidated A/B Rations. Under this option, all units initially operate with the T ration, then as the opportunity develops, those units which are conveniently co-located will combine into approximately 1000 man area kitchens, except for hospital units, which by virtue of their size and mission, will continue to function at the unit level. Certain selected units in the Corps areas and COMMZ will be authorized auxiliary equipment items that permit expanding to A/B ration operations. Area kitchens of this size require twenty food service personnel, and fourteen KP personnel when employing the improved sanitation methods. If the individual units involved are normally authorized personnel only for unit T ration operations, then staffing will have to be augmented on transition to consolidate A/B operations.

e. **Total Staffing Requirements.** More than fifty different concepts of operation can be defined by simply combining all possible alternatives considered for the divisional and non-divisional units. However, most of these were eliminated from further detailed evaluation and comparison by the following assumptions:

(1) Food service operations do not differ between units located in the CORPS areas and the COMMZ, except as already indicated for medical hospital units.

(2) Unit T ration operations are not conducted in the non-divisional areas unless they are also performed by division units, but unit T ration operations by the divisions does not necessarily limit the non-divisional units to the same kind of food service.

TABLE E-5

DIVISION EQUIVALENT STAFFING REQUIREMENTS

Alternative	H-Series Divisions <sup>1</sup>		T-Series Divisions <sup>2</sup>	
	FSP	KP	FSP	KP
○ Unit A/8	617	445	755	554
○ Consolidated A/8	375	372	415	411
○ Consolidated A/8 <sup>3</sup>	375	262	415	287
○ Unit T	332	133	409	163
○ Unit T and Consolidated A/8	332 411	133 262	409 482	163 287
○ Unit T and Consolidated A/8 W/Reassignment	332 375	133 262	409 415	163 287

NOTES:

<sup>1</sup> 16,402 troops supported, exclusive of food service personnel.

<sup>2</sup> 17,723 troops supported, exclusive of food service personnel.

<sup>3</sup> Improved sanitation methods allows for reduced KP strength.

TABLE E-6

DIVISION STAFFING REQUIREMENTS

THEATER LEVEL SCENARIO

Alternative	H-Series Divisions <sup>1</sup>		T-Series Divisions <sup>2</sup>	
	FSP	KP	FSP	KP
● Unit A/B	15,646	11,284	17,964	13,181
● Consolidated A/B	9,509	9,433	9,874	9,779
Consolidated A/8 <sup>3</sup>	9,509	6,644	9,874	6,829
● Unit T	8,419	3,373	9,731	3,878
● Unit T and Consolidated A/B	8,419 10,422	3,373 6,644	9,731 11,468	3,878 6,829
● Unit T and Consolidated A/B W/Reassignment	8,419 9,509	3,373 6,644	9,731 9,874	3,878 6,829

NOTES:

<sup>1</sup> TLS division force equals 25.357 H-series division equivalents.

<sup>2</sup> TLS division force equals 23.793 T-series division equivalents.

<sup>3</sup> Improved sanitation methods allows for reduced KP strength.

TABLE E-7

STAFFING REQUIREMENTS FOR NON-DIVISIONAL FORCE

THEATER LEVEL SCENARIO

Force Element	Troop Strength Supported	Alternative	Staff Requirements	
			FSP	KP
Corps Areas Non-Medical	424,305	Unit A/B	13,610	11,236
		Unit T	7,510	2,973
		Unit T and Consolidated A/B	8,486	5,940
Corps Areas Medical	33,109	Unit A/B	1,562	1,334
		Unit A/B*	1,562	938
		Unit T	898	681
Commz Non-Medical	117,382	Unit A/B	3,920	3,007
		Unit T	2,181	1,073
		Unit T and Consolidated A/B	2,348	1,643
Commz Medical	36,586	Unit A/B	2,411	1,958
		Unit A/B*	2,411	1,337
		Unit T	1,480	1,188

\*Improved sanitation methods allows for reduced KP strength.

(3) The concept of consolidation would be jointly implemented, rather than being considered as independent and separate options for division and non-division units.

Of those remaining concepts, food service personnel and KP staffing requirements for the total Theater Level Scenario force were then ascertained from the data in Tables E-6 and E-7, and are summarized in Table E-8.

**3. RESULTS AND CONCLUSIONS.** Compared to the baseline system, i.e., unit A/B ration operations throughout, the other alternatives offer potential manpower reductions ranging from nearly 6,000-18,000 food service personnel, and approximately 2000-21,000 KP personnel, in the Theater Level Scenario, as detailed in Table E-9. In general the differences between the H-series and T-series division organizations, for a particular alternative is relatively small, around 1000-2000 food service and 1400-1700 KP personnel.

Consolidation of unit A/B operations in the divisions, as proposed in the division restructuring plans, results in only minimal decreased in personnel requirements; 17-20% fewer food service personnel and 16-21% less KP personnel. Significantly greater savings can be obtained with unit T ration operations, which if extended to all non-divisional units as well, amounts to a 45% reduction in food service personnel and a 66% reduction in KP personnel. The actual numbers of positions saved varies between 15,138 and 38,590, depending on the types of divisions involved and the degree to which T rations are utilized by the CORPS and COMMZ force. Whether or not hospital units in the theater are unit A/B or T ration operations is of little consequence with respect to total personnel requirements, because they comprise such a small portion of the entire force strength, even including patient loads.

Dual mode alternatives, that is, unit T ration operations which subsequently transition to consolidated A/B ration operations, also provide for substantial advantages in this regard, although, slightly less than with the pure unit T ration strategies. In the initial phase, the maximum decrease in staffing is obtained, but upon conversion to consolidated operations, augmentation is necessary, so that 32-37% reductions in food service personnel and 43-46% reductions in KP requirements are possible.

Therefore, as a result of this staffing analysis, it is concluded that the new combat feeding system should be designed for a concept of operations based on the T ration. Such a system can provide at least the same level of food service as present operations, but much more efficiently, since the labor required for food preparation is minimized with this kind of ration. The decision as to whether to rely wholly on the T ration, or to use both A/B rations under varying conditions, is examined in APPENDIX F, COST ANALYSIS.

TABLE E-B

TOTAL STAFFING REQUIREMENTS  
THEATER LEVEL SCENARIO

Divisions	Alternatives		Staff Requirements			
	Non-Divisional Force Non-Medical	Medical	H-Series Divisions FSP	KP	T-Series Divisions FSP	KP
● Unit A/B	Unit A/B	Unit A/B	37,149	28,819	39,467	30,716
● Consolidated A/B	Unit A/B	Unit A/B	31,012	26,968	31,377	27,314
● Consolidated A/B <sup>1</sup>	Unit A/B	Unit A/B	31,012	24,179	31,377	24,364
● Unit T	Unit T	Unit T	20,488	9,288	21,800	9,793
● Unit T	Unit T	Unit A/B	22,083	9,694	23,395	10,199
● Unit T	Unit A/B	Unit A/B	29,922	20,908	31,234	21,413
● Unit T and Consolidated A/B	Unit T and Consolidated A/B	Unit T and Unit A/B	20,488 25,229	9,288 16,502	21,800 26,275	9,793 16,687
● Unit T and Consolidated A/B W/Reassignment	Unit T and Consolidated A/B	Unit T and Unit A/B	20,488 24,316	9,288 16,502	21,800 24,681	9,793 16,687

NOTES:

<sup>1</sup> Improved sanitation methods allows for reduction KP strength.

TABLE E-9

PERSONNEL SAVINGS RELATIVE TO BASELINE SYSTEM

THEATER LEVEL SCENARIO

Alternatives	Non-Divisional Force		H-Series Divisions		Personnel Savings	
	Non-Medical	Medical	FSP	KP	FSP	KP
• Unit A/B	Unit A/B	Unit A/B	Baseline System	Baseline System	Baseline System	Baseline System
• Consolidated A/B	Unit A/B	Unit A/B	6,137 (17%)	1,851 (6%)	8,090 (20%)	3,402 (11%)
• Consolidated A/B <sup>1</sup>	Unit A/B	Unit A/B	6,137 (17%)	4,640 (16%)	8,090 (20%)	6,352 (21%)
• Unit T	Unit T	Unit T	16,661 (45%)	19,531 (68%)	17,667 (45%)	20,923 (68%)
• Unit T	Unit T	Unit A/B	15,066 (41%)	19,125 (66%)	16,072 (41%)	20,517 (67%)
• Unit T	Unit A/B	Unit A/B	7,227 (19%)	7,911 (27%)	8,233 (21%)	9,303 (30%)
• Unit T and Consolidated A/B	Unit T and Consolidated A/B	Unit T and Unit A/B	16,661 (45%) 11,920 (32%)	19,531 (68%) 12,317 (43%)	17,667 (45%) 13,192 (33%)	20,923 (68%) 14,029 (46%)
• Unit T and Consolidated A/B W/Reassignment	Unit T and Consolidated A/B	Unit T and Unit A/B	16,661 (45%) 12,833 (35%)	19,531 (68%) 12,317 (43%)	17,667 (45%) 14,786 (37%)	20,923 (68%) 14,029 (46%)

## APPENDIX F

### COST ANALYSIS

1. **INTRODUCTION.** Investment and annual costs are determined for both the baseline systems and the new system concept, as defined in the preceding appendices. The major system cost factors addressed are rations, labor, intertheater transportation, fuel, equipment, water, and, in the case of the new system, disposable messgear. Although not separately identified, intra-theater transportation costs are implicitly contained in several other cost factors. Except for rations, labor, and possibly intertheater transportation costs, which amount to some 93 to 96% of the total system costs, other cost factors are relatively insignificant to the analysis and comparison.

2. **BASELINE SYSTEMS COSTS.** The baseline system is intended to represent the existing Army field feeding system as it would be projected into the Theater Level Scenario. There are, however, several significant actions now being considered or implemented that can substantially alter the form and content of the present system, if it is retained for future Army combat operations. These include the current procurement of the MKT, which will replace at least in part, the M48 field kitchens in the divisions; the Division Restructuring Evaluation, that might result in the reorganization of the H series TOE divisions in line with the new, proposed T series TOE; and finally, the pending decisions regarding the Unit Dining Facilities concept, wherein food service operations of selected division units may be consolidated. To our knowledge, at this time, there are no considerations to modify the food service system as it affects the nondivisional force. They would be expected to continue to generally operate at company level with M48 kitchens.

Thus, there is no single baseline system which can be defined appropriately to exemplify all possible future developments. For cost analysis, though, it is sufficient to determine an average of the costs of the individual alternatives for comparative purposes, so long as they are not widely deviant. In this case, two average baseline system costs are derived: the first involving company level operations, for both H series and T series divisions, with the MKT and M48 kitchens; and, secondly, for H series and T series divisions conducting consolidated food service operations from the MKT. The M48 kitchens were specifically excluded in the latter instance, since consolidation is being evaluated by the Army with only the MKT.

In addition, the types and proportions of rations consumed will vary by regions of the theater, i.e., division areas, and between medical and non-medical units in the corps area and COMMZ, and, as a function of time. Therefore, three different ration mixes were also evaluated, representing the status of combat food service operations at discrete intervals in the evolution of a conflict.

The annual costs for the baseline systems are presented in Table F-1. The methodology and assumptions used to derive these costs are described in the following discussion.

a. **Feeding Strengths.** The numbers of troops supported by food service operations in each part of the theater, is determined in the APPENDIX E, STAFFING ANALYSIS. To these, must also be added the numbers of patients being treated in field medical units, also requiring subsistence. At 100% bed strength, there would be 24,860 patients in corps, and

TABLE F-1

## BASELINE SYSTEMS ANNUAL COST SUMMARY (M\$)

	Ration Mix	Ration	FSP	Labor KP	Transportation	Fuel	Equipment	Water	Annual	Total Costs Per Ration
Divisions	B/MRE	687.169	282.593	170.234	46.130	32.788	28.457	4.874	1252.245	7.876
	A/MRE	702.415	282.593	170.234	71.902	32.788	28.457	4.874	1293.263	8.134
	A	497.655	282.593	170.234	85.380	54.874	28.457	9.540	1128.733	7.099
Divisions, Consolidated	8/MRE	675.948	162.981	133.677	45.377	22.945	17.999	4.795	1063.722	6.801
	A/MRE	690.945	162.981	133.677	70.728	22.945	17.999	4.795	1104.070	7.059
	A	489.528	162.981	133.677	83.986	39.172	17.999	9.384	936.727	5.989
Corps, Non-Medical	8/MRE	642.128	228.866	156.360	42.619	27.267	18.720	5.919	1121.879	7.019
	A/MRE	661.418	228.866	156.360	75.228	27.267	18.720	5.919	1173.778	7.344
	A	500.296	288.866	156.360	85.834	40.233	18.720	9.590	1038.899	6.506
Corps, Medical	8/MRE	87.292	26.267	18.564	5.794	2.828	1.717	0.805	143.267	6.593
	A/MRE	89.914	26.267	18.564	10.227	2.828	1.717	0.805	150.322	6.918
	A	68.011	26.267	18.564	11.668	4.311	1.717	1.304	131.842	6.068
COMMZ, Non-Medical	8/MRE	134.995	65.919	41.845	8.499	10.187	4.529	2.537	268.511	6.065
	A/MRE	143.828	65.919	41.845	23.430	10.187	4.529	2.537	292.275	6.601
	A	138.581	65.919	41.845	23.776	10.602	4.529	2.657	287.909	6.503
COMMZ, Medical	8/MRE	103.673	40.543	27.248	6.527	5.727	1.834	1.948	187.510	5.515
	A/MRE	110.457	40.543	27.248	17.994	5.737	1.834	1.948	205.761	6.051
	A	106.427	40.543	27.248	18.259	6.003	1.834	2.040	202.354	5.951
Total with Divisions	8/MRE	1655.257	644.188	414.251	109.569	78.807	55.257	16.083	2973.412	7.099
	A/MRE	1708.032	644.188	414.251	198.781	78.807	55.257	16.083	3115.399	7.438
	A	1310.970	644.188	414.251	224.917	116.023	55.257	25.131	2790.737	6.663
Total with Consolidated Divisions	B/MRE	1644.036	524.576	377.694	108.816	68.964	44.799	16.004	2784.889	6.691
	A/MRE	1696.592	524.576	377.694	197.607	68.964	44.799	16.004	2926.206	7.030
	A	1302.843	524.576	377.694	223.523	100.321	44.799	24.975	2598.731	6.243

54,160 patients in the COMMZ. Obviously, this assumes that casualties are replaced, so that there is no reduction in operating unit strengths. Final estimates of the total feeding strengths for each baseline system are provided in Table F-2.

b. **Ration Costs.** The ration costs are a product of feeding strengths, cost per ration, Table F-3, and the ration mix, that is, the proportions of each type of ration being consumed. These are shown in Table F-4, and reflect current prices (October 1978), except for the MRE. The first buy of the MRE has not yet been consumated, but it is anticipated will cost approximately \$8.25 per ration. Historically, from Army experience with past procurements of this sort, the costs of subsequent buys should be reduced. Since the initial production of the major MRE components involves a very substantial cost for new processing equipment and plants and training of production personnel, and because the contractors have no assurance of repeat sales, a significant proportion of this original capital investment must therefore be returned by the first procurement. Once these costs have been recovered, however, the price of subsequent ration purchases from these same contractors will be appropriately less. Taking this into account, and comparing to the MCI price trend, the estimated future cost of the MRE is \$5.50 per ration, in current dollars (October 1978).

The logistics planning factor for total ration consumption, 60% bulk and 40% individual rations, was used to assess the ration mix for each area of the theater. Percentages of bulk and individual rations for the divisions, calculated from the SCORES analysis, were 46% bulk and 54% individual rations. Guidance provided at the third meeting of the Joint Working Group<sup>1</sup> was 95% bulk and 5% individual rations for the COMMZ. Then, to obtain the average proportions of 60%/40%, the remainder had to be allocated at the rate of 57% bulk and 43% individual rations to the corps areas.

c. **Labor Costs.** Food service personnel costs include only the costs of persons with food service MOS directly involved in the supervision and operation of the kitchens. Other food service personnel, responsible for higher level management functions, are not charged as a system cost. It is expected that these indirect personnel costs would remain essentially constant between the baseline systems. An average annual cost of \$16,816 per man year<sup>2</sup> was applied against the required staffing for each alternative system as shown in Table F-2, to establish the food service personnel costs. The KP labor costs, estimated at \$13,916 per man year, represent average Army wide costs for pay grades E2/E3.<sup>3</sup> Total KP staffing

<sup>1</sup> US Army Quartermaster School, ATSM-CD-C, Memorandum for Record, Subject: JWG Meeting on JSR AM 3-1 (Appendix I) Food Service System for the Army in the Field. Fort Lee, Virginia, 13 November 1978.

<sup>2</sup> US Army Training and Doctrine Command Systems Analysis Activity. ATAA-TDA. MOS Cost Update Information for Force Stratification Analysis Reports 78039-78043. Letter. US Army Natick R&D Command. White Sands Missile Range, New Mexico: 14 September 1978.

<sup>3</sup> Comptroller of the Army. Directorate of Cost Analysis Office. Army Force Planning Cost Handbook. Washington: June 1977.

TABLE F--2

THEATER LEVEL SCENARIO FEEDING STRENGTHS FOR BASELINE SYSTEMS

	Non-Food Service Personnel	Patients	Food Service Personnel	Total
H Divisions	415,912	-	15,646	431,558
H Divisions -- Consolidated	415,912	-	9,509	425,421
T Divisions	421,684	-	17,964	439,648
T Divisions -- Consolidated	421,684	-	9,874	431,558
Average	418,798	-	16,805	435,603
Average -- Consolidated <sup>1</sup>	418,798	-	9,692	428,490
Corps -- Non-Medical <sup>1</sup>	424,305	-	13,610	437,915
Corps -- Medical <sup>1</sup>	33,109	24,860	1,562	59,531
COMMZ -- Non-Medical <sup>1</sup>	117,382	-	3,920	121,302
COMMZ -- Medical <sup>1</sup>	<u>36,586</u>	<u>54,160</u>	<u>2,411</u>	<u>93,157</u>
Total -- Average	1,030,180	79,020	38,308	1,147,508
Total -- Average Consolidated	1,030,180	79,020	31,195	1,140,395

NOTES:

<sup>1</sup>Strengths utilized for cost analysis, from Table E-1.

TABLE F-3  
RATION COSTS

Type Ration	\$/Ration <sup>1</sup>
B	2.92
MRE	5.50
T	3.91
T Augmented	4.41
A	3.13
Minimum Volume	3.83

**NOTES:**

<sup>1</sup> Estimated cost for October 1978, from Table C-10.

TABLE F-4

RATION MIX AND COSTS FOR BASELINE SYSTEMS

THEATER LEVEL SCENARIO

Baseline Systems	Strength	Ratio	Bulk Rations	Individual Rations	Annual Cost (M\$)		
					B/MRE	A/MRE	A
Divisions - Average	435,603	46/54	198,900	236,703	687.169	702.415	497.655
Divisions - Average Consolidated	428,490	46/54	195,652	232,838	675.948	690.945	489.528
Corps - Non-Medical	437,915	57/43	251,658	186,257	642.128	661.418	500.296
Corps - Medical	59,531	57/43	34,211	25,320	87.292	89.914	68.011
COMMZ - Non-Medical	121,302	95/5	15,237	6,065	134.995	143.828	138.581
COMMZ - Medical	93,157	95/5	88,499	4,658	103.673	110.457	106.427
Total - with Divisions	1,147,508	60/40	688,505	459,003	1,655.257	1,708.032	1,310.970
Total - with Consolidated Divisions	1,140,395	60/40	685,257	455,138	1,644.036	1,696.562	1,302.843

requirements were derived from Tables E-6 and E-7. The resulting food service and KP labor costs are included in Table F-5.

d. **Intertheater Transportation Costs.** The nominal route assumed for estimating costs of intertheater transportation of rations is Chicago to the European theater, via commercial container transport. Commercial charges are specified per measurement ton of a given product category (equivalent to 40 ft<sup>3</sup> of container volume — not the shipping volume of one ton of a particular product). From the established costs, and using empirical container utilization factors, the actual rates for dry cargo and refrigerated products, corresponding to non-perishable and perishable subsistence supplies, were determined in Table F-6. Based upon the transportation costs per type ration, Table F-7, and ration requirements, Table F-4, the transportation costs for the baseline systems were calculated and are summarized in Table F-8.

e. **Equipment Costs.** Equipment allocation criteria for both the MKT and M48 kitchen are presented in Table F-9, and the annual costs of specific equipment items contained in these kitchens are given in Table F-10. From these data, and the force structures delineated in Tables E-1, E-3, and E-4, detailed equipment costs were obtained for the baseline systems, as shown in Tables F-11 to F-16.

f. **Fuel Costs.** The only fuel burning equipment in the baseline systems are the M-2 burners, the immersion heaters and the 2½ ton trucks. Fuel usage rates and costs for this equipment are included in Table F-17, assuming three A or B ration meals are served, and that the trucks average 100 miles a day. For fewer than three hot meals a day, proportionally less fuel is used, since the MRE is not heated and served from the kitchens. Fuel costs in each baseline system are adjusted in this manner for the different ration mixes, Tables F-18 and F-19. Total fuel costs for all the baseline systems are presented in Table F-20.

g. **Water Costs.** An Engineer Water Supply Company (SRC 05067H) was assumed to establish the cost of water production in the field, which is detailed in Table F-21. Water is required for food preparation and sanitation purposes, as shown in Table F-22. Total water costs for the baseline systems, given in Table F-23, were calculated from these data for the ration mixes specified in Table F-4. Cost for transporting water from the water supply point to the kitchen, approximately 25 miles per day, is included in the fuel costs for the 2½ ton trucks.

3. **NEW SYSTEM COSTS.** Under the new system concept, all active combat units, which in most instances are those operating from brigade forward, will have just the trailer mounted Food Service Unit to deliver T ration meals, in adjunct to the MRE rations. The necessary equipment and capacity for A ration operations will be maintained at that level of organization, usually battalion but sometimes company, consistent with the plan of consolidation that would eventually become operative. All other units, now provided with a 8/MRE capability, will have, instead, the equipment and capacity to service A rations, but will generally be staffed only for T/MRE ration operations.

The ration mix, as with the baseline systems, will vary within the theater, and transition from T/MRE, to T Augmented/MRE, to A/MRE, as the conflict matures and combat conditions

**TABLE F-5**  
**LABOR COSTS FOR BASELINE SYSTEMS**

**THEATER LEVEL SCENARIO**

Baseline Systems	Food Service Personnel Required      M\$/Year		KP Personnel Required <sup>1</sup> M\$/Year	
Divisions – Average	16,805	282.593	12,233	170.234
Divisions – Average Consolidated	9,692	162.981	9,606	133.677
			6,737 <sup>2</sup>	93,752
Corps – Non-Medical	13,610	228.866	11,236	156,360
Corps – Medical	1,562	26,267	1,334	18.564
COMMZ – Non-Medical	3,920	65.919	3,007	41.845
COMMZ – Medical	<u>2,411</u>	<u>40,543</u>	<u>1,958</u>	<u>27.248</u>
Total with Divisions	38,308	644.188	29,768	414.251
Total with Consolidated Divisions	31,195	524.576	27,141	377.694
			24,272 <sup>2</sup>	337.769

**NOTES:**

<sup>1</sup>Based on the current KP planning factor of two for the first fifty and one for each additional fifty or major fraction thereof, rations served, except as noted.

<sup>2</sup>Based on a KP planning factor of two for the first 75, and one for each additional 75, or major fraction thereof, rations served proposed for system employing improved sanitation equipment and methods.

TABLE F-6

COMMERCIAL CONTAINER TRANSPORTATION COSTS PER ACTUAL  
PRODUCTION MEASUREMENT TON

Component	Dry Cargo	Refrigerated
Drayage (Chicago to Hatteras)	\$ 9.43 <sup>1</sup>	\$ 12.80 <sup>1</sup>
Ocean Freight <sup>2</sup>	32.06	85.56
Bunker Fuel Allowances <sup>2</sup>	- 0.12	- 0.12
Port Handling <sup>3</sup>	5.27	5.27
Total Per Container MTON	46.64	103.51
% Container Utilization	<u>71%</u>	<u>62%</u>
Total Per Actual Product MTON	\$65.69	\$166.95

NOTES:

<sup>1</sup> Per 'Container Rate Agreement', averaged for three carriers.

<sup>2</sup> PAM 55-5, 31 August 1978

<sup>3</sup> PAM 55-3

TABLE F-7

COMMERCIAL COSTS FOR INTERTHEATER TRANSPORTATION OF VARIOUS TYPES OF RATIONS

Type Ration	Ration Component <sup>1</sup>	Lbs	Ft <sup>3</sup>	\$/Component	\$/Ration
A	P	3.80	0.101	0.422	0.537
	NP	2.19	0.070	0.115	
T Augmented	P	0.28	0.012	0.050	0.336
	NP	5.54	0.174	0.286	
T	NP	4.86	0.147	0.241	0.241
Minimum Volume	P	0.28	0.012	0.050	0.236
	NP	3.17	0.113	0.186	
B	NP	3.96	0.111	0.182	0.182
MRE	NP	3.88	0.232	0.381	0.381

NOTES:

<sup>1</sup>Perishable components, P, require refrigeration, and non-perishable components, NP, require only dry cargo transport.

**TABLE F-8**  
**ANNUAL INTERTHEATER RATION TRANSPORTATION COSTS**  
**THEATER LEVEL SCENARIO**  
**(M\$/YR)**

<b>Baseline Systems</b>	<b>B/MRE</b>	<b>Ration Mix A/MRE</b>	<b>A</b>
Divisions - Average	46.130	71.902	85.380
Divisions - Average Consolidated	45.377	70.728	83.986
Corps - Non-Medical	42.619	75.228	85.834
Corps - Medical	5.794	10.227	11.668
COMMZ - Non-Medical	8.499	23.430	23.776
COMMZ - Medical	6.527	17.994	18.259
<hr/>			
Total - with Divisions	109.569	198.781	224.917
Total - with Divisions Consolidated	108.816	197.607	223.523

TABLE F-9

EQUIPMENT ALLOCATION RULES

Type Kitchen	Item	Allocation Criteria	
MKT & M48	Immersion Heaters	4 per 85 troops or fraction	
	Water Trailer, 400 gal	Feeding Strength	No. Auth.
		1 - 400	1
		401 Plus	2
MKT	MKT Units	Feeding Strength	No. Auth.
		1 - 300	1
		301 - 650	2
		651 Plus	3
	Trucks, 2½ ton	Authorized one less than number of MKT units and number of water trailers.	
M48	Ranges	Feeding Strength	No. Auth.
		1 - 50	1
		51 - 100	2
		101 - 225	3
		226 - 325	4
		326 Plus	1 for each additional 100 or fraction
	Accessory Outfits	1 per 4 ranges or fractions	
	M48 Tent	1 per accessory outfit	
	Water Bags	1 per 100 troops or major fraction	
	Insulated Food Containers	1 per 25 troops or fraction	
Trucks, 2½ ton	1 per water trailer		

**TABLE F-10**  
**EQUIPMENT COSTS<sup>4</sup>**

Item	Cost/Item	Economic Life (Years)	Uniform Annual Cost
MKT Unit	\$ 8,829	Variable	\$2,950
Range	744	4	235
Accessory Pack	89	3	36
M48 Tant	718	1	790
Immersion Heater	86	4	27
Can, 32 gallon	17	2/3	27
Insulated Food Container	85	2	49
Water Bag	67	1	74
Water Trailer, 400 gallon	4,244	6	974
Truck, 2½ ton	17,813	6	4,090

<sup>4</sup>HQ, Department of the Army. SB 700-20: Army Adopted/Other Items Selected for Authorization/List of Reportable Items. Washington, 1978 Microfichen Edition.

TABLE F-11

EQUIPMENT COSTS FOR COMPANY LEVEL M48 KITCHENS IN DIVISION

Item	H Series			T Series		
	Number Authorized	Investment Cost	Uniform Annual Cost	Number Authorized	Investment Cost	Uniform Annual Cost
Ranges	315	\$ 234,360	\$ 74,025	423	\$ 314,712	\$ 99,405
Accessory Outfits	117	10,413	4,212	183	16,287	6,588
M48 Tents	117	84,006	92,430	183	131,394	144,570
Water Bags	182	12,194	13,468	211	14,137	15,614
Insulated Food Containers	726	61,710	35,574	836	71,060	40,964
Immersion Heaters	1,080	92,880	29,160	1,268	109,048	34,236
Garbage Cans	1,080	18,360	29,160	1,268	21,556	34,236
Water Trailers, 400 gal	113	479,572	110,062	179	759,676	174,346
<u>Trucks, 2½ ton</u>	<u>113</u>	<u>2,012,869</u>	<u>462,170</u>	<u>179</u>	<u>3,188,527</u>	<u>732,110</u>
Total Division Cost	-	\$3,006,364	\$850,261	-	\$4,626,397	\$1,282,069
Division Equivalents	25.357	-	-	23.793	-	-
Total Cost (M\$)	-	76.232	21.560	-	110.076	30.504

TABLE F-12

EQUIPMENT COST FOR COMPANY LEVEL MKT IN DIVISION

Item	H Series			T Series		
	Number Authorized	Investment Cost	Uniform Annual Cost	Number Authorized	Investment Cost	Uniform Annual Cost
MKT	118	\$1,041,822	\$348,100	183	\$1,615,707	\$ 539,850
Immersion Heaters	1,080	92,880	29,160	1,268	109,048	34,236
Garbage Cans	1,080	18,360	29,160	1,268	21,556	34,236
Water Trailers, 400 gal	113	479,572	110,062	179	759,676	174,346
<u>Trucks, 2 1/2 ton</u>	<u>118</u>	<u>2,101,934</u>	<u>482,620</u>	<u>183</u>	<u>3,259,779</u>	<u>748,470</u>
Total Division Cost	-	\$3,734,568	\$999,102	-	\$5,765,766	\$1,531,138
Division Equivalents	25.357	-	-	23.793	-	-
Total Cost (M\$)	-	94.697	25.334	-	137.185	36.430

TABLE F-13

EQUIPMENT COST FOR CONSOLIDATED MKT IN DIVISION

Item	H Series			T Series		
	Number Authorized	Investment Cost	Uniform Annual Cost	Number Authorized	Investment Cost	Uniform Annual Cost
MKT	74	\$ 653,346	\$218,300	80	\$ 706,320	\$236,000
Immersion Heaters	880	75,860	23,760	952	81,872	25,704
Garbage Cans	880	14,960	23,760	952	16,184	25,704
Water Trailer, 400 gal	59	250,396	57,446	69	292,836	67,206
<u>Truck, 2½ ton</u>	<u>91</u>	<u>1,620,983</u>	<u>372,190</u>	<u>102</u>	<u>1,816,926</u>	<u>417,180</u>
Total Division Cost	-	\$2,615,545	\$695,456	-	\$2,914,138	\$771,794
Division Equivalents	25.357	-	-	23.793	-	-
Total Cost (M\$)	-	66.322	17.635	-	69.336	18.363

TABLE F-14

NON-DIVISION NON-MEDICAL UNIT EQUIPMENT COSTS WITH M48 KITCHENS

Item	Corps Area			COMMZ Area		
	Auth/1000 Troops	Investment Cost	Uniform Annual Cost	Auth/1000 Troops	Investment Cost	Uniform Annual Cost
Ranges	16.60	\$ 12,350	\$ 3,901	14.50	\$ 10,788	\$ 3,408
Accessory Outfits	5.73	510	206	4.83	430	174
M48 Tents	5.73	4,114	4,527	4.83	3,468	3,816
Water Bags	9.21	617	682	9.30	623	688
Insulated Food Containers	38.30	3,256	1,877	40.40	3,434	1,980
Immersion Heaters	53.60	4,610	1,447	54.90	4,721	1,482
Garbage Cans	53.60	911	1,447	54.90	933	1,482
Water Trailers, 400 gal	5.66	24,021	5,513	4.80	20,371	4,675
Trucks, 2½ ton	5.66	100,822	23,149	4.80	85,502	19,632
Total/1000 Troops	-	\$151,211	\$42,749	-	\$130,270	\$37,337
Total Strength (1000)	437.915	-	-	121.302	-	-
Total Cost (M\$)	-	66.218	18.720	-	15.802	4.529

TABLE F-15

NON-DIVISION MEDICAL UNIT EQUIPMENT COSTS WITH M48 KITCHENS

Item	Corps Area			COMMZ Area		
	Auth/1000 Troops	Investment Cost	Uniform Annual Cost	Auth/1000 Troops	Investment Cost	Uniform Annual Cost
Ranges	20.10	\$ 14,954	\$ 4,724	25.80	\$ 19,196	\$ 6,063
Accessory Outfits	6.83	608	246	7.57	674	273
M48 Tents	6.83	4,904	5,396	7.57	5,436	5,980
Water Bags	14.70	985	1,088	22.80	1,528	1,687
Insulated Food Containers	61.30	5,211	3,004	92.50	7,863	4,533
Immersion Heaters	81.90	7,043	2,211	113.00	9,718	3,061
Garbage Cans	81.90	1,393	2,211	113.00	1,921	3,061
Water Trailers, 400 gal	6.05	25,676	5,893	4.42	18,758	4,305
<u>Trucks, 2½ ton</u>	<u>6.05</u>	<u>107,769</u>	<u>24,745</u>	<u>4.42</u>	<u>78,733</u>	<u>18,078</u>
Total/1000 Troops	.	\$168,453	\$49,518	.	\$143,825	\$47,021
Total Strength (1000)	34.671	.	.	38.997	.	.
Total Cost (M\$)	.	5.840	1.717	.	5.609	1.834

TABLE F-16

TOTAL ANNUAL EQUIPMENT COSTS FOR BASELINE SYSTEMS IN THE

THEATER LEVEL SCENARIO

(M\$/YR)

Baseline Systems	T Series		Nonconsolidated		H Series		T Series		Consolidated		H Series	
	Investment	Annual	Investment	Annual	Investment	Annual	Investment	Annual	Investment	Annual	Investment	Annual
Divisions	123.630 <sup>1</sup>	33.467 <sup>1</sup>	85.464 <sup>1</sup>	23.447 <sup>1</sup>	69.336 <sup>2</sup>	18.363 <sup>2</sup>	66.322 <sup>2</sup>	17.635 <sup>2</sup>				
Corps - Non-Medical <sup>3</sup>	66.218	18.720	66.218	18.720	66.218	18.720	66.218	18.720				
Corps - Medical <sup>3</sup>	5.840	1.717	5.840	1.717	5.840	1.717	5.840	1.717				
COMMZ - Non-Medical <sup>3</sup>	15.802	4.529	15.802	4.529	15.802	4.529	15.802	4.529				
COMMZ - Medical <sup>3</sup>	5.609	1.834	5.609	1.834	5.609	1.834	5.609	1.834				
Total	217.099	60.267	178.933	50.247	162.805	45.163	159.791	44.435				

NOTES:

<sup>1</sup> Average of company level M48 and MKT equipment costs.

<sup>2</sup> Only MKT considered in consolidated mode of food service operations.

<sup>3</sup> Only company level M48 kitchens considered for these units.

TABLE F-17

FUEL USAGE RATES AND COSTS BY EQUIPMENT ITEM

	Range w/M-2 Burner	Immersion Heaters	Truck, 2½ ton
Type Fuel	Mogas	Mogas	Diesel
Cost (\$/gal) <sup>1</sup>	\$0.507	\$0.507	\$0.449
Consumption Rate	0.50 gal/hr <sup>2</sup>	0.43 gal/hr <sup>2</sup>	0.24 gal/mi <sup>3</sup>
Usage Rate	12 hr/day <sup>4</sup>	12 hr/day <sup>2</sup>	100 mi/day
Usage	2190 gal/yr	1883 gal/yr	8760 gal/yr
Cost	\$1110/yr	\$955/yr	\$3933/yr

NOTES:

<sup>1</sup> Average cost, provided by DFSC, October 1978.

<sup>2</sup> Estimated based on operational experience.

<sup>3</sup> FM 101-0, Staff Officers Field Manual: Organizational, Technical and Logistical Data: Unclassified Data, July 1971.

<sup>4</sup> Assumes three A/8 ration type meals per day.

TABLE F-18

## ANNUAL DIVISIONAL FUEL COSTS WITH ALTERNATIVE BASELINE SYSTEMS

Division/System	Item	Per Division (1000\$)		Annual Cost		Total Division Strength (M\$)	
		A-B/MRE <sup>1</sup>	A/B <sup>2</sup>	A-B/MRE <sup>1</sup>	A/B <sup>2</sup>	A-B/MRE <sup>1</sup>	A/B <sup>2</sup>
Division - H Series	Ranges	159.654	349.650	4.048	8.866	4.048	8.866
Level - Unit	Immersion Heaters	470.948	1,031.400	11.942	26.153	11.942	26.153
Kitchen - M48	Trucks, 2½ ton	444.429	444.429	11.269	11.269	11.269	11.269
	All	<u>1,075.031</u>	<u>1,825.479</u>	<u>27.259</u>	<u>46.288</u>	<u>27.259</u>	<u>46.288</u>
Division - H Series	MKT	239.227	523.920	6.066	13.285	6.066	13.285
Level - Unit	Immersion Heaters	470.948	1,031.400	11.942	26.153	11.942	26.153
Kitchen - MKT	Trucks, 2½ ton	464.094	464.094	11.768	11.768	11.768	11.768
	All	<u>1,174.269</u>	<u>2,019.414</u>	<u>29.778</u>	<u>51.206</u>	<u>29.778</u>	<u>51.206</u>
Division - T Series	Ranges	214.392	469.530	5.101	11.172	5.101	11.172
Level - Unit	Immersion Heaters	552.927	1,210.940	13.156	28.812	13.156	28.812
Kitchen - M48	Trucks, 2½ ton	704.007	704.007	16.751	16.751	16.751	16.751
	All	<u>1,471.328</u>	<u>2,384.477</u>	<u>35.008</u>	<u>56.736</u>	<u>35.008</u>	<u>56.736</u>
Division - T Series	MKT	371.005	812.520	8.827	19.332	8.827	19.332
Level - Unit	Immersion Heaters	552.927	1,210.940	13.156	28.812	13.156	28.812
Kitchen - MKT	Trucks, 2½ ton	719.739	719.739	17.125	17.125	17.125	17.125
	All	<u>1,643.671</u>	<u>2,743.199</u>	<u>39.108</u>	<u>65.269</u>	<u>39.108</u>	<u>65.269</u>
Division - H Series	MKT	150.024	328.560	3.804	8.331	3.804	8.331
Level - Consolidated	Immersion Heaters	383.735	840.400	9.730	21.310	9.730	21.310
Kitchen - MKT	Trucks, 2½ ton	357.903	357.903	9.075	9.075	9.075	9.075
	All	<u>891.662</u>	<u>1,526.863</u>	<u>22.609</u>	<u>38.716</u>	<u>22.609</u>	<u>38.716</u>
Division - T Series	MKT	162.188	355.200	3.859	8.451	3.859	8.451
Level - Consolidated	Immersion Heaters	415.132	909.160	9.877	21.632	9.877	21.632
Kitchen - MKT	Trucks, 2½ ton	401.166	401.166	9.545	9.545	9.545	9.545
	All	<u>978.486</u>	<u>1,665.526</u>	<u>23.281</u>	<u>39.628</u>	<u>23.281</u>	<u>39.628</u>

## NOTES:

<sup>1</sup> Based upon the established ration mix, Table F-4.<sup>2</sup> All bulk rations.

TABLE F-19

ANNUAL NON-DIVISIONAL FUEL COSTS WITH BASELINE SYSTEMS

Non-Divisional Group	Item	Per 1000 Troops (1000\$)		Annual Cost	
		A-B/MRE <sup>1</sup>	A/B <sup>2</sup>	A-B/MRE <sup>1</sup>	A/B <sup>2</sup>
Corps - Non-Medical	Ranges	10,589	18,426	4,637	8,069
	Immersion Heaters	29,416	51,188	12,882	22,416
	Trucks, 2½ ton	22,261	22,261	9,748	9,748
	All	62,266	91,875	27,267	40,233
Corps - Medical	Ranges	12,821	22,311	0,445	0,774
	Immersion Heaters	44,948	78,214	1,568	2,712
	Trucks, 2½ ton	23,795	23,795	0,825	0,825
	All	81,564	124,320	2,828	4,311
COMMZ - Non-Medical	Ranges	15,290	16,095	1,855	1,952
	Immersion Heaters	49,808	52,430	6,042	6,360
	Trucks, 2½ ton	18,878	18,878	2,290	2,290
	All	83,976	87,403	10,187	10,802
COMMZ - Medical	Ranges	27,206	28,638	1,061	1,117
	Immersion Heaters	102,519	107,915	3,998	4,208
	Trucks, 2½ ton	17,384	17,384	0,678	0,878
	All	147,109	153,937	5,737	6,003

NOTES:

<sup>1</sup> Based upon the established ration mix, Table F-4.

<sup>2</sup> All bulk rations.

**TABLE F-20**

**FUEL COSTS FOR BASELINE SYSTEMS**

**THEATER LEVEL SCENARIO**

**(M\$/YR)**

<b>Baseline Systems</b>	<b>A/MRE or B/MRE</b>	<b>A</b>
Divisions – Average	32.788	54.874
Division – Average Consolidated	22.945	39.172
Corps – Non-Medical	27.267	40.233
Corps – Medical	2.828	4.311
COMMZ – Non-Medical	10.187	10.602
COMMZ – Medical	5.737	6.003
<u>Total – with Divisions</u>	<u>78.807</u>	<u>116.023</u>
Total – with Consolidated Divisions	68.964	100.321

**TABLE F-21<sup>5</sup>**

**WATER PRODUCTION COSTS**

Unit:	SRC 05067H Engineer Water Supply Company
Annual Recurring Cost	\$2,138,000.
Production Rate	27,000 gallons/hour, 1B hours/day
Yearly Production	177,390,000 gallons
Cost (\$)/Gallon	\$0.012/gallon

**NOTES:**

<sup>5</sup>Directorate of Cost Analysis, Office, Comptroller of the Army. Army Force Planning. Cost Handbook. Washington, June 1977. (cost updated to FY 79)

**TABLE F-22**

**WATER USAGE RATES<sup>1</sup>**

Food Preparation	0.5 gallons per A/B or MRE ration*
Messkit Sanitation	1.0 gallons per A/B type meal
Pot/Pan and Other Sanitation	0.5 gallons per A/B type meal

\*Ration is three meals per day.

**NOTES:**

<sup>1</sup>Water usage rates estimated based on operational experience.

**TABLE F-23**  
**WATER COSTS FOR BASELINE SYSTEMS**  
**THEATER LEVEL SCENARIO**

(M\$)

Baseline Systems	A/MRE or B/MRE	A
Divisions -- Average	4.874	9.540
Divisions -- Average Consolidated	4.795	9.384
Corps -- Non-Medical	5.919	9.590
Corps -- Medical	0.805	1.304
COMMZ -- Non-Medical	2.537	2.657
COMMZ -- Medical	<u>1.948</u>	<u>2.040</u>
<u>Total -- with Divisions</u>	<u>16.083</u>	<u>25.131</u>
Total -- with Consolidated Divisions	16.004	24.975

allow; ultimately converting to total A rations, although in some cases, not until after the conflict is concluded. Since most of the individual units will not have sufficient food service personnel for A ration operations, either additional staffing will have to be provided, or designated units will combine their resources into larger, more efficient kitchens that can operate effectively within the limits of the available food service personnel. A cost summary for the new system is presented in Table F-24, which is compatible for comparison with the baseline systems cost in Table F-1.

a. **Feeding Strengths.** The variations in feeding strengths from those of the baseline systems are attributable solely to differences in food service personnel authorizations, as discussed in the STAFFING ANALYSIS, APPENDIX E. Otherwise, the numbers of personnel and patients requiring subsistence support remain unchanged, as shown in Table F-25.

b. **Ration Costs.** The total ration costs for the new system, Table F-26, were calculated for these feeding strengths from the ration cost estimates in Table F-3 and the ration mixes noted in Table F-27.

c. **Labor Costs.** Food Service labor costs for T ration and A ration operations are given in Table F-28. These costs are based on \$16,816 per year per food service MOS and \$13,916 per year per KP, as previously explained in paragraph 2.c, and staffing requirements as indicated in Tables E-6, E-7 and F-25.

d. **Intartheater Transportation Costs.** The costs of transporting rations in the new system, from CONUS to the European Theater, are based on the same assumptions as for the baseline systems, paragraph 2.d. The results are contained in Table F-29.

e. **Equipment Costs.** Equipment allowances for all units are outlined in Table F-30. Every company in division, now authorized a food service section, would be allocated a trailer mounted Food Service Unit, if a high degree of responsiveness is required, e.g., mechanized or tank companies, or a Modular Field Kitchen. Costs are shown in Tables F-31 and F-32.

As these companies convert to consolidated or integrated food service operations, equipment and capacities will have to be expanded. Kitchens hosting companies equipped only with the Food Service Units will require some additional food preparation equipment and shelter, Table F-33. Every host kitchen under consolidation will be provided a sanitation center, Table F-34, and if the feeding strength is greater than 350 troops, additional food processing equipment as well, Table F-35.

Two different kinds of prime movers would be used in the new system. A 2½ ton truck is still needed with the Modular Field Kitchens, but the smaller size and lighter weight of the trailer mounted Food Service Unit should not require more than a 1¼ ton truck. Criteria for truck and water trailer authorizations are also indicated in Table F-30.

Investment and annual equipment costs for the divisions are summarized in Table F-36.

Equipment costs for the remaining non-divisional force are presented in Tables F-37 and F-38. As in the divisions, every unit now authorized a food service capability would have

TABLE F-24

## NEW SYSTEM ANNUAL COST SUMMARY (M\$)

Division	RATION MIX	RATIONS	LABOR		TRANSPORTATION	FUEL	EQUIPMENT	WATER	DISPOSABLE	ANNUAL PER RATION	TOTAL COST
			FSP	KP							
Division	T/MRE	745,572	152,606	50,459	48,518	13,215	23,873	1,364	24,208	1060,918	9,793
	T-AUG/MRE	781,227	152,606	50,459	56,293	13,215	23,973	1,364	24,208	1103,245	7,064
	A/MRE	682,986	184,051	93,752	70,935	14,952	23,873	3,777	-	1084,306	6,913
	A	490,960	184,051	93,752	84,232	21,798	23,873	7,153	-	906,919	5,775
Corps - Non-Medical	T/MRE	722,854	126,268	41,372	47,370	11,982	21,357	1,489	30,749	1003,461	8,367
	T-AUG/MRE	768,141	126,268	41,372	56,874	11,982	21,357	1,489	30,749	1067,352	6,709
	A/MRE	653,679	142,701	82,661	74,348	14,955	21,357	4,543	-	984,244	6,294
	A	494,442	142,701	82,661	84,929	18,883	21,357	7,203	-	852,079	5,384
Corps - Medical	T/MRE	98,543	15,101	9,477	6,458	1,036	2,128	0,203	4,192	137,138	6,383
	T-AUG/MRE	104,717	15,101	9,477	7,631	1,036	2,128	0,203	4,192	144,485	8,724
	A/MRE	89,914	26,267	13,053	10,227	1,875	2,128	0,625	-	143,889	6,822
	A	68,011	26,267	13,053	11,668	2,318	2,128	0,991	-	124,434	5,777
COMMZ - Non-Medical	T/MRE	174,104	36,878	14,932	10,823	3,159	5,010	3,511	14,074	259,289	5,941
	T-AUG/MRE	194,833	36,878	14,932	14,791	3,158	5,010	0,511	14,074	283,956	6,507
	A/MRE	141,964	39,484	22,864	23,127	4,694	5,010	1,906	-	239,049	5,470
	A	135,786	39,484	22,864	23,468	4,820	5,010	1,993	-	234,425	5,364
COMMZ - Medical	T/MRE	134,296	24,888	18,532	8,348	1,115	2,063	0,394	10,856	198,492	5,897
	T-AUG/MRE	150,286	24,888	18,532	11,386	1,115	2,063	0,394	10,856	217,520	6,482
	A/MRE	110,457	40,543	18,806	17,994	2,444	2,063	1,483	-	193,590	5,693
	A	106,427	40,543	18,806	18,259	2,537	2,063	1,551	-	189,986	5,587
Total	T/MRE	1975,369	355,559	132,772	122,518	30,507	54,431	3,961	84,079	2659,196	6,445
	T-AUG/MRE	1999,204	355,559	132,772	146,045	30,507	54,431	3,961	84,079	2808,558	9,803
	A/MRE	1688,980	433,046	230,835	198,631	38,720	54,431	12,334	-	2855,078	6,409
	A	1286,826	433,046	230,936	222,456	50,354	54,431	18,891	-	2308,740	5,588

TABLE F-25

FEEDING STRENGTHS FOR NEW SYSTEM

New System	T Ration			A or T Ration	
	Adjusted Troop Strength <sup>1</sup>	Food Service Personnel <sup>2</sup>	Total	Food Service Personnel <sup>2</sup>	Total
Divisions - Average	418,798	9,075	427,873	10,945	429,743
Corps - Non-Medical	424,305	7,510	431,815	8,486	432,791
Corps - Medical	57,969	898	58,867	1,562	59,531
COMMZ - Non-Medical	117,382	2,181	119,563	2,348	119,730
<u>COMMZ - Medical</u>	<u>90,746</u>	<u>1,480</u>	<u>92,226</u>	<u>2,411</u>	<u>93,157</u>
Total	1,109,200	21,144	1,130,344	25,752	1,134,952

NOTES:

<sup>1</sup> Troop and patient strength, less food service personnel.

<sup>2</sup> Staffing requirements from Tables E-6 and E-7.

TABLE F-26

NEW SYSTEM ANNUAL RATION COSTS (M\$)

Ration Mix

New System	T/MRE	T-AUG/MRE	A/MRE	A
Divisions	745.572	781.227	692.966	490.960
Corps - Non-Medical	722.854	768.141	653.679	494.442
Corps - Medical	98.543	104.717	89.914	68.011
COMMZ - Non-Medical	174.104	194.833	141.964	136.786
<u>COMMZ - Medical</u>	<u>134.296</u>	<u>150.286</u>	<u>110.457</u>	<u>106.427</u>
Total	1,875.369	1,999.204	1,688.980	1,296.626

TABLE F-27

## NEW SYSTEM RATION MIXES

New System	Type Rations	Feeding Strength <sup>1</sup>	Ration Mix <sup>3</sup>		
			A	T	MRE
Division	T/MRE <sup>2</sup>	427,873	-	195,370	232,503
	A/MRE	429,743	196,224	-	233,519
	A	429,743	429,743	-	-
Corps - Non-Medical	T/MRE	431,815	-	248,152	183,663
	A/MRE	432,791	248,713	-	184,078
	A	432,791	432,791	-	-
Corps - Medical	T/MRE	58,867	-	33,829	25,038
	A/MRE	59,531	34,211	-	25,320
	A	59,531	59,531	-	-
COMMZ - Non-Medical	T/MRE	119,563	-	113,585	5,978
	A/MRE	119,730	113,744	-	5,986
	A	119,730	119,730	-	-
COMMZ - Medical	T/MRE	92,226	-	87,615	4,611
	A/MRE	93,157	88,499	-	4,658
	A	93,157	93,157	-	-
Total	T/MRE	1,130,344	-	678,551	451,793
	A/MRE	1,134,952	681,391	-	453,561
	A	1,134,952	1,134,952	-	-

## NOTES:

<sup>1</sup> Includes food service and non-food service personnel, and rations.

<sup>2</sup> T/MRE figures apply to T Augmented/MRE ration plan as well.

<sup>3</sup> Ration mix ratios as indicated in Table F-4.

TABLE F-28

NEW SYSTEM FOOD SERVICE PERSONNEL AND KP REQUIREMENTS AND COSTS

New System	FSP		KP		FSP		KP	
	Required	M\$/Year	Required	M\$/Year	Required	M\$/Year	Required	M\$/Year
Divisions - Average	9,075	152,606	3,626	50,459	10,945	184,051	6,737	93,752
Corps - Non-Medical	7,510	126,288	2,973	41,372	8,486	142,701	5,940	82,661
Corps - Medical	898	15,101	681	9,477	1,562	26,267	938	13,053
COMMZ - Non-Medical	2,181	36,676	1,073	14,932	2,348	39,484	1,643	22,864
<u>COMMZ - Medical</u>	<u>1,480</u>	<u>24,888</u>	<u>1,188</u>	<u>16,532</u>	<u>2,411</u>	<u>40,543</u>	<u>1,337</u>	<u>18,606</u>
Total	21,144	355,559	9,541	132,772	25,752	433,046	16,595	230,936

TABLE F-29

NEW SYSTEM ANNUAL INTERTHEATER RATION TRANSPORTATION COSTS

(M\$/YR)

New System	Ration Mix			
	T/MRE	T-AUT/MRE	A/MRE	A
Divisions	49.519	56.293	70.935	84.232
Corps - Non-Medical	47.370	55.974	74.348	84.829
Corps - Medical	6.458	7.631	10.227	11.668
COMMZ - Non-Medical	10.823	14.761	23.127	23.468
COMMZ - Medical	<u>8.348</u>	<u>11.386</u>	<u>17.994</u>	<u>18.259</u>
Total	122.518	146.045	196.631	222.456

TABLE F-30

NEW SYSTEM EQUIPMENT ALLOCATION RULES

Item	Allocation Rule								
Food Service Unit, Trailer Mounted	1 per forward divisional unit								
1¼ ton Truck	1 per Food Service Unit, Trailer Mounted not requiring augmentation								
Food Service Unit, Trailer Mounted, Augmentation	<table border="1"> <thead> <tr> <th>Consolidated Feeding Strength</th> <th>No. Authorized</th> </tr> </thead> <tbody> <tr> <td>1 - 325</td> <td>1</td> </tr> <tr> <td>326 - 725</td> <td>2</td> </tr> <tr> <td>726 or greater</td> <td>3</td> </tr> </tbody> </table>	Consolidated Feeding Strength	No. Authorized	1 - 325	1	326 - 725	2	726 or greater	3
Consolidated Feeding Strength	No. Authorized								
1 - 325	1								
326 - 725	2								
726 or greater	3								
Modular Field Kitchen	<p>To units not requiring a Food Service Unit, Trailer Mounted, as follows:</p> <table border="1"> <thead> <tr> <th>Feeding Strength</th> <th>No. Authorized</th> </tr> </thead> <tbody> <tr> <td>1 - 325</td> <td>1</td> </tr> <tr> <td>326 - 725</td> <td>2</td> </tr> <tr> <td>726 Plus</td> <td>1 additional per each 400 or fraction</td> </tr> </tbody> </table>	Feeding Strength	No. Authorized	1 - 325	1	326 - 725	2	726 Plus	1 additional per each 400 or fraction
Feeding Strength	No. Authorized								
1 - 325	1								
326 - 725	2								
726 Plus	1 additional per each 400 or fraction								
2½ ton Truck	1 per first Food Service Unit, Trailer Mounted, Augmentation; or first Modular Field Kitchen								
Food Processing Augmentation	1 per kitchen servicing 350 or more								
Water Trailer, 400 gallon	<table border="1"> <thead> <tr> <th>Feeding Strength</th> <th>No. Authorized</th> </tr> </thead> <tbody> <tr> <td>1 - 400</td> <td>1</td> </tr> <tr> <td>401 Plus</td> <td>2</td> </tr> </tbody> </table>	Feeding Strength	No. Authorized	1 - 400	1	401 Plus	2		
Feeding Strength	No. Authorized								
1 - 400	1								
401 Plus	2								
Sanitation Center	<p>1 per non-divisional medical kitchen                      1 per divisional kitchen at the consolidated level</p>								

TABLE F-31

## EQUIPMENT COST PER FOOD SERVICE UNIT, TRAILER MOUNTED

Item	Cost/ Item <sup>1</sup>	Number/ Kitchen	Economic Life (Years) <sup>1</sup>	Investment Cost	Uniform Annual Cost
Generator (3kw)	\$1,283	1	6	\$1,283	\$ 295
Water Heater (Circulator)	1,500	1	8	1,500	281
Tray Pack Heater	400	4	10	1,600	260
Work Table	125	2	4	250	79
Can Opener	95	1	2	95	55
Pastry Cabinet	200	1	10	200	33
Holding Cabinet	200	1	10	200	33
Hot Water Heater	350	1	8	350	66
Beverage Dispenser	50	2	1	100	110
Insulated Food Container	85	4	2	340	196
Trailer	<u>1,700</u>	<u>1</u>	<u>6</u>	<u>1,700</u>	<u>390</u>
Total				\$7,618	\$1,798

## NOTES:

<sup>1</sup> Costs and economic life for most items are estimates.

TABLE F-32

## EQUIPMENT COST PER MODULAR FIELD KITCHEN

Item	Cost/ Item <sup>1</sup>	Number/ Kitchen	Economic Life (Years) <sup>1</sup>	Investment Cost	Uniform Annual Cost
Tent Section (8 Feet)	\$1,400	2	5	\$ 2,800	\$ 739
Generator (3kw)	1,283	1	6	1,283	295
Water Heater (Circulator)	1,500	1	8	1,500	281
Sink	550	2	8	1,100	206
Griddle	1,000	1	10	1,000	163
Steam Table	750	1	8	750	141
Work Table	125	3	4	375	118
Oven	1,500	1	4	1,500	473
Burner Unit	135	6	3	810	326
Pot Cradle	400	1	8	400	75
Can Opener	95	1	2	95	55
Shelving	90	2	2	180	104
Pastry Cabinet	200	1	10	200	33
Holding Cabinet	200	1	10	200	33
Hot Water Heater	350	1	8	350	60
Beverage Dispenser	50	2	1	100	110
Pot and Pan Set	200	1	6	200	46
<u>Insulated Food Container</u>	<u>85</u>	<u>4</u>	<u>2</u>	<u>340</u>	<u>196</u>
<b>Total</b>				<b>\$13,183</b>	<b>\$3,460</b>

## NOTES:

<sup>1</sup> Cost and economic life for most items are estimates.

TABLE F-33

EQUIPMENT COST PER FOOD SERVICE UNIT, TRAILER MOUNTED AUGMENTATION

Item	Cost/ Item <sup>1</sup>	Number/ Kitchen	Economic Life (Years) <sup>1</sup>	Investment Cost	Uniform Annual Cost
Tent Section (8 Feet)	\$1,400	2	5	\$2,800	\$ 739
Griddle	1,000	1	10	1,000	163
Steam Table	750	1	8	750	141
Work Table	125	3	4	375	118
Oven	1,500	1	4	1,500	473
Burner Unit	135	6	3	810	326
Pot Cradle	400	1	8	400	75
Shelving	90	2	2	180	104
Pot and Pan Set	<u>200</u>	<u>1</u>	<u>6</u>	<u>200</u>	<u>46</u>
Total				\$8,015	\$2,185

NOTES:

<sup>1</sup> Cost and economic life for most items are estimates.

TABLE F-34

EQUIPMENT COST PER SANITATION CENTER

Item	Cost/ Item <sup>1</sup>	Number/ Kitchen	Economic Life (Year) <sup>1</sup>	Investment Cost	Uniform Annual Cost
Tent Section (8 Feet)	\$1,400	2	5	\$2,800	\$ 739
Sink	550	4	8	2,200	412
Shelving	90	4	2	360	208
Drain Tables	<u>300</u>	<u>2</u>	<u>4</u>	<u>600</u>	<u>189</u>
Total				\$5,960	\$1,548

NOTES:

<sup>1</sup> Cost and economic life for most items are estimates.

TABLE F-35

EQUIPMENT COST PER FOOD PROCESSING AUGMENTATION

Item	Cost/ Item <sup>1</sup>	Number/ Kitchen	Economic Life (Years) <sup>1</sup>	Investment Cost	Uniform Annual Cost
Meat Sliver	\$ 500	1	8	\$ 500	\$ 94
Vegetable Cutter	<u>1,000</u>	<u>1</u>	<u>8</u>	<u>1,000</u>	<u>187</u>
Total				\$1,500	\$281

NOTES:

<sup>1</sup> Cost and economic life for most items are estimates.

TABLE F-36

NEW SYSTEM EQUIPMENT COSTS PER DIVISION

Item	H Series		T Series		Uniform Annual Cost	Number Authorized <sup>1</sup>	Investment Cost	Uniform Annual Cost
	Number Authorized	Investment Cost	Investment Cost	Uniform Annual Cost				
Modular Field Kitchen	34	\$ 448,222	\$ 500,954	\$ 117,640	38		\$ 500,954	\$ 131,480
Food Service Unit, Trailer Mounted	83	632,294	1,096,992	149,234	144		1,096,992	258,912
Food Service Unit, Trailer Mounted, Augmentation	44	352,660	384,720	96,140	48		384,720	104,880
Food Processing Augmentation	21	31,500	36,000	5,901	24		36,000	6,744
Sanitation Center	42	250,320	280,120	65,016	47		280,120	72,756
Water Trailer, 400 Gallon	113	479,572	759,676	110,062	179		759,676	174,346
1½ Ton Truck	59	265,500	522,000	60,947	116		522,000	119,828
2½ Ton Truck	54	961,902	1,122,219	220,860	63		1,122,219	257,670
Total Division Cost	-	\$3,421,970	\$4,702,681	\$825,800	-		\$4,702,681	\$1,126,616
Division Equivalents	25.357	-	-	-	23.793		-	-
Total Cost (M\$)	-	86.771	111.891	20.940	-		111.891	26.806

NOTES:

<sup>1</sup> Based on Tables E-3 and E-4.

TABLE F-37

NEW SYSTEM EQUIPMENT COSTS FOR NON-DIVISIONAL NON-MEDICAL TROOPS

Item	Corps Area		COMMZ Area	
	Auth/1000 Troops	Investment Cost	Auth/1000 Troops	Investment Cost
Modular Tent Kitchen	5.80	\$ 76,433	4.89	\$ 64,510
Food Processing Augmentation	1.01	1,518	1.01	1,520
Water Trailer, 400 Gallon	5.73	24,305	4.86	20,639
Trucks, 2½ Ton	5.73	102,015	4.86	86,625
Total/1000 Troops	-	\$204,271	-	\$173,294
Total Strength (1000)	432.791	-	119.730	-
Total Cost (M\$)	-	88.407	-	20.748
				5.010
				\$16,931
				285
				4,737
				19,890
				\$41,843

TABLE F-38

NEW SYSTEM EQUIPMENT COSTS FOR NON-DIVISIONAL MEDICAL TROOPS

Item	Corps Area		COMMZ Area	
	Auth/1000 Troops	Investment Cost	Auth/1000 Troops	Investment Cost
		Uniform Annual Cost		Uniform Annual Cost
Modular Field Kitchen	6.83	\$ 90,040	7.57	\$ 99,795
Food Processing Augmentation	2.50	3,750	2.00	3,000
Sanitation Center	4.14	24,674	2.43	14,483
Water Trailer, 400 Gallon	6.05	25,676	4.42	18,758
Trucks, 2½ Ton	6.05	107,769	4.42	78,733
Total/1000 Troops	-	\$251,909	-	\$214,769
Total Strength (1000)	34.671	-	38.997	-
Total Cost (M\$)	-	8,734	-	8,375
		2,128		2,063
		\$61,380		\$52,899
		24,774		18,078
		5,893		4,305
		6,409		3,762
		702		562
		\$23,632		\$26,192

a Modular Field Kitchen. Except for medical unit kitchens, a meat slicer and vegetable cutter is supplied for every 1000 troops for consolidated food service operations. Medical units are already provided complete equipment as part of their food preparation and service sets. Trucks and water trailers are authorized according to the baseline systems allowances.

f. **Fuel Costs.** Tables F-39 through F-41 indicate the fuel consumption rates and costs for the various type kitchens with different ration mixas. Tables F-42 through F-44 summarize annual fuel costs for divisional and non-divisional troops with T rations and with A rations. As with the baseline systems, fuel costs are prorated by the bulk to individual ration mix. Fuel consumption for 2½ ton trucks is based on the same rationale as in the baseline systems. The fuel consumption for the 1¼ ton trucks is 3650 gallons of diesel per year at a cost of \$1,639 based on a daily usage of 100 miles. In other than the division areas, excepting medical units, it is assumed that A ration operations will be performed from area kitchens assembled from the Modular Field Kitchens of participating units, serving 1000 rations per day. All medical units conduct independent food service operations.

g. **Water Costs.** Water requirements for each type ration are specified in Table F-45, and the annual water costs for each area of the theater, shown in Table F-46, were determined by using the ration mixes in Table F-27 and the water production costs from Table F-21.

h. **Disposable Messgear Cost.** The T and T augmented rations are served on disposables. Non-disposable messgear is to be used with A ration meals, which involve labor and fuel costs for sanitation. Cost estimates for disposables, derived in APPENDIX H, are included, in the proportions determined by the ration mix, Table F-27, in the new system cost summary in Table F-24.

4. **DISCUSSION.** The major cost factors specifically evaluated for the baseline systems were rations, food service and KP personnel, intertheater transportation, fuel, equipment, and water. The new system concept costs included the additional factor of disposable messgear.

Two baseline systems are considered: company level kitchens, or consolidated kitchens in division, with company kitchens elsewhere. Both would operate initially with a B/MRE ration mix, which would transition to an A/MRE mix, and finally, to a total A ration. On the other hand, with the new system, the initial ration mix is T/MRE at company level, then a T Augmented/MRE mix, subsequently converting to an A/MRE mix with consolidated kitchens, and eventually, a total A ration.

The baseline systems bulk operational ration is the B ration, and the individual operational ration is the MRE. In the new system, the T ration replaces the B ration as the bulk operational ration, but the MRE remains the individual operational ration. However, additional ration mixes, where the bulk operational ration is either augmented or replaced by the A ration, were considered because, at least historically, the A ration has usually been introduced into the theater at some point in time. Four ration mixes were considered for the new system, and only three for the baseline systems. The additional ration mix, T Augmented/MRE, is essentially the beginning of transition to an A ration, with the augmentation being mostly milk, salads, cereals, and a limited number of other items. The baseline systems would probably experience a similar transition process. If explicitly considered, the incremental cost of a

TABLE F-39

FUEL COSTS PER KITCHEN TO PROVIDE T RATIONS<sup>1</sup>

Unit Kitchen	Item	Number	Type Fuel <sup>2</sup>	Consumption Rate (gal/hr)	Usage Rate (hrs/day)	Annual Cost
Food Service Unit, Trailer Mounted	3 kw Generator	1	Diesel	0.84	9.0	\$1,239
	Water Heater	1	Diesel	1.00	9.0	<u>1,475</u>
Total						\$2,714
Modular Field Kitchen	3 kw Generator	1	Diesel	0.84	1.5	\$ 206
	Water Heater	1	Diesel	1.00	1.5	246
	Sink (with burner)	2	Mogas	0.50	6.0	<u>1,110</u>
Total						\$1,562

NOTES:

<sup>1</sup> Three T ration meals per day.

<sup>2</sup> Costs: diesel, \$0.449/gallon; Mogas, \$0.507/gallon.

TABLE F-40

FUEL COSTS PER MODULAR FIELD KITCHEN TO PROVIDE A RATIONS<sup>1</sup>

Item	Number	Power Source	Type Fuel <sup>2</sup>	Consumption Rate (gal/hr)	Usage Rate (hrs/day)	Annual Cost
Griddle	1	2 Burners	Mogas	1.0	4	\$ 740
Steam Table	1	Burner	Mogas	0.5	6	555
Pot Cradle	1	Burner	Mogas	0.5	6	555
Sink	2	Burner	Mogas	0.5	9	1,665
Oven	1	Burner	Mogas	0.5	4	370
3 kw Generator	1	-	Diesel	0.84	B	1,101
Water Heater	1	-	Diesel	1.0	B	<u>1,311</u>
Total						\$6,297

NOTES:

<sup>1</sup> Three A ration meals per day.

<sup>2</sup> Costs: diesel, \$0.449/gallon; Mogas, \$0.507/gallon.

TABLE F-41

FUEL COSTS PER CONSOLIDATED KITCHEN TO PROVIDE A RATIONS<sup>1</sup>

Item	Number	Power Source	Type Fuel <sup>2</sup>	Consumption		Annual Cost
				Rate (gal/hr)	Usage Rate (hrs/day)	
Griddle	4	2 Burners	Mogas	1.0	4	\$ 2,961
Steam Table	4	Burner	Mogas	0.5	6	2,221
Oven	4	Burner	Mogas	0.5	6	2,221
Pot Cradle	4	Burner	Mogas	0.5	6	2,221
Sink	4	Burner	Mogas	0.5	9	3,331
3 kw Generator	3	-	Diesel	0.84	12	4,956
Water Heater	3	-	Diesel	1.0	6	<u>2,950</u>
<b>Total</b>						<b>\$20,861</b>

NOTES:

<sup>1</sup> Three A ration meals per day.

<sup>2</sup> Costs: diesel, \$0.449/gallon; Mogas, \$0.507/gallon.

TABLE F-42

NEW SYSTEM ANNUAL DIVISIONAL FUEL COSTS

Division/Ration	Item	No. Auth/ Division	Annual Cost			
			Mix <sup>1</sup>	Bulk <sup>2</sup>	Mix <sup>1</sup>	Bulk <sup>2</sup>
			Per Division (\$)		Total Division Strength (M\$)	
H Series/T Rations	Modular Field Kitchen	34	\$ 24,430	\$ 53,108	\$ 0.619	\$ 1.347
	Food Service Unit, Trailer Mounted	83	103,621	225,262	2.628	5.712
	1½ ton Truck	59	96,701	96,701	2.452	2.452
	2½ ton Truck	54	212,382	212,382	5.385	5.385
	Total		\$437,134	\$587,453	\$11.084	\$14.896
T Series/T Rations	Modular Field Kitchen	38	\$ 27,304	\$ 59,356	\$ 0.650	\$ 1.412
	Food Service Unit, Trailer Mounted	144	179,775	390,816	4.277	9.299
	1½ ton Truck	116	190,124	190,124	4.524	4.524
	2½ ton Truck	63	247,779	247,779	5.895	5.895
	Total		\$644,982	\$888,075	\$15.346	\$21.130
H Series/A Rations	Modular Field Kitchen	34	\$ 98,485	\$214,098	\$ 2.497	\$ 5.429
	Food Service Unit, Trailer Mounted Augmentation	44	127,451	277,068	3.232	7.026
	1½ ton Truck	59	96,701	96,701	2.452	2.452
	2½ ton Truck	54	212,382	212,382	5.385	5.385
	Total		\$535,019	\$800,249	\$13.566	\$20.292
T Series/A Rations	Modular Field Kitchen	38	\$110,072	\$239,286	\$ 2.619	\$ 5.693
	Food Service Unit, Trailer Mounted Augmentation	48	139,038	302,256	3.308	7.192
	1½ ton Truck	116	190,124	190,124	4.524	4.524
	2½ ton Truck	63	247,779	247,779	5.895	5.895
	Total		\$687,013	\$979,445	\$16.346	\$23.304

NOTES:

<sup>1</sup> Based upon established ration mix, Table F-27.

<sup>2</sup> All bulk rations.

TABLE F-43

NEW SYSTEM ANNUAL NON-DIVISIONAL FUEL COSTS WITH A RATIONS

Area	Item	Auth/1000 Troops	Per 1000 Troops (\$)		
			A/MRE <sup>1</sup>	A <sup>2</sup>	A/MRE <sup>1</sup> A <sup>2</sup>
Corps - Non-Medical	1000 Man Kitchen	1.01	\$12,032	\$21,108	\$ 5.207 \$ 9.135
	2½ ton Truck	5.73	22,524	22,524	9.748 9.748
	Total		\$34,556	\$43,632	\$14.955 \$18.883
Corps - Medical	Company Kitchen	6.83	\$24,515	\$43,009	\$ 0.850 \$ 1.491
	2½ ton Truck	6.05	23,795	23,795	0.825 0.825
	Total		\$48,310	\$66,804	\$ 1.675 \$ 2.316
COMMZ - Non-Medical	1000 Man Kitchen	1.01	\$20,078	\$21,135	\$ 2.404 \$ 2.530
	2½ ton Truck	4.86	19,126	19,126	2.290 2.290
	Total		\$39,204	\$40,261	\$ 4.694 \$ 4.820
COMMZ - Medical	Company Kitchen	7.57	\$45,285	\$47,668	\$ 1.766 \$ 1.859
	2½ ton Truck	4.42	17,384	17,384	0.678 0.678
	Total		\$62,669	\$65,052	\$ 2.444 \$ 2.537

NOTES:

<sup>1</sup> Based upon the established ration mix, Table F-27.

<sup>2</sup> Three A ration type meals per day.

TABLE F-44

NEW SYSTEM ANNUAL NON-DIVISIONAL FUEL COSTS WITH T RATIONS<sup>1</sup>

Area	Item	Auth/1000 Troops	Annual Cost	
			Per 1000 Troops(\$)	Total Non-Division Strength(M\$)
Corps - Non-Medical	Company Kitchen	5.81	\$ 5,174	\$ 2.234
	2½ ton Truck	5.74	22,575	9.748
	Total		\$27,749	\$11.982
Corps - Medical	Company Kitchen	6.96	\$ 6,200	\$ 0.211
	2½ ton Truck	6.17	24,259	0.825
	Total		\$30,459	\$ 1.036
COMMZ - Non-Medical	Company Kitchen	4.90	\$ 7,271	\$ 0.869
	2½ ton Truck	4.87	19,153	2.290
	Total		\$26,424	\$ 3.159
COMMZ - Medical	Company Kitchen	7.76	\$11,508	\$ 0.438
	2½ ton Truck	4.53	17,809	0.677
	Total		\$29,317	\$ 1.115

NOTES:

<sup>1</sup> Based upon established ration mix, Table F-27.

**TABLE F-45**

**NEW SYSTEM WATER USAGE RATES<sup>1</sup>**

Item	A	Ration Type	
		T	MRE
Menu Requirement	0.5	0.5	0.5
Tray Pack Heating	-	0.5	.
Messkit Sanitation	1.8	.	.
Pot and Pan Sanitation	<u>1.5</u>	<u>-</u>	<u>-</u>
Total	3.8	1.0	0.5

**NOTES:**

<sup>1</sup>Water usage rates estimated based on operational experience.

**TABLE F-46**

**NEW SYSTEM ANNUAL WATER COSTS (M\$)**

Area	T/MRE	Ration Mix	
		A/MRE	A
Divisions - Average	1.364	3.777	7.153
Corps - Non-Medical	1.489	4.543	7.203
Corps - Medical	0.203	0.625	0.991
COMMZ - Non-Medical	0.511	1.906	1.993
COMMZ - Medical	0.394	1.483	1.551

similarly augmented B/MRE mix for the baseline systems would be approximately equal to the difference in costs between the T Augmented/MRE mix and the T/MRE mix, or about \$150 million annually.

The baseline systems were evaluated with the standard messkit, regardless of the ration mix. The costs of the messkit washline equipment, labor, fuel, and water required to operate it, are included in the appropriate cost factors. The new system cost was established using disposables with the T ration, and permanent messgear, other than the messkit, when A rations are served. The rationale was that the washlines needed for messkit sanitation, besides being relatively costly and labor intensive are just not operationally feasible for future combat operations. Considering the alternatives, it was decided that disposables are preferable under these conditions. The cost of disposables and the transportation costs are included in the new system cost when operating with T rations.

However, when the new system converts to A rations, permanent messgear will be used, for which the labor, fuel, and water required for sanitation are included under the appropriate cost elements. By pooling the unit level food service equipment into a consolidated mode of operation with the A ration, sufficient equipment is available for sanitizing the permanent messgear. Thus, the cost of equipment required for the sanitation has already been included elsewhere. However, equipment for the sanitation of permanent messgear at unit level may, or may not, exist, depending upon the type unit, and usually the location within the theater. If this capability is required or desired, additional equipment will need be authorized some units. As will be seen later, such matters are quite insignificant from a systems cost standpoint.

## 5. RESULTS AND CONCLUSIONS.

a. **Baseline Systems.** The costs for the two baseline systems are summarized in Tables F-47 to F-49 considering each ration mix. Based on these results:

(1) The cost of rations and labor, account for 85% to 91% of the total baseline system costs. Adding intertheater transportation increases these costs to 93% to 95% of the total system costs.

(2) All other costs considered — fuel, equipment, and water — are relatively insignificant, collectively accounting for only 5% to 7% of the total system costs.

(3) For a given ration mix, the baseline systems with consolidated kitchens cost approximately \$190M less annually than company level kitchens.

(4) Within divisions, the cost per ration is approximately \$1.087 less for the consolidated versus the nonconsolidated system, primarily because of reduced labor requirements.

(6) In general, the more forward a unit is located, the higher the cost per ration, because of the increased utilization of the more expensive MRE rations.

TABLE F-47

BASELINE ANNUAL SYSTEM COST SUMMARY WITH COMPANY

LEVEL KITCHENS IN DIVISION

Factor	B/MRE		A/MRE		A	
	M\$	Total%	M\$	Total%	M\$	Total%
Rations	1,655	55.69	1,708	54.83	1,311	46.97
Labor - FSP	644	21.67	644	20.67	644	23.07
Labor - KP	414	13.93	414	13.29	414	14.83
Transportation	109	3.67	199	6.39	225	8.06
Fuel	79	2.66	79	2.54	116	4.16
Equipment	55	1.85	55	1.77	55	1.97
Water	<u>16</u>	<u>0.54</u>	<u>16</u>	<u>0.51</u>	<u>25</u>	<u>0.90</u>
Total <sup>1</sup>	2,973	100.00	3,115	100.00	2,791	100.00

NOTES:

<sup>1</sup> Costs and proportions may not add to total because of rounding errors.

TABLE F-48

BASELINE ANNUAL SYSTEM COST SUMMARY WITH  
 CONSOLIDATED KITCHENS IN DIVISION

Factor	B/MRE		A/MRE		A	
	M\$	Total%	M\$	Total%	M\$	Total%
Rations	1,644	59.03	1,697	58.00	1,303	50.13
Labor - FSP	525	18.85	525	17.94	525	20.20
Labor - KP	378	13.57	378	12.92	378	14.54
Transportation	109	3.91	198	6.77	224	8.62
Fuel	69	2.48	69	2.36	100	3.85
Equipment	45	1.62	45	1.54	45	1.73
Water	<u>16</u>	<u>0.57</u>	<u>16</u>	<u>0.55</u>	<u>25</u>	<u>0.96</u>
Total <sup>1</sup>	2,785	100.00	2,926	100.00	2,599	100.00

NOTES:

<sup>1</sup> Costs and proportions may not add to totals because of rounding errors.

**TABLE F-49****BASELINE SYSTEM COSTS/RATION (\$)**

<b>COMPONENT</b>	<b>B/MRE</b>	<b>A/MRE</b>	<b>A</b>
Division - Average	7.876	8.134	7.099
Divisions - Average Consolidated	6.801	7.059	5.989
Corps - Non-Medical	7.019	7.344	6.506
Corps - Medical	6.593	6.918	6.068
COMMZ - Non-Medical	6.065	6.601	6.503
COMMZ - Medical	<u>5.515</u>	<u>6.051</u>	<u>5.951</u>
Total - with Divisions	7.099	7.438	6.663
Total - with Divisions Consolidated	6.691	7.030	6.243

b. **New System.** The new system costs are summarized in Tables F-50 and F-51, from which it can be observed that:

(1) Two factors, rations and labor, account for 85% to 89% of the total system cost, which increases to 93% to 96% if intertheater transportation costs are included.

(2) Other cost factors, fuel, equipment, water, and disposables are insignificant, representing only 4% to 7% of the total system cost.

(3) For the new system to transition to a total A ration mix, additional food service personnel are required, which are not needed in a peacetime garrison environment. If staffing for A ration food service is necessary on D-day, then these additional personnel must be maintained in the TOE, resulting in an increased peacetime cost for readiness. However, if this level of staffing is not necessary, the additional personnel must be provided from other sources, when required, but greatly reducing the peacetime costs of combat food service readiness.

c. **Breakpoint Analysis.** Table F-52 summarizes the system cost breakpoints between unit level, augmented T ration and consolidated A ration operations in the new system, considering ration, labor, intertheater transportation, and equipment costs, which amount to 96% to 98% of the total costs. For example, in divisions, the breakpoint is 46%. Thus, if the consumption of bulk rations exceeds 46%, the consolidated A ration operation is the least costly. The additional labor and intertheater transportation costs associated with the A ration is more than offset by the reduced ration costs, as compared to the T ration costs.

The cost differential between the two modes of operation is about \$4.5 million for each percentage point increase or decrease in the consumption of the bulk rations, above and below the breakpoint. Since the average ration mix for the total theater is 60% bulk and 40% MRE, and the breakpoint for the new system, as a whole, is 41% bulk and 59% MRE, it suggests that a total A ration operation might be more economical, that is,  $(60\% - 41\%) \times \$4.5$  million, or \$86 million on an annual basis in the Theater Level Scenario.

Such savings are only an illusion. First of all, the cost differential diminishes with the magnitude of the force involved in the conflict, and the Theater Level Scenario is, perhaps, an extreme situation. Secondly, in actuality, the total force will never be operating with strictly one ration discipline for any lengthy period of time. The A ration will probably be utilized, to a lesser or greater extent, throughout the entire conflict, so that the difference in the percentage of A rations consumed will never be as great as indicated. Thirdly, food service personnel are required to implement the A ration operation, for which there is an additional continuing \$38 million a year cost, with an active TOE strength of 530,000 troops, since they would be in excess of peacetime garrison requirements. Finally, and most important, it would not even be feasible to operate a totally consolidated A ration food service system in the Scenario, or any other conflict in which highly mobile combat forces will be engaged.

d. **Cost Comparison.** A comparison of the annual system costs between the two baseline systems and the new system, as a function of the ration mix, is included in Table F-53.

TABLE F-50

NEW SYSTEM ANNUAL COST SUMMARY

Factor	T/MRE		T AUG/MRE		A/MRE		A	
	M\$	Total%	M\$	Total%	M\$	Total%	M\$	Total%
Rations	1,875	70.52	1,999	71.21	1,689	63.62	1,297	56.22
Labor - FSP	356	13.39	356	12.68	433	16.31	433	18.77
Labor - KP	133	5.00	133	4.74	231	8.70	231	10.01
Transportation	123	4.63	146	5.20	197	7.42	222	9.62
Fuel	31	1.17	31	1.10	39	1.47	50	2.17
Equipment	54	2.03	54	1.92	54	2.03	54	2.34
Water	4	0.15	4	0.14	12	0.45	19	0.82
Disposables	<u>84</u>	<u>3.16</u>	<u>84</u>	<u>2.99</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>-</u>
Total <sup>1</sup>	2,659	100.00	2,807	100.00	2,655	100.00	2,307	100.00

NOTES:

<sup>1</sup> Costs and proportions may not add to total because of rounding errors.

TABLE F-51

NEW SYSTEM COSTS/RATION (\$)

Area	T/MRE	T AUG/MRE	A/MRE	A
Divisions	6.793	7.064	6.913	5.775
Corps - Non-Medical	6.367	6.709	6.294	5.394
Corps - Medical	6.383	6.724	6.622	5.727
COMMZ - Non-Medical	5.941	6.507	5.470	5.364
COMMZ - Medical	<u>5.897</u>	<u>6.462</u>	<u>5.693</u>	<u>5.587</u>
Total	6.445	6.803	6.409	5.568

**TABLE F-52**

**SYSTEM COST BREAKPOINTS BETWEEN UNIT LEVEL T AUGMENTED**

**RATION SYSTEM AND CONSOLIDATED A RATION SYSTEM<sup>1</sup>**

<b>Area</b>	<b>Breakpoint<sup>2</sup></b>
Divisions	46%
Corps - Non-Medical	35%
Corps - Medical	68%
COMMZ - Non-Medical	23%
COMMZ - Medical	53%
Total	41%

**NOTES:**

<sup>1</sup> Assumes sufficient personnel are authorized to operate with the T ration at unit level and the A ration at consolidated level.

<sup>2</sup> When the percent of bulk ration consumption (remainder MRE rations) exceeds this value, the consolidated A ration system is less costly than the Unit Level T Augmented ration system.

TABLE F-53

SYSTEM COST COMPARISON

System	Ration Mix	Annual Cost-M\$
Baseline - Company	B/MRE	2,973
	A/MRE	3,115
	A	2,791
Baseline - Consolidated	B/MRE	2,785
	A/MRE	2,926
	A	2,599
New System	T/MRE	2,659
	T-Aug/MRE	2,807
	A/MRE	2,655
	A	2,307

Depending upon which baseline system is considered, the new system is about \$126 to \$314 million less costly, on an annual basis, in a combat environment, when operating with a mix of operational rations; and, costs \$292 to \$484 million less with a total A ration.

## APPENDIX G

### MEDICAL COMBAT FOOD SERVICE

1. **INTRODUCTION.** A brief, general description and evaluation of the existing medical combat food service presented and compared with the new combat food service system concept. The proposed changes that would result from the Division Restructuring Evaluation (DRE) and the Combat Zone Hospitalization (CZH) concept are also considered, for if adopted, they will significantly impact on the food service requirements and operations of medical units and hospitals in the field. This discussion will be limited to only those elements which have a patient care capability, and are in support of combat divisions. Various other field, general and station hospitals, and convalescent centers may be operating elsewhere in the theater. They generally vary in number according to the particular organization for the theater. There are also many other medical units without patient care facilities located in the combat zone or elsewhere in the theater, which are either subsisted with their host organizations, or if they have a field kitchen, conduct food service operations in essentially the same manner as non-medical units. None of these units are included in the evaluation.

#### 2. BASELINE SYSTEMS.

a. **Food Service Requirements.** As presently planned, there will generally be a Medical Battalion, two Combat Support Hospitals and an Evacuation Hospital in direct support of each division committed to combat. Each of these units have food service branches or sections which are staffed and equipped to prepare and distribute food to assigned personnel and patients. A summary of their personnel strengths and patient capacities, which determines the potential level of food service requirements, is given in Table G-1. Under the DRE force concept the only relevant change will be a realignment of the Medical Battalion resources, which will substantially reduce their personnel strength, but patient capacity is not affected, as shown in Table G-1. The Combat Zone Hospitalization concept, proposed by the Academy of Health Sciences and approved by the Surgeon General in 1978, would replace one of the Combat Support Hospitals normally allocated to a division with two Mobile Army Surgical Hospital (MASH) units.

b. **Staffing.** Food service personnel authorized, including KP allowances, for the Medical Battalion and the several hospital facilities are included in Table G-2. These staffing levels presume two twelve hour shifts per day, supporting the total number of assigned personnel and maximum patient loads.

c. **Equipment.** The food service equipment of the various units, described in Table G-3, is similar in terms of the types of equipment provided, but the allowance varies depending on the numbers of personnel and patients supported.

d. **Rations.** During combat operations, only the Standard B Ration and individual combat rations, the Meal-Ready-to-Eat, are to be utilized for subsistence within the theater. Realistically, however, in a longer duration conflict, it may reasonably be expected that, at such time as perishable food items can be made available, they will be used to augment and/or

TABLE G-1

FOOD SERVICE SUPPORT REQUIREMENTS

Unit Designation	Personnel Strength	Patient Capacity	Total
Medical Battalion	396	160	556
Medical Battalion (DRE)	301	160	461
MASH	176	60	236
Combat Support Hospital	253	200	453
Evacuation Hospital	384	400	784

TABLE G-2

FOOD SERVICE PERSONNEL AUTHORIZATIONS

Grade	Medical Battalion	DRE Medical Battalion	MASH	Combat Support Hospital	Evacuation Hospital
E-8					
E-7	1				
E-6	4	1	1	2	1
E-5	7	1	2	2	5
E-4	8	5	2	4	7
E-3	5	9	2	3	6
Subtotal	25	16	7	11	19
KP	14	11	6	10	17
Total	39 <sup>1</sup>	27 <sup>1</sup>	13	21 <sup>2</sup>	36 <sup>2</sup>

NOTES:

<sup>1</sup> All MOS 948.

<sup>2</sup> Also authorized Captain, MOS 65C000, Diatitian.

TABLE G-3

## FOOD SERVICE EQUIPMENT ALLOWANCES

Line Item	Description	Medical Battalion	DRE Medical Battalion	MASH	Combat Support Hospital	Evacuation Hospital
A03210	Field Range Accessory Outfit	4	1	1	2	2
H85461	Food Preparation and Service Set	0	1	0	1	0
H85050	Food Preparation and Service Set	0	0	1	0	0
H85872	Food Preparation and Service Set	0	0	0	0	1
K25342	Immersion Heater	36	13	12	20	32
L28351	MKT	4	0	0	0	0
R14154	Field Range Outfit	12	4	3	6	8
R61428	Refrigeration Unit, 10,000 BTU	0	0	0	1	1
R63352	Refrigerator, 600 ft <sup>3</sup>	0	0	0	1	1
W95811	Cargo Trailer, 1½ ton	0	1	0	1	0
W98825	Water Trailer, 400 gal	4	1	1	1	1
X40009	Truck, 2½ ton	4	2	1	2	2

substitute for Standard B Ration menu items. In this case, it is anticipated that priority will be placed on delivering fresh milk, salad ingredients and other high preference foods that will promote ration consumption, thereby contributing to the improved morale and nutritional sustenance of the troops. Of course, unless these food items can be obtained locally, this situation is not likely to occur until it can be assured that all critical war materials are being adequately supplied. Then, depending on the circumstances, after cessation of hostilities the combat food service system may transition to base development, and eventually even to full garrison food service operations. During this period, the menu would gradually evolve towards a total A Ration.

Thus, in a combat environment, all personnel assigned or attached to the medical units will be subsisted on the Standard B Ration, under the same feeding policies as prevail throughout the theater for the remaining forces, i.e., a minimum of one hot meal per day, with all other meals being individual combat rations. In general, hospital patients will receive only the Standard B Ration, except for those patients requiring modified dietary rations. The modified rations will consist of the B Hospital Ration or the B Hospital Liquid Ration, as appropriate. Patients would be routinely fed individual combat rations only under exceptional, extenuating circumstances, because of the possible adverse effect on the healing process. The relevant characteristics of the different rations are described in Table G-4.

e. **Systems Costs.** The uniform annual costs of food service operations for the different medical units are summarized in Table G-5. These costs were derived in terms of 1978 dollars, using a 10% interest rate for future costs, but do not reflect the effect of inflationary trends. Further, it is assumed that the conditions under which the costs were evaluated remain essentially unchanged; that is, the units are operating in combat, supporting a constant level of personnel and patients, with no change in the ration mix during the entire period of the evaluation.

All significant, identifiable costs are considered. Food and labor comprise nearly 90% to 92% of the total costs, with transportation and fuel accounting for the largest portion of the remaining costs.

Food costs are calculated for the mix of rations and costs specified in Table G-4, and the food service requirements in Table G-1.

Labor costs for the food service and KP personnel were determined for the personnel authorizations, Table G-2, using average annual personnel costs (including salary and benefits, support, training and other costs) as follows:

Cooks (MOS 94B)	\$16,816*
Cooks (MOS 94F)	\$16,309
KP (E-2 and E-3)	\$13,916

\*Difference between MOS 94B and MOS 94F is attributable to higher training costs of MOS 94B.

TABLE G-4

RATION CHARACTERISTICS

Type Ration	Weight (lbs)	Cube (ft <sup>3</sup> )	Utilization Rates Per 100 Troops/Patients	Cost Per Ration
Standard B	3.96	0.111	33.3/70.0	\$2.92
Hospital B	5.98	0.170	00.0/15.0	\$4.35
Hospital B Liquid	3.62	0.100	00.0/15.0	\$2.23
Meal-Ready-to-Eat	3.88	0.232	66.7/00.0	\$5.50

TABLE G-5

UNIT FOOD SERVICE COSTS

BASELINE SYSTEMS

Cost Element	Medical Battalion	DRE Medical Battalion	MASH	Combat Support Hospital	Evacuation Hospital
Rations	\$ 847,676	\$ 686,784	\$364,453	\$ 649,744	\$1,092,868
Labor	615,224	422,132	197,659	318,559	546,443
Equipment	35,991	14,543	8,793	17,154	22,153
Fuel	63,437	24,723	18,724	37,329	51,008
Water	6,394	5,701	2,599	6,227	11,563
Transportation	<u>56,712</u>	<u>45,813</u>	<u>24,422</u>	<u>43,128</u>	<u>72,259</u>
Total Annual Cost	\$1,625,434	\$1,199,696	\$616,650	\$1,072,141	\$1,796,294

Each item of equipment is amortized over its projected economic life, then annual costs are obtained for the total equipment allowances of each unit, as indicated in Table G-3. Estimates of the costs for maintenance and repair of this equipment were not available, but these costs are considered to have little effect on the total system costs, so may be safely disregarded.

Fuel consumption rates are 0.428 gallons/hour for immersion heaters, 0.500 gallons/hour for the field range, and an average of 20 gallons/day for operating refrigeration in a field kitchen. It is assumed that, for a two-shift food service operation, necessary to feed patients, each heater and range will be used an average of twelve hours per day. Using a cost of gasoline, \$0.507/gallon, delivered in the theater, total annual fuel costs were determined for the above rates and the equipment allowances for each unit, Table G-3. Fuel cost for operating the food service vehicles an average of 100 miles a day, which is \$10.78 per truck based on the cost of \$0.449/gallon of diesel, is included to cover the transportation of food service related items within the theater. All other related vehicle costs are subsumed under personnel and equipment costs.

Water costs, in the theater, are estimated as \$0.012 a gallon. One gallon per troop or patient per meal is needed for messkit or patient tray washing. Water consumed for cooking purposes amounts to 0.5 gallons/ration/day for the Standard B Ration or Hospital B Rations. Total annual water costs are obtained by applying these consumption rates, and the ration utilization factors from Table G-4, to the personnel and patient strengths listed for the Medical Battalion and hospital facilities, given in Table G-1.

The transportation costs of the rations into the theater are assessed at:

Standard B	\$0.182
Hospital B	\$0.279
Hospital B Liquid	\$0.164
Meal-Ready-to-Eat	\$0.381

Costs for the hospital rations were calculated as a proportion of the Standard B Ration costs, based on the ratio of their respective cubes.

Because the DRE and Combat Zone Hospitalization options are still being considered, the medical combat facilities cannot be precisely determined at this time. Instead, an average cost of the baseline system is established by evaluating all of the several alternatives that might result from decisions regarding these options. As previously indicated, the present system consists of the Medical Battalion, two Combat Support Hospitals and an Evacuation Hospital. The DRE system involves only changes to the Medical Battalion, whereas, the Combat Zone Hospitalization system adds two MASH units in lieu of one Combat Support Hospital. Finally, if both concepts are adopted, only the Evacuation Hospital is unchanged. Costs were calculated accordingly, for each of the four configurations, which are displayed in Table G-6. Since these costs differ by only about 10% at the extremes, an average of \$5,433,721 is taken as the baseline system cost.

**TABLE G-6****BASELINE SYSTEMS COSTS**

<b>Cost Element</b>	<b>Present System</b>	<b>DRE</b>	<b>CZH</b>	<b>DRE/CZH</b>
Food	\$3,240,032	\$3,079,140	\$3,319,194	\$3,158,302
Labor	1,798,785	1,606,693	1,875,544	1,682,452
Equipment	92,452	71,004	92,884	71,436
Fuel	189,103	150,389	189,222	150,507
Water	30,411	29,718	29,382	28,689
Transportation	215,227	204,328	220,943	210,044
<b>Total Annual Cost</b>	<b>\$5,566,010</b>	<b>\$5,140,272</b>	<b>\$5,727,169</b>	<b>\$5,301,431</b>

### 3. NEW SYSTEM CONCEPT.

a. **Food Service Requirements.** Patient capacities are unaffected by introduction of the new food service system concept, but personnel strengths are slightly decreased, reflecting the lower food service personnel requirements, Table G-7.

b. **Staffing.** Fewer food service personnel are required with T ration operations, as shown in Table G-8. However, in this event, some measures will have to be taken to ensure the availability of the incremental staffing needed to ultimately transition to A ration operations. This number will vary from 23 to 38 more personnel, depending on which configuration of medical units are actually supporting a division.

c. **Equipment.** Changes in the equipment allowances occur by replacing the field range and accessory outfits and the immersion heaters authorized each unit kitchen with one Modular Field Kitchen (MFK) for each approximately 200 troops or patients, and adding a sanitation center. In the Medical Battalions, the MKT is completely eliminated.

d. **Rations.** Ration characteristics for the new system concept are presented in Table G-9. A further discussion and description of the hospital ration is contained in ANNEX 1. The ration discipline assumed for the baseline systems also applies in this instance, noting, once again that augmentation of the T ration, and eventual conversion to A rations, is the more likely situation in any reasonably long conflict duration.

e. **System Costs.** A summary of the annual costs of food service operations for the different medical units is contained in Table G-10, calculated under the same conditions as specified for the baseline systems.

The ration costs and mix, Table G-9, were combined with the food service support requirements, Table G-7, to obtain the total ration costs.

Average annual cost of individual food service and KP personnel are unchanged from the baseline systems. Total annual labor costs are a product of these costs and the food service personnel authorizations in Table G-8.

Equipment costs for the Modular Field Kitchen and sanitation center are indicated in Table G-11. Based on the equipment allocation criteria previously specified, total annual equipment costs were calculated.

Fuel consumption rates amount to 2.76 gallons of diesel fuel and 6.00 gallons of MOGAS per day, for a two-shift operation of the Modular Field Kitchen. Cost of gasoline and diesel fuel remain as specified for the baseline systems. The costs of fuel for operating the food service trucks has already been established as \$10.78 per truck assigned to the unit food service operation, Table G-3. Total annual fuel costs were estimated for the unit equipment allowances at these rates and costs.

Water requirements are about 2/3 gallon per day for troops, and one gallon per day for patients, for the assumed ration mix. Total annual water costs were determined for the food

**TABLE G-7**  
**FOOD SERVICE SUPPORT REQUIREMENTS**  
**NEW SYSTEM CONCEPT**

Unit Designation	Personnel Strength	Patient Capacity	Total
Medical Battalion	386	160	546
Medical Battalion (DRE)	294	160	454
MASH	173	60	233
Combat Support Hospital	249	200	449
Evacuation Hospital	376	400	776

**TABLE G-8**  
**FOOD SERVICE PERSONNEL AUTHORIZATIONS**  
**NEW SYSTEM CONCEPT**

Unit Designation	Food Service Personnel	KP	Total
Medical Battalion <sup>1</sup>	15	14	29
Medical Battalion (DRE) <sup>1</sup>	9	11	20
MASH	4	6	10
Combat Support Hospital <sup>2</sup>	7	10	17
Evacuation Hospital <sup>2</sup>	11	17	28

**NOTES:**

<sup>1</sup> All MOS 94B.

<sup>2</sup> Also authorized Captain, MOS 65C000, Dietitian.

**TABLE G-9**

**RATION CHARACTERISTICS**

**NEW SYSTEM CONCEPT**

<b>Type Ration</b>	<b>Weight (lbs)</b>	<b>Cube (ft<sup>3</sup>)</b>	<b>Utilization Rates Per 100 Troops/Patients</b>	<b>Cost Per Ration</b>
T Ration	4.86	0.147	33.3/90.0	\$3.91
Hospital Ration <sup>1</sup>	3.00	0.180	00.0/10.0	\$2.35
Meal-Ready-to-Eat	3.88	0.232	66.7/00.0	\$5.50

**NOTES:**

<sup>1</sup> Estimated weight, cube and cost.

TABLE G-10

UNIT FOOD SERVICE COSTS

NEW SYSTEM CONCEPT

Cost Element	Medical Battalion	DRE Medical Battalion	MASH	Combat Support Hospital	Evacuation Hospital
Rations	\$ 919,457	\$ 752,564	\$396,043	\$ 725,740	\$1,230,167
Labor	447,064	304,420	148,732	253,323	415,971
Equipment	30,638	20,135	11,187	22,051	33,175
Fuel	20,427	10,994	5,498	14,695	17,821
Water	1,828	1,559	768	1,603	2,850
Transportation	<u>61,489</u>	<u>50,263</u>	<u>26,506</u>	<u>48,370</u>	<u>81,854</u>
Total Annual Cost	\$1,480,903	\$1,139,935	\$588,734	\$1,065,782	\$1,781,838

**TABLE G-11**

**EQUIPMENT COSTS**

**NEW SYSTEM CONCEPT**

<b>Equipment</b>	<b>Investment Cost</b>	<b>Annual Cost</b>
Modular Shelter	\$ 2,800	\$ 739
Food Preparation Equipment	\$10,383	\$2,721
Sanitation Center	\$ 5,960	\$1,548

service support requirements of each unit, Table G-7, using a cost of water produced in the theater equal to \$0.012 per gallon.

Intertheater transportation costs were based on the following shipping costs per ration:

T Ration	\$0.241
Hospital Ration	\$0.295
Meal-Ready-to-Eat	\$0.381

Disposable messgear will be used to serve the T ration at a cost of \$0.113 per meal, which includes the intertheater shipping costs. The number of meals are found from the food service requirements, Table G-7, and ration utilization factors, Table G-9.

A summary of the annual system costs, when employing the new food service system concept, is provided in Table G-12. As before, these costs differ so little, slightly less than 10%, that an average of \$5,279,664 can be used to represent the new system concept costs.

4. **CONCLUSIONS.** Comparing the average costs of the baseline and the new system concepts, there is a difference of \$154,057 a year for each division supported. In the theater level Scenario, there will be 25.357 H-series or 23.793 T-series equivalent divisions involved, so that the total potential cost savings is on the order of \$3.6 to \$3.9 million annually, in combat.

Perhaps, more significant, is the possible reduction in staffing with the new system concept, which amounts to 23 to 28 food service personnel for each division supported, depending on the alternative organization of medical facilities considered. This means that from about 550 to more than 700 troops maintained in peacetime for readiness purposes may be eliminated, if not actually required for peacetime operations, amounting to more than \$9 to \$11 million annual savings during this period.

TABLE G-12

NEW SYSTEM CONCEPT COSTS

Cost Element	Present System	DRE	CZH	DRE/CZH
Food	\$3,601,104	\$3,434,211	\$3,667,450	\$3,500,557
Labor	1,369,681	1,227,037	1,413,822	1,271,178
Equipment	107,915	97,412	108,238	97,735
Fuel	67,638	58,205	63,939	54,506
Water	7,884	7,615	7,817	7,548
Transportation	240,083	228,857	244,725	233,499
Total Annual Cost	\$5,394,305	\$5,053,337	\$5,505,991	\$5,165,023

## ANNEX I TO APPENDIX G

### HOSPITAL RATION

1. **INTRODUCTION.** The medical staff, and the greatest majority of patients, will subsist on the bulk ration. For those patients requiring special diets, a powdered nutritional supplement, and thermally processed, shelf-stable, single serving meals are proposed.

2. **NUTRITIONAL SUPPLEMENT.** The powdered nutritional supplement will be formulated to provide not less than the minimum requirements for a full liquid diet, and the recommended daily dietary allowances for males between the ages of 19 to 51, when consumed in quantities of at least 3000 cc. It will be flexibly packaged in portions to supply 1000 cc of solution, with the following minimum nutritional composition:

Energy	1000 kCals
Protein	34 g
Fat	35 g
Carbohydrate	138 g
Vitamin A	2500 IU
Vitamin D	200 IU
Vitamin E	15 IU
Ascorbic acid	50 mg
Folacin	200 $\mu$ g
Niacin	15 mg
Riboflavin B <sub>2</sub>	1 mg
Thiamin B <sub>1</sub>	1 mg
Vitamin B <sub>6</sub>	1 mg
Vitamin B <sub>12</sub>	3 $\mu$ g
Calcium	900 mg
Phosphorus	900 mg
Iodine	70 $\mu$ g
Iron	9 mg
Magnesium	200 mg
Zinc	7.5 mg

Flavoring agents such as strawberry, cherry, lemon, orange, chocolate and vanilla will be supplied so that some taste variety may be provided for those subsisting on this diet.

3. **INDIVIDUAL MEALS.** Patients requiring sodium, calorie, fat and fiber restricted type II HLP (Hyperlipoproteinemia) diabetic bland diets will be provided with meals that are shelf-stable, and flexibly packaged in single serving portions. Entrees, which have already been developed to meet the aforementioned dietary characteristics in a frozen form, can be thermally processed instead, with a minimum of modification. Suggested entrees are:

Baked Salisbury steak with mushroom sauce  
Beef stew  
Grilled loin steak

Roast beef with vegetable sauce  
Lemon baked perch  
Chicken cacciatore  
Roast chicken  
Roast pork  
Roast lamb with mint sauce  
Roast veal with currant sauce

At least nine entree items should be supplied in a single shipping container, corresponding to a three day cycle.

Vegetable, starch and dessert items may also be packaged separately, or provided in other forms, e.g., dehydrated and/or compressed, to provide the necessary flexibility to adapt them to particular dietary requirements; or, they will be prepared from components of the bulk ration. In the latter instance, portions of vegetables and starches would have to be extracted before seasonings are added, and finished separately. Dessert items can be prepared separately, if necessary, in limited quantities. Some recipes which have already been developed to fill these special dietary needs are:

Whole kernel corn  
Green beans  
Mixed vegetables  
Green peas  
Spinach  
Hashed brown potatoes  
Parsley sliced potatoes  
Oven browned potatoes  
Mashed potatoes  
Steamed rice  
Spaghetti in tomato sauce  
Sponge cake  
Peanut butter cookies  
Pound cake

**4. CONCEPT OF OPERATIONS.** The estimated 10% of patients requiring special diets, bland fiber restricted soft, bland, dental soft, fat restricted, sodium restricted, calorie restricted/diabetic, protein restricted, clear liquid, full liquid, and dental liquid, will be fed as follows:

a. Patients requiring bland fiber restricted soft, bland, sodium restricted, fat restricted, calorie restricted, or diabetic rations will be served sodium, calorie, fat and fiber restricted, type II HLP diabetic bland antrees, and vegetable, starch and dessert items especially prepared for them. When the patient need not observe all of these dietary restrictions, appropriate adjustments can be made.

b. Patients on a protein restricted diet will be fed combinations of fruit, fruit juices, hot cereal, potato, vegetable, salad (when available), bread or roll, butter, jam or jelly, sugar, salt-pepper, coffee and tea with lemon juice powder from the tray pack or the minimum cube ration. When more than 40 g/day of protein can be tolerated by the patient, calculated amounts of meat entrees may be added to the diet.

c. Dental soft diets will be created by grinding the bulk ration or special diet items in accordance with the patients nutritional requirements.

d. Clear liquid diets will consist of beef and chicken bouillon, cherry, orange, strawberry, raspberry, lemon, black raspberry and lime gelatin, gum based for room temperature set, coffee, tea, lemon powder, sugar and salt.

e. Dental liquid diets can be prepared from components of the bulk ration by grinding to very fine particle sizes that will flow readily through a straw.

f. Patients on a full liquid diet will be fed either reconstituted dehydrated fruit juices, strained cereals and cream soups, room temperature setting gelatins, coffee, tea with lemon juice powder, sugar and salt and/or the powdered nutritional supplement, if a more nutritious liquid diet is desired.

g. If patients do not have any special dietary requirements, but are unable to tolerate the regular ration, they can be fed the sodium, calorie, fat and fiber restricted, type II HLP diabetic bland entrees, with specially prepared vegetables, starches and desserts, with consistency modifications, as necessary.

h. If the sodium, calorie, fat and fiber restricted, type II HLP diabetic bland entrees are not available, for whatever reason, the nutritional supplement can be fed to patients requiring any of these special diets. The nutritional supplement will probably be satisfactory, if it is not fed to a patient for an extended period of time.

## APPENDIX H

### ANALYSIS OF INDIVIDUAL MESSGEAR ALTERNATIVES

1. **INTRODUCTION.** Three different types of individual messgear are considered for the future combat food service system. These include the individual messkit now used by the Army, permanent plastic compartmented trays and utensils, and disposable trays and other items. Each alternative is evaluated in terms of costs of equipment and the associated sanitation requirements.

2. **DESCRIPTION OF ALTERNATIVES.** Currently, the field messgear consists of a metal messpan, canteen cup, and knife, fork and spoon, which are issued to, and maintained by, the individual soldier. A messkit washline is assembled at the food service site for sanitation purposes, comprised of four 32 gallon G.I. cans with immersion heaters attached for heating water. After a meal is completed, the messkit is brought to the washline, where the food waste is scrapped, and it is washed and rinsed in these cans. An assigned KP attends to preparing, maintaining and cleaning the washline components at each meal period.

The permanent plastic ware will be issued directly to the food service operation, where it will be maintained and available for use by each person attending a meal. A sanitation center, which includes an integral hot water supply and manual tray washing capability, is provided as a part of the authorized food service equipment. At the conclusion of the meal, the tray and utensils are delivered to the sanitation center, the food waste is scrapped, and the items are sorted for washing, which is done by the assigned KP personnel.

Disposable messgear includes a fiberboard, biodegradable compartmented tray, paper cup and plastic eating utensils, which will be issued to the food service operation and then distributed to the troops at each meal. No sanitation facilities are required since the used items will be discarded following the meal. However, appropriate and acceptable procedures for handling of the disposed materials will have to be established.

3. **COST ANALYSIS.** Investment and replacement costs of the messgear and related sanitation equipment, which in this case, apply only to the individual messkit and plastic dinnerware alternatives, are shown in Tables H-1 and H-2. Initial costs were obtained from standard sources, i.e., Army Publication SB 700-20 and the GSA Supply Catalog, and representative replacement factors were taken from Army Publication SB 10-496. The capital recovery factor used to calculate the corresponding uniform annual costs is based on a 10% interest rate. It is assumed, per AR 310-34, that one messkit washline will be provided for each 85 or less troops, and that the sanitation center will service, on the average, 160 troops. Further, since the sanitation center is also intended for pot and pan washing, only 50% of these costs are charged to messgear sanitation. Cost of the disposable messgear are provided in Table H-3.

Costs relating to consumable and expendable supplies for the messkit washline and sanitation center operations, are shown in Tables H-4 and H-5. The indicated usage rates are best estimates derived from operating experience at several field exercises.

**TABLE H-1****ANNUAL COST OF INDIVIDUAL MESSKIT AND WASHLINE EQUIPMENT**

<b>Equipment Item</b>	<b>Unit Cost</b>	<b>Economic Life, Months</b>	<b>Annual<sup>1</sup> Cost</b>
Pan, Mess Kit	\$ 5.40	12	\$483.65
Knife, Field Mess	.44	9	51.85
Fork, Field Mess	.19	9	22.10
Spoon, Field Mess	.17	9	20.40
Cup, Water Canteen	2.24	12	209.10
Heater, Immersion (4) <sup>2</sup>	86.32	51	99.25
Can, 32 Gallon (4) <sup>2</sup>	17.40	8	108.19
Total Annual Cost			\$994.54
Annual Cost/Person			\$ 11.70

**NOTES:**

<sup>1</sup> Annual cost per 85 persons, the capacity of the washline.

<sup>2</sup> Number in parentheses indicates quantity required for single washline.

**TABLE H-2**  
**ANNUAL COST OF PERMANENT PLASTIC MESSGEAR**  
**AND SANITATION CENTER**

Equipment Item	Unit Cost	Economic Life, Months	Annual <sup>1</sup> Cost
Plastic Tray	\$ 3.70	48	\$ 187.20
Plastic Cup, 10 oz.	.73	27	57.60
Fork, Stainless	.28	9	62.40
Knife, Stainless	.42	9	92.80
Spoon, Stainless	.23	9	51.20
<b>Sanitation Shelter</b>			
Frame	\$1320.00	96	\$ 247.00
Fabric	1052.00	48	606.00
Fly	290.00	12	319.00
Sink (3) <sup>2</sup>	666.00	96	375.00
Shelving (2) <sup>2</sup>	109.00	24	126.00
M-2 Burner	163.00	48	51.00
Total Annual Cost <sup>3</sup>			\$1313.20
Annual Cost/Person			\$ 8.21

**NOTES:**

<sup>1</sup> Annual cost per 160 persons, the capacity of the sanitation center.

<sup>2</sup> Number in parentheses indicates quantity required for a single sanitation center.

<sup>3</sup> Only 50% of the cost of the sanitation center charged to warewashing.

TABLE H-3

ANNUAL COST OF DISPOSABLE MESSGEAR

Item	Cube/ 1000 Units	Cost/ 1000 Units	Annual <sup>1</sup> Cost
Tray	7.56	\$41.80	\$1525.70
Fork	1.10	13.00	474.50
Knife	1.10	13.00	474.50
Spoon	1.10	12.00	438.00
Hot Cup, 10 oz.	2.62	15.70	573.05
Total Annual Cost			\$3485.75
Annual Cost/Person			\$ 34.86

NOTES:

<sup>1</sup> Annual cost per 100 persons, assuming one meal a day served on disposables.

**TABLE H-4**  
**ANNUAL COST OF CONSUMABLES/EXPENDABLES**  
**FOR MESSKIT WASHLINE**

<b>Item</b>	<b>Usage Rate<sup>1</sup></b>	<b>Unit Cost</b>	<b>Annual<sup>2</sup> Cost</b>
Dishwashing Compound	.75 lbs/meal <sup>3</sup>	\$ .30/lb	\$ 82.13
Water	80 gal/meal	.012/gal <sup>4</sup>	350.40
Fuel, Gasoline	6.85 gal/meal	.507/gal <sup>5</sup>	1267.63
Scraper	1/week	.54 each	28.08
Brush	1/week	1.45 each	75.40
<b>Total Annual Cost</b>			<b>\$1803.64</b>
<b>Annual Cost/Person</b>			<b>\$ 21.22</b>

**NOTES:**

<sup>1</sup> Derived from operational data.

<sup>2</sup> Based on serving one meal per day to each of 85 persons, the capacity of the washline.

<sup>3</sup> MIL-HDBK 740.

<sup>4</sup> Estimated cost of water production by Engineer Water Supply Company (SRC 05067H).

<sup>5</sup> Cost data provided by Defense Fuel Supply Center.

**TABLE H-5**  
**ANNUAL COST OF CONSUMABLES/EXPENDABLES**  
**FOR SANITATION CENTER**

Item	Usage Rate <sup>1</sup>	Unit Cost	Annual <sup>2</sup> Cost
Dishwashing Compound	1.5 lbs/meal	\$ .30/lb	\$ 164.25
Water	96 gal/meal	.012/gal <sup>5</sup>	420.48
Fuel, Gasoline <sup>3</sup>	2 gal/meal	.507/gal <sup>6</sup>	370.11
Fuel, Diesel <sup>4</sup>	2.5 gal/meal	.449/gal <sup>6</sup>	409.71
Screper	2/week	.54 each	56.16
Brush	2/week	1.45 each	150.80
Total Annual Cost			\$1571.51
Annual Cost/Person			\$ 9.82

**NOTES:**

<sup>1</sup> Derived from operational data.

<sup>2</sup> Based on serving one meal per day to each of 160 persons, the capacity of the sanitation center.

<sup>3</sup> For M-2 burner.

<sup>4</sup> For water heating.

<sup>5</sup> Estimated cost of water production by Engineer Water Supply Company (SRC 05067H).

<sup>6</sup> Cost data provided by Defense Fuel Supply Center.

The only labor costs explicitly included in the cost analysis are for the sanitation functions, and are presented in Table H-6. Approximately four manhours are required to assemble, maintain, and clean each messkit washline operated during a meal period, servicing 85 persons. Manual washing of trays and other items in the sanitation center is estimated will require about one manhour for each 40 persons served. Of course, no such costs are incurred with the use of disposable messgear. It is assumed that all KP labor will be provided by enlisted personnel in pay grades E-2 and E-3, for which the average annual cost is \$13,916.

In-theater transportation costs for disposables consist of overseas freight, port handling and bunker fuel allowance charges, which total \$52.40 per measurement ton, the equivalent of 40 cubic feet. The volume of disposables required to serve a person one meal each day for a year is 4.92 cubic feet, therefore the annual shipping costs are \$6.45. Assuming the disposables are transported from the port area to division direct support by the Medium Truck Company, using semitrailer trucks which cost \$252.54 a day, and that the average cost of transporting disposables in the theater is approximately \$0.285 per cubic foot, from Tables 1-6 and 1-7, this portion of the transportation costs amounts to \$1.40 a year. Finally, the disposables are transhipped in 2½ ton truckload quantities to the using units over an average distance of 25 miles per day. Fuel costs for operating a truck are nearly \$0.108 a mile, amounting to \$983.31 a year.\* The effective hauling capacity of the 2½ ton truck is approximately 10.6 measurement tons, or 425 cubic feet, so that the corresponding transportation costs are \$11.38 per year. Then, the total annual transportation costs for this alternative are estimated as \$19.23.

Water required for sanitation is to be transported to the kitchen site in a 400 gallon water trailer towed by a 2½ ton truck. The distances and costs are assumed to be identical to those for the disposables. From the data given in Table H-4 and H-5, the annual water consumption rates per person, receiving one meal a day, are 344 gallons for the messkit washline, and 219 gallons for the sanitation center, with associated transportation costs of \$2.32 and \$1.47 a year, respectively.

Fuel costs include delivery into the theater. Transportation costs for other expendables and consumables could not be readily determined from available data, but are thought to be relatively insignificant, and are therefore ignored.

Total annual costs for each alternative are summarized and compared in Table H-7.

**4. CONCLUSIONS.** If considered completely independently of all other aspects of combat feeding operations, the permanent plastic ware alternative is quite obviously the most cost-effective, by a substantial margin. Certainly, in any situation that offers a choice of methods

\*The trucks used for this purpose are those assigned to the food service units, which are also used for various other functions as well, so that the additional costs for maintenance and operation of the vehicles is otherwise charged as an annual equipment cost to the food service system, and not explicitly included in this analysis.

**TABLE H-6**

**ANNUAL LABOR COSTS FOR MESSGEAR SANITATION**

	<b>Messkit<sup>1</sup> Washline</b>	<b>Sanitation<sup>2</sup> Center</b>
<b>KP Labor/Meal</b>	4 manhours	4 manhours
<b>Annual Labor Requirements</b>	1/3 manyear	1/3 manyear
<b>Cost/Manyear<sup>3</sup></b>	\$ 13,916	\$ 13,916
<b>Total Annual Cost</b>	\$4638.67	\$4638.67
<b>Annual Cost/Person</b>	\$ 54.57	\$ 28.99

**NOTES:**

<sup>1</sup> Capacity 85 persons/meal.

<sup>2</sup> Capacity 160 persons/meal.

<sup>3</sup> Average annual cost for pay grades E-2 and E-3.

TABLE H-7

ANNUAL COSTS OF MESSGEAR ALTERNATIVES<sup>1</sup>

	Messkits	Permanent Ware	Disposables
Equipment	\$ 11.70	\$ 8.21	\$ -
Consumables/Expendables	38.20	17.68	62.75
Labor	98.23	52.18	-
Transportation	4.18	2.65	34.61
Total	\$152.31	\$80.72	\$97.36

NOTES:

<sup>1</sup> Expressed as annual cost per person, assuming an average of 1.8 meals are served each person daily, in accordance with the logistics planning factor of 60% bulk rations and 40% individual combat rations for the total theater.

for serving meals, it should be utilized. This generally will be the case in the Corps areas and COMMZ after the forces and battle lines become established. However, in the divisions, conditions are expected to remain somewhat uncertain and unstable, so that any concept of food service operations necessitating sanitation functions to be performed is just too limiting. Hence, even though disposables result in the higher costs, this alternative is most compatible with the requirements for flexibility and responsiveness in the feeding of active combat units.

The reported cost of disposables in Table H-7 may be greater than should actually be anticipated in this instance, for the basis of the cost estimates, 1.8 meals per person a day, is probably more than can be routinely accomplished under such conditions. But, even if as many as 50% of the meals in the entire theater were served on disposables, and the remainder on permanent plastic ware, this combination would still be more cost-effective than the current individual messkit operations.

It is realized that, even though the canteen cup and messkit are no longer required for feeding purposes in the new system, there may be other arguments for retaining and issuing them, at least to the combat troops. For instance, the messkit represents a fallback position in the event that disposables are not available, and, under some circumstances, the canteen cup offers a simple expedient for heating the MRE ration. In this case, the problem may exist as to how these items can be cleaned in the absence of any sanitation facilities as part of the food service operation. Several alternatives can be suggested. A nonstick coating can be permanently applied to the messkit and canteen cup which would allow easy cleaning with a disposable, chemically treated wiping pad. Another possibility would be to provide disposable inserts or covers for these utensils which could be thrown away after use, or some combination of these different options. Unlike disposables, however, these methods would have to be developed, and if so, would be unique to the military so that there would be no existing production base, and would likely result in higher costs.

## APPENDIX I

### LOGISTICS ANALYSIS

1. **INTRODUCTION.** A matter of continuing concern in the planning and organization of Army combat forces for the future is the availability of adequate transportation and shipping to support and sustain large scale military actions. Therefore, the projected logistic demands of the new combat food service system should be examined and compared with those for the existing system.

2. **SUPPLY REQUIREMENTS.** The amounts of each of the various supply items are estimated for the existing system assuming company level operations with B and MRE rations. Similarly, for the new system, it is presumed that food service operations are being conducted with either the Food Service Unit or Modular Field Kitchen, in a nonconsolidated mode, using the T and MRE rations.

a. **Rations.** The assumed ration mix for the entire theater of operations is 60% bulk and 40% individual rations, but these proportions are varied by the particular area of the theater. Specifically, approximately 46% B or T rations will be consumed in the divisions, about 57% in the corps areas, and 95% in the COMMZ, with the remainder of the meals consisting of MRE rations, as discussed in paragraph F.2.b. Using these data, the mean weight and cube of the different combinations of rations for each area were calculated, and are included in Table I-1. Then, the total weights and cubes of the rations to be supplied daily were computed on the basis of the expected numbers of troops in each area, Table I-2.

b. **Bread.** Fresh bread, one-half pound per person per day, is included as a component of the A, B or T ration. This bread is expected to be provided from the Automated Bakery Systems (ABS), operating at the general support level and supplying the finished product to direct support units for distribution with the rations. A single baker of this kind can produce 14,700 one pound loaves of bread a day, from 10,400 pounds or 2.27.3 cubic feet of dry ingredients and 735 gallons of water. At this rate of output, the ingredient supply and bread distribution requirements necessary to support each area of the theater, corresponding to the numbers of B or T rations served, are as indicated in Table I-3.

c. **Water.** The quantities of water used for meal preparation and sanitation depend on the type of ration served and the kind of messgear used. Five gallons per day are needed with the B ration and standard issue messkit and canteen cup; one gallon per day is required for preparing and serving the T rations on disposables; 1.8 gallons per ration served are needed for tray sanitation; and, one-half gallon per day is consumed with the MRE ration, as shown in Tables F-22 and F-45. Total water supply requirements are estimated, in Table I-4, for the specified B/MRE and T/MRE ration mixes in each area.

d. **Fuel.** Fuel supply requirements for the food service equipment and vehicles are provided in Table I-5. Total quantities of the various items of fuel burning equipment operated in the different areas of the theater were derived from Tables F-11 through F-13 for the existing system, and from Tables F-31, F-32 and F-36 through F-38 for the new system.

TABLE I-1

MEAN WEIGHT AND CUBE PER RATION

Type	Ration Characteristics		Weight Contributions, lbs			Cube Contribution, ft <sup>3</sup>		
	Weight, lbs	Cube, ft <sup>3</sup>	COMMZ	Corps	Division	COMMZ	Corps	Division
T	4.86	.147	4.62	2.77	2.24	.140	.084	.068
B	3.96	.111	3.76	2.26	1.82	.105	.063	.051
MRE	3.88	.232	.19	1.67	2.10	.012	.100	.125
	Mean, T/MRE		4.81	4.44	4.34	.152	.184	.193
	Mean, B/MRE		3.95	3.93	3.92	.117	.163	.176

NOTES:

1 From Table F-7.

TABLE I-2

RATION WEIGHT AND CUBE REQUIREMENTS

Area	Number of <sup>1</sup> Personnel	B/MRE		Total, tons	ft <sup>3</sup> / Ration		Total, ft <sup>3</sup>	Number of <sup>2</sup> Personnel		T/MRE		Total, tons	ft <sup>3</sup> / Ration		Total, ft <sup>3</sup>
		lbs/ Ration	Ration		ft <sup>3</sup> / Ration	Ration		lbs/ Ration	Ration	ft <sup>3</sup> / Ration	Ration				
Division	435,603	3.92	3.92	853	.176	.176	76,993	427,873	4.34	4.34	926	.193	.193	82,660	
Corps	497,446	3.93	3.93	976	.163	.163	80,817	490,682	4.44	4.44	1090	.184	.184	89,870	
COMMZ	214,459	3.95	3.95	424	.117	.117	25,103	211,789	4.81	4.81	509	.152	.152	32,033	
Total				2253			182,913				2525			204,563	

NOTES:

<sup>1</sup> From Table F-4.

<sup>2</sup> From Table F-27.

TABLE I-3

## BREAD SUPPLY REQUIREMENTS

Area	Number of B Rations <sup>1</sup>	B/MRE Ingredients		Water, gallons	Product	
		tons	ft <sup>3</sup>		tons	ft <sup>3</sup>
Division	198,900	35.2	1,538	4,960	49.7	17,205
Corps	285,869	50.6	2,210	7,128	71.5	24,728
COMMZ	203,736	36.0	1,575	5,080	50.9	17,623
Total	688,505	121.8	5,323	17,168	172.1	59,556

Area	Number of T Rations <sup>2</sup>	T/MRE Ingredients		Water, gallons	Product	
		tons	ft <sup>3</sup>		tons	ft <sup>3</sup>
Division	195,370	34.6	1,510	4,871	48.8	16,900
Corps	281,981	49.9	2,180	7,031	70.5	24,391
COMMZ	201,200	35.6	1,555	5,017	50.3	17,404
Total	678,551	120.1	5,245	16,919	169.6	58,695

## NOTES:

<sup>1</sup> From Table F-4.<sup>2</sup> From Table F-27.

TABLE 1-4

WATER SUPPLY REQUIREMENTS

Area	Number of Ratings <sup>1</sup> B	Water gallons	Area	Number of Ratings <sup>2</sup> T	Water, gallons
	MRE			MRE	
Division	198,900	1,112,852	Division	195,370	311,622
Corps	285,869	1,535,132	Corps	281,981	893,897
COMMZ	203,736	1,024,062	COMMZ	201,200	568,654
Total	688,505	3,672,046	Total	678,551	1,774,173

NOTES:

<sup>1</sup> From Table F-4.

<sup>2</sup> From Table F-27.

TABLE I-5

## FUEL SUPPLY REQUIREMENTS

Equipment	Fuel Use Rate, gallons/day	B/MRE		Authorized Equipment Corps	COMMZ
		Division			
M-2 Burner	6 <sup>2</sup>	11,860		7,967	2,766
Immersion Heater	5.16 <sup>2</sup>	28,778		26,313	11,067
2½ ton Truck	24	3,619		2,689	756
Fuel Consumption, gallons	Equipment Trucks	219,654 86,856		183,577 64,536	73,702 18,144
Ration Mix		46/54		57/43	95/5
Fuel Requirements gallons	Mogas Diesel	100,297 86,856		105,499 64,536	70,017 18,144
Equipment	Fuel Use Rate, gallons/day	T/MRE		Authorized Equipment Corps	COMMZ
		Division			
Food Service Unit	16.56	2,766		-	-
Modular Field Kitchen	2.76/6.00 <sup>2</sup>	883		2,746	880
1¼ ton Truck	10	2,128		-	-
2½ ton Truck	24	1,434		2,689	753
Fuel Consumption, gallons	Equipment Trucks Sanitation <sup>3</sup>	48,243/5,298 <sup>2</sup> 55,696 -		7,580/16,476 <sup>2</sup> 64,536 13,218/10,574 <sup>2</sup>	2,430/5,280 <sup>2</sup> 18,072 9,431/7,545 <sup>2</sup>
		46/54		57/43	95/5
Fuel Requirements, gallons	Mogas Diesel	2,420 77,726		20,044 82,111	12,562 29,813

## NOTES:

<sup>1</sup> Average of H and T series divisions with M48 kitchen or MKT.

<sup>2</sup> Uses Mogas; other equipment uses diesel fuel.

<sup>3</sup> Based on 3.75 gallons MOGAS and 4.6875 gallons DIESEL per 100 T-Rations served.

Fuel consumption rates for this equipment, except for the trucks, is not used with the MRE ration.

e. **Disposables and Expendables.** Usage rates for expendables required with the messkit washline — dishwashing compound, scrub brushes and scrapers — are given in Table H-4. Shipping cubes were estimated from data listed in the GSA Supply Catalog. Information relating to the volume of disposables used with the T ration in the new system was developed in Table H-3. Total supply requirements for disposables and expendables, based on the quantities of B and T rations used in the several areas of the theater, are presented in Table I-6.

**3. TRANSPORTATION AND SHIPPING REQUIREMENTS.** Transportation within the theater will be provided by the Medium Truck Company (TOE 55-018H), using either semi-trailer trucks, each with an effective hauling capacity of 11.1 tons or 800 cubic feet, or by 5000 gallon fuel trucks. Supply networks for the Theater Level Scenario (consistent with the Phase II Study, Logistics Operations in the Communications Zone) which describe the flow of materials are illustrated in Figures I-1 through I-5. Twenty percent of the loads are from the port of entry or pipeline terminal to the direct support units (DSU), and the other 80% of the loads are transhipped via the area general support units (GSU). The trucks are capable of two line hauls per day, from the port or terminal directly to corps or division and between corps and division, or four short hauls per day on the other segments of the network. Distribution below the direct support unit level is not explicitly considered.

In the case of bread, ingredients are shipped to the port of entry, and then delivered to the bakeries located with the general support units. The finished bread products are transferred to the direct support units.

Fuel will be delivered into the theater by pipeline, and then transported to the direct support units in 5000 gallon fuel trucks in the same manner as all other supplies.

Water does not figure in this analysis of transportation requirements, since each kitchen and bakery is authorized a 2½ ton truck and 400 gallon water trailer to provide for its own water supply. But, the truck is also used for a variety of other purposes, and will be retained even if the water requirements are less.

At present, ration distribution represents the largest single demand for logistical support, followed by fuel, bread, and then bread ingredients, as indicated in Table I-7. Expendables are of relatively little significance in this regard. With the new food service system, there is a noticeable increase in the number of semi-trailer trucks needed to transport rations and disposables, which is more than balanced by the sizable reduction in the number of fuel trucks required. Bread requirements produce almost no differences between the two systems.

Although water consumption is of no direct consequence pertaining to transportation requirements, it is perhaps relevant to observe, that with the present system, nearly 2,000,000 more gallons of water are required daily than with the new system. This translates into more than 4,700 additional trailer loads that must be obtained each day by the kitchen trucks, and has obvious implications concerning the number of Engineer Water Supply Companies that must be maintained and operated in the field.

TABLE I-6

DISPOSABLES/EXPENDABLES SUPPLY REQUIREMENTS

Area	B/MRE		Number of T Rations <sup>2</sup>	T/MRE	
	Number of B Rations <sup>1</sup>	Expendables ft <sup>3</sup>		Expendables ft <sup>3</sup>	Disposables ft <sup>3</sup>
Division	198,900	273	195,370	-	7,901
Corps	285,869	393	281,981	411	-
COMMZ	203,736	280	201,200	293	7,901
Total	688,505	946	678,551	704	7,901

NOTES:

<sup>1</sup> From Table F-4.

<sup>2</sup> From Table F-27.

TABLE I-7

SUMMARY OF TRANSPORTATION REQUIREMENTS

	Supply Item	B/MRE	T/MRE	Net Change
	Rations	173.1	191.0	+17.9
Semi-Trailer Trucks	Bread Ingredients	4.6	4.6	
	Bread Products	23.9	23.6	- 0.3
	Expendables	0.8	0.5	- 0.3
	Disposables	-	8.9	+ 8.9
Fuel Trucks	Mogas	39.1	4.4	-34.7
	Diesel Fuel	26.3	28.2	+ 1.9

$B = B/MRE, ft^3$   
 $T = T/MRE, ft^3$   
 $T_T = Trucks for B/MRE$

\*Weight limited rather than volume constrained.

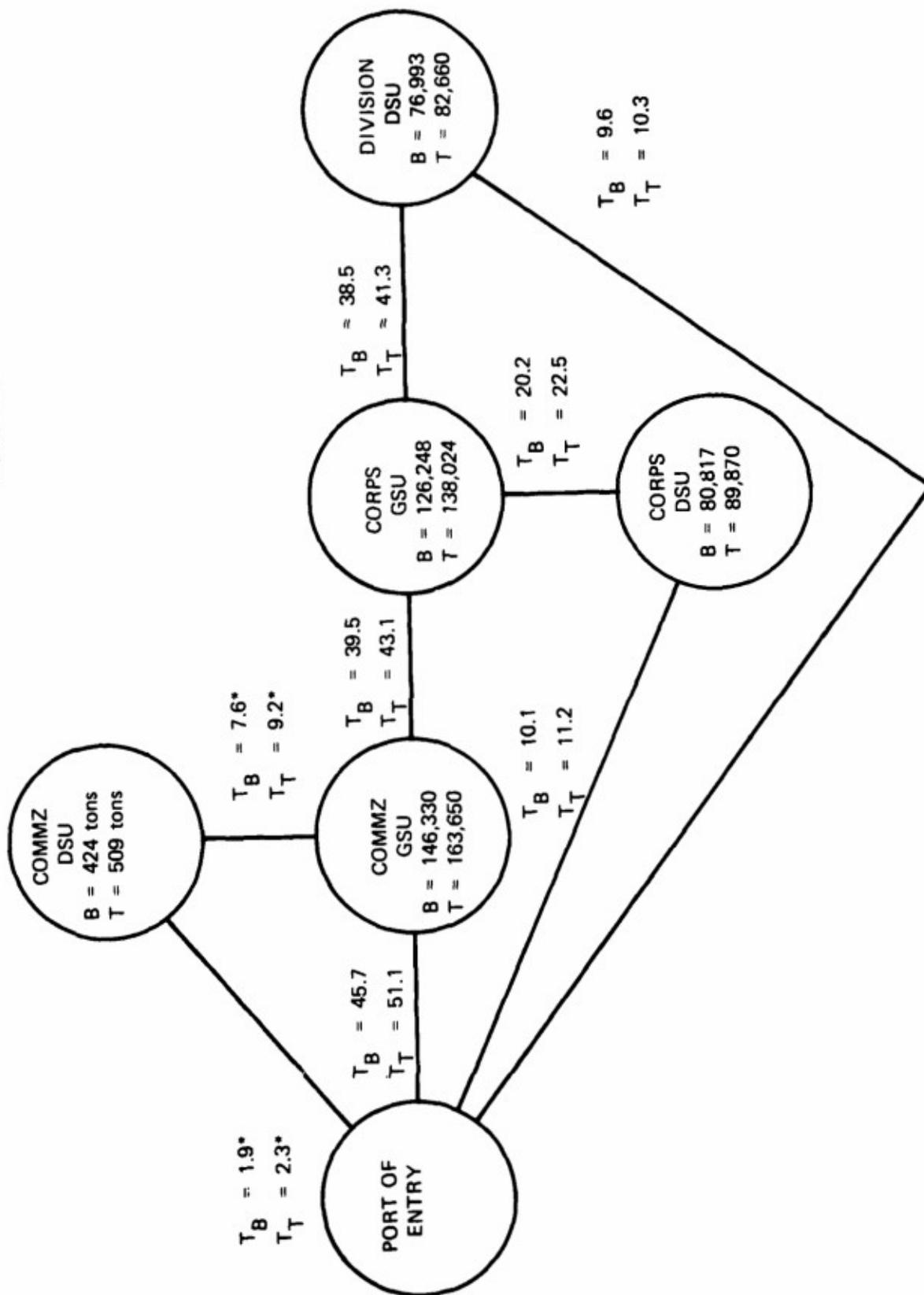


FIGURE I-1. TRANSPORTATION OF RATIONS

$I_B$  = Ingredients for B ration, tons

$I_T$  = Ingredients for T ration, tons

B = Bread for B ration, tons

T = Bread for T ration, tons

$T_B$  = Trucks for B ration

$T_T$  = Trucks for T ration

\*The effective capacity of a semi-trailer truck is 4625 one pound loaves of bread.

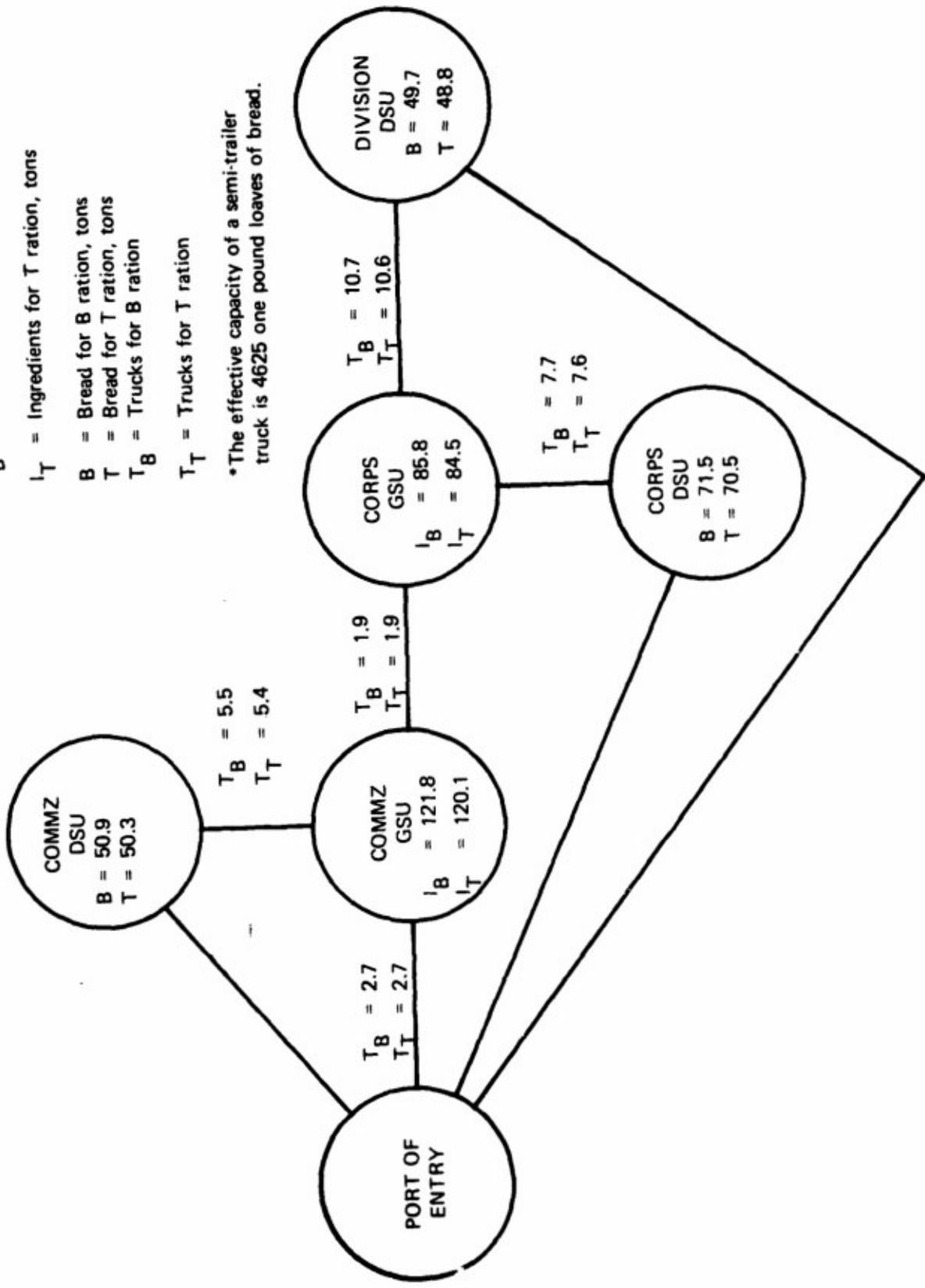


FIGURE 1-2. TRANSPORTATION OF BREAD AND INGREDIENTS\*

M = Mogas, gallons  
 D = Diesel, gallons  
 T<sub>M</sub> = Trucks for Mogas  
 T<sub>D</sub> = Trucks for diesel fuel

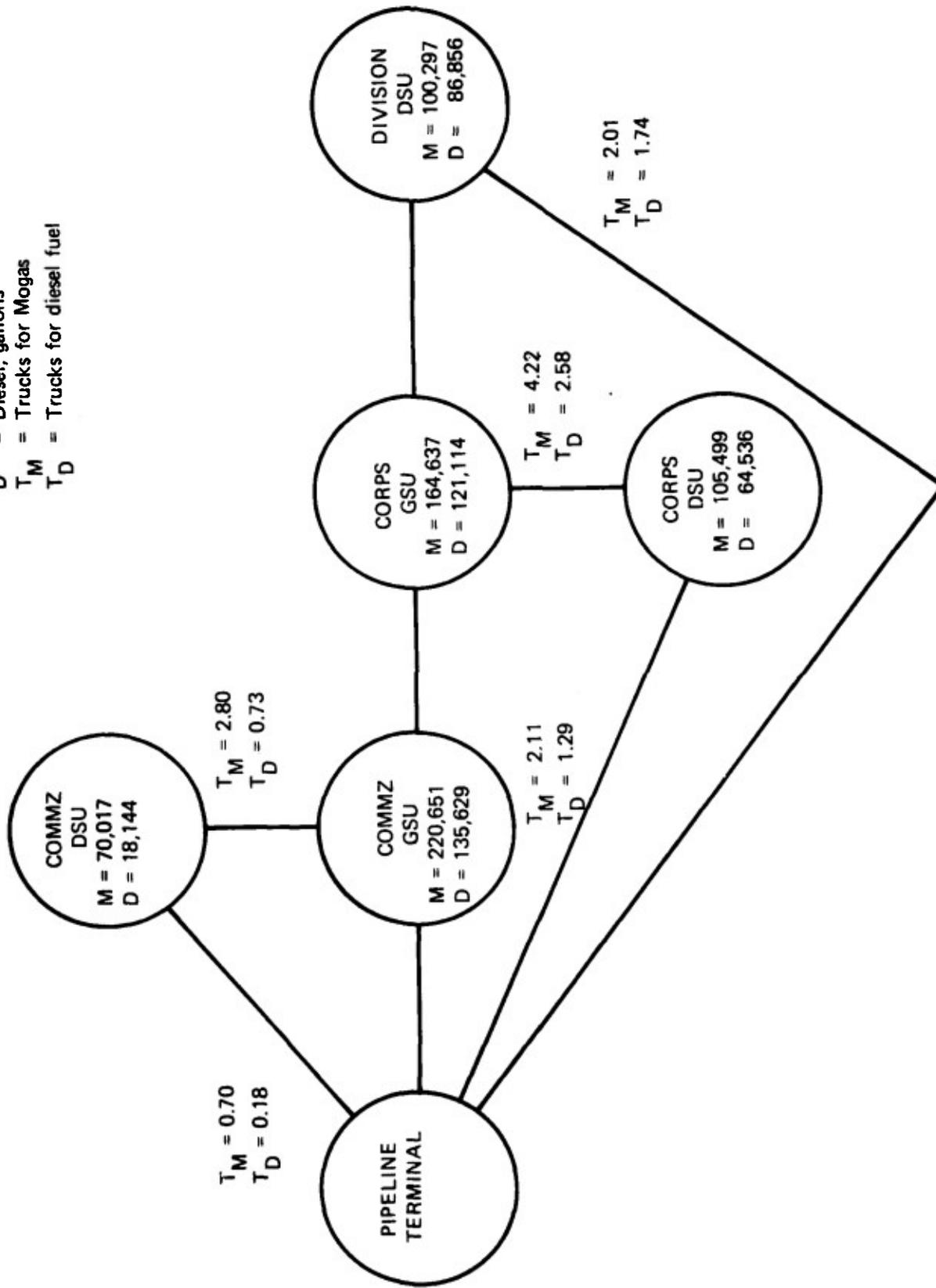
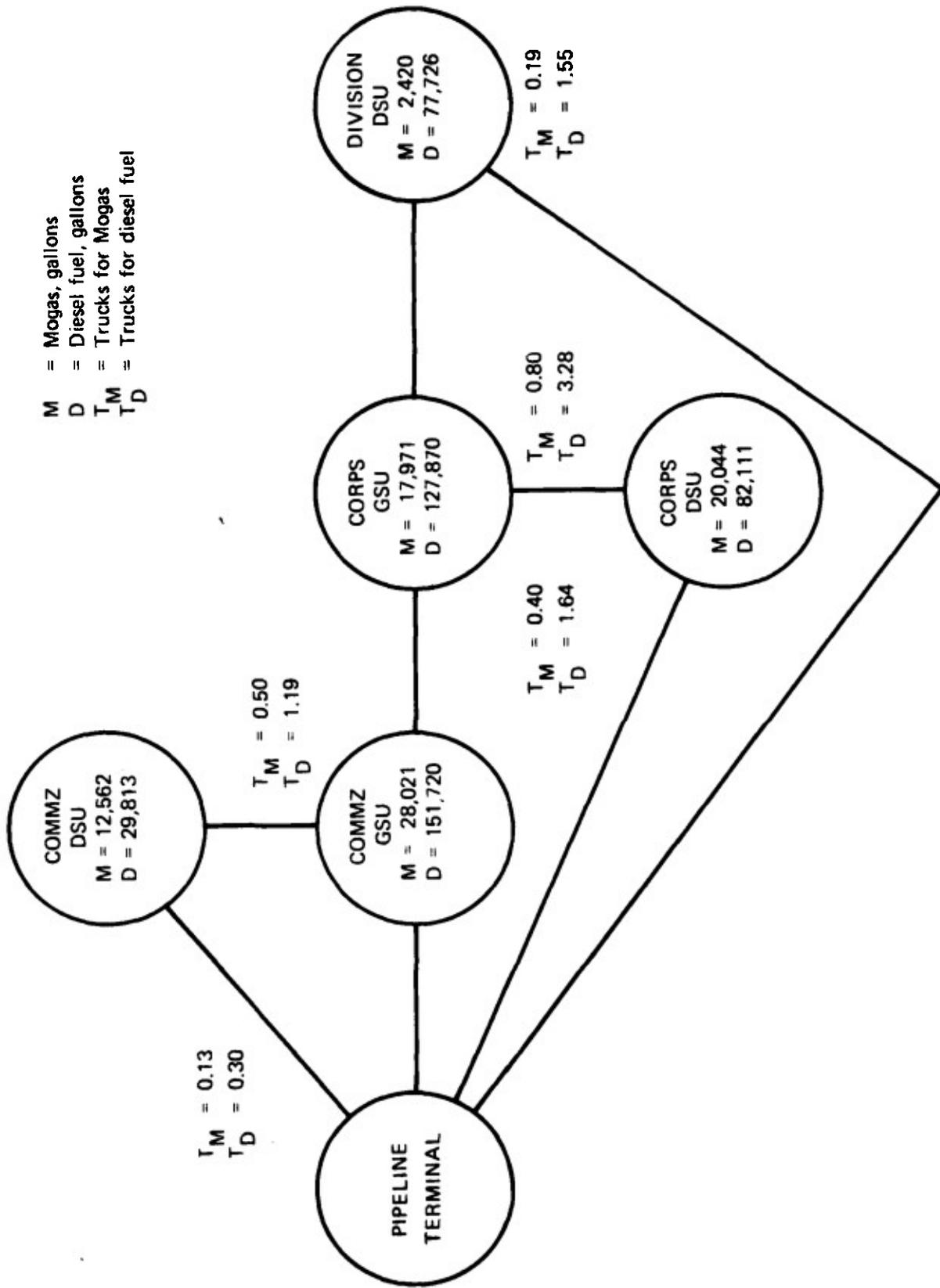


FIGURE I-3. TRANSPORTATION OF FUEL FOR B/MRE RATIONS



M = Mogas, gallons  
 D = Diesel fuel, gallons  
 $T_M$  = Trucks for Mogas  
 $T_D$  = Trucks for diesel fuel

FIGURE I-4. TRANSPORTATION OF FUEL FOR T/MRE RATIOS

$E_B$  = Expendable for B/MRE,  $ft^3$   
 $E_T$  = Expendable for T/MRE,  $ft^3$   
 $D_T$  = Disposable for T/MRE,  $ft^3$   
 $T_B$  = Trucks for B/MRE expendable  
 $T_T$  = Trucks for B/MRE expendable and disposable.

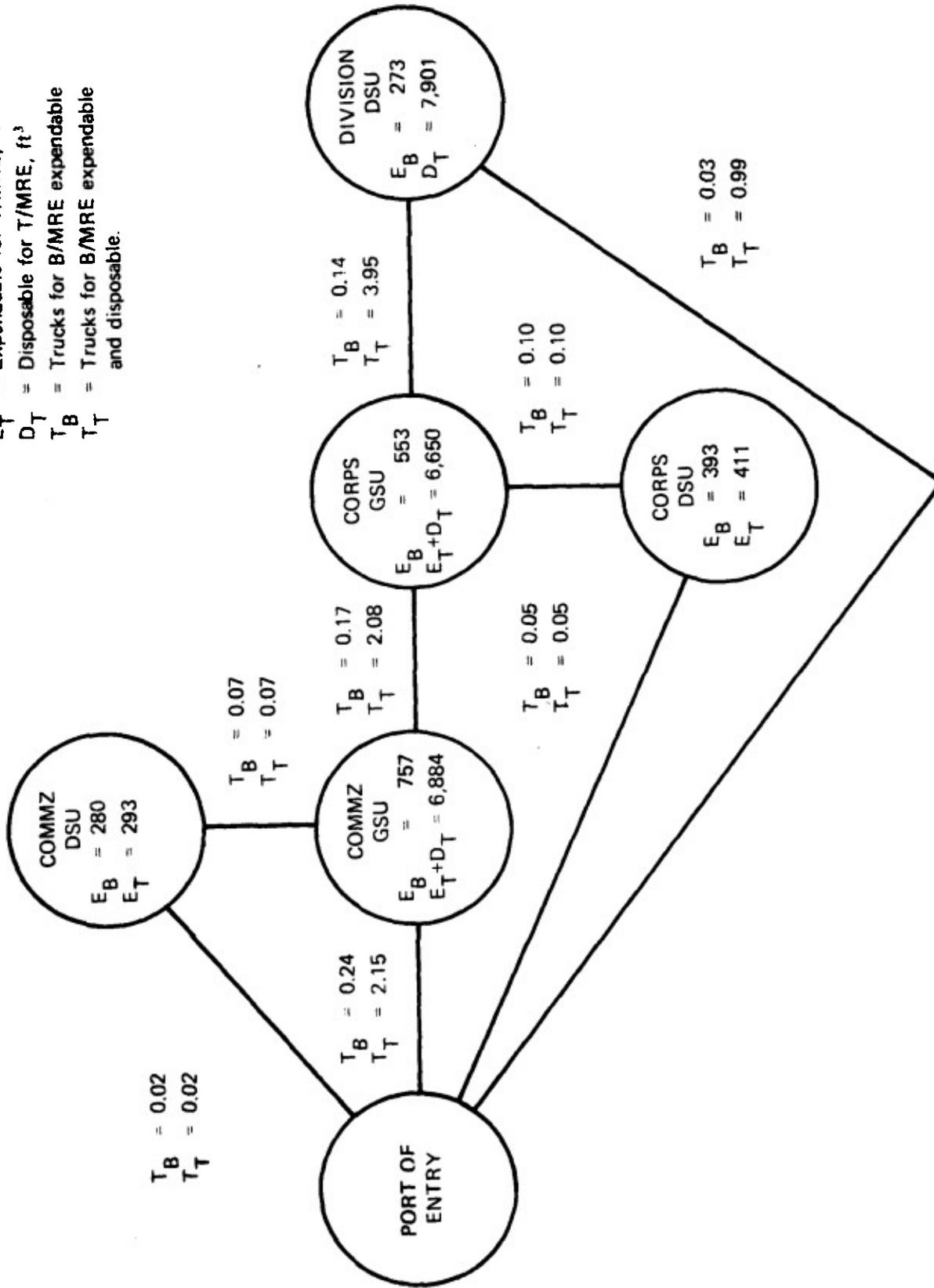


FIGURE 1-5. TRANSPORTATION OF DISPOSABLES/EXPENDABLES

Shipping requirements, summarized in Table I-8, are determined by the volume of rations, bread ingredients, disposables and expendables that must be delivered to the ports of entry. Suppose that all shipping will be accomplished by commercial container vessels, each with a nominal capacity of 332 containers, and that a container can effectively be filled to 1800 cubic feet. Then the additional shipping requirements for the new system, which are about 15% greater when compared to the existing system, amount to about one shipload every three weeks.

Another perspective of the differences between the two systems is obtained by comparing the total transportation and shipping requirements, including water supply, in Table I-9. To do so, the volume of all food service supplies were expressed in common units of cubic feet. Intertheater shipping requirements for the new system are greater, by slightly over 15%, while the intratheater transportation requirements are more than 30% less, for a net reduction in the total volume of nearly 255,000 cubic feet. Although some variations can be observed relative to every item, the differences can be explained almost wholly in terms of the sanitation methods employed with each of the two systems. Disposables in the new system account for the major proportion of the difference in shipping requirements, whereas the difference in transportation requirements is primarily a result of the higher water and fuel usage in the present system, most of which is for sanitation operations.

In conclusion, there are real differences in the logistical support required by the two systems; both in the magnitude of the effort, and in the allocation among transportation and shipping resources. The advantage clearly lies with the new combat food service system concept.

TABLE I-8

SUMMARY OF SHIPPING REQUIREMENTS

Supply Item	Total Cube	
	B/MRE	T/MRE
Rations	182,913	204,563
Bread Ingredients	5,323	5,245
Expendables	946	704
Disposables	-	7,901
Total, ft <sup>3</sup>	189,182	218,413

TABLE I-9

COMPARISON OF SYSTEM REQUIREMENTS

INTERTHEATER SHIPPING

Supply Item	Total Cube	
	B/MRE	T/MRE
Rations	182,913	204,563
Bread Ingredients	5,323	5,245
Expendables	946	704
Disposables	.	7,901
Total, ft <sup>3</sup>	189,182	218,413

INTRATHEATER TRANSPORTATION

Supply Item	Total Cube	
	B/MRE	T/MRE
Rations	182,913	204,563
Bread Ingredients	5,323	5,245
Bread Products	59,556	58,695
Expendables	946	704
Disposables	-	7,901
Fuels*	59,535	30,035
Water*	493,178	239,435
Total, ft <sup>3</sup>	801,451	546,578

\*One gallon equals approximately 0.133681 cubic feet.

## APPENDIX J

### RESEARCH AND DEVELOPMENT PLAN

A new combat food service system has been defined for the Army in the 1990's. This Appendix outlines a plan for the research and development that will be necessary to translate this concept into an acceptable operating system, available to the Army within the desired time period. The overall plan is structured in accordance with the prescribed research, development, test and evaluation (RDT&E) procedures for acquisition of nonmajor systems, as delineated in AR 70-1 and related regulations and directives.

This work will be programmed and funded under the DOD Food RDT&Engineering Program. Any current or planned performance on relevant Army requirements in this Program will be subsumed under this project, or will be directly tasked for specific contributions to the system development. The exception is the Automated Bakery System (ABS), which is an independent, on-going approved project at NARADCOM. Insofar as other military service requirements in the Program are commensurate with this project, in particular, USAF 9-1, Mobility and Augmentation Food Service System, and JSR AM 3-1 (Appendix II), Food Service System for Supporting Marine Air/Ground Task Force Elements, common development requirements will be integrated, whenever possible, to minimize the total development effort, time and costs. The resulting plan:

- a. Identifies specific actions to be taken, and the food, equipment and ancillary items to be developed, Table J-1.
- b. Provides detailed estimates of the professional and technical manpower, funding and other resources required for these purposes, Tables J-2 and J-3.
- c. Establishes a realistic schedule and milestones, consistent with current budgeting practices, and the controlling documentation, testing and decision processes required for acquisition of a nonmajor system, through type classification, Figure J-1.

The Project Office will be responsible for all technical efforts at NARADCOM required to complete concept evaluation and for system development, and insuring that all activities are conducted in accordance with the established schedule and milestones.

Development of all equipment and ancillary items required by the new concept, including experimental prototypes necessary for the concept evaluations, will be accomplished by the Food Systems Equipment Division, Food Engineering Laboratory.

The Food Technology Division, Food Engineering Laboratory, efforts will be directed toward the development, testing and evaluation of both commercial and new food products for the T ration menu, and preparing the appropriate technical data and specifications for procurement of these items; and, for packaging developments necessary to insure the protection of tray pack components of the T ration during shipping, handling and storing, to the point of consumption.

TABLE J-1

TASK DESCRIPTIONS

PROJECT OFFICE

I	II	III
<p>Project Management</p> <ul style="list-style-type: none"><li>i. Review/Control</li><li>ii. Planning/Budgeting</li><li>iii. Reporting</li></ul>	<p>Stock Equipment Control</p> <ul style="list-style-type: none"><li>i. Generators</li><li>ii. Vehicles/Trailers</li></ul>	<p>System Documentation</p> <ul style="list-style-type: none"><li>i. Letter of Agreement</li><li>ii. Outline Development Plan</li><li>iii. Development Plan</li><li>iv. Required Operational Capability</li><li>v. In-Process Reviews</li><li>vi. Technical Data Package</li></ul>

TABLE J-1

TASK DESCRIPTIONS (Cont'd)

OPERATIONS RESEARCH AND SYSTEMS ANALYSIS OFFICE (ORSA)

I	II	III
<p>Concept Evaluation Tests</p> <ul style="list-style-type: none"> <li>i. Test Organization and Management</li> <li>ii. Operational Evaluation</li> <li>iii. Analysis and Reporting of Results</li> </ul>	<p>System Development</p> <ul style="list-style-type: none"> <li>i. Evaluation of Alternatives</li> <li>ii. Trade-off Studies</li> <li>iii. Cost-Effectiveness Analyses</li> </ul>	<p>System Testing</p> <ul style="list-style-type: none"> <li>i. Engineering Tests</li> <li>ii. DT/OT</li> </ul>

TABLE J-1

TASK DESCRIPTIONS (Cont'd)

FOOD ENGINEERING LABORATORY (FEL)  
Food Systems Equipment Division

I	II	III	IV
<p><b>Food Service Unit</b></p> <ul style="list-style-type: none"> <li>i. Tray Pack Configured Components</li> <li>ii. Fluid Tanks and Dispensers</li> <li>iii. Sanitization</li> <li>iv. Ancillary Items</li> </ul>	<p><b>Modular Field Kitchen</b></p> <ul style="list-style-type: none"> <li>i. Heat Source Control Equipment</li> <li>ii. Food Preparation and Serving Equipment</li> <li>iii. Ancillary Items</li> </ul>	<p><b>Field Sanitation Unit</b></p> <ul style="list-style-type: none"> <li>i. Washer and Plumbing Accessories</li> <li>ii. Serving Ware</li> </ul>	<p><b>Combat Vehicle Ration Heater</b></p> <ul style="list-style-type: none"> <li>i. MRE Individual Ration Heater</li> </ul>

TABLE J-1

TASK DESCRIPTIONS (Cont'd)

FOOD ENGINEERING LABORATORY (FEL)  
Food Technology Division

I	II	III
<b>Menu Development</b>	<b>Product Development</b>	<b>Packaging</b>
i. Define and Evaluate Menus	i. New Items Development	i. Tray Pack Shipping
ii. Recipes and Methods	ii. Storage Studies and Other Product Evaluations	Containers

TABLE J-1

TASK DESCRIPTIONS (Cont'd)

FOOD SCIENCES LABORATORY (FSL)  
Behavioral Sciences Division

I

Concept Evaluation Tests

- i. Food Acceptance
- ii. Human Engineering  
Microbiological Assessments

II

System Testing

- i. Engineering Tests
- ii. DT/OT

TABLE J-1

TASK DESCRIPTIONS (Cont'd)

AERO-MECHANICAL ENGINEERING LABORATORY (AMEL)  
Shelters Division

I

Diesel Fired Boiler

II

Shelters

i. Kitchen Shelter

ii. Food Service Unit Covering

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS

Tasks	PROJECT OFFICE						
	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
I. Project Management							
i. Review/Control	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ii. Planning/Budgeting	0.125	0.125	0.125	0.125	0.125	0.125	0.125
iii. Reporting	0.125	0.125	0.25	0.25	0.50	0.125	1.50
II. Stock Equipment Control			0.125	0.125	0.125		
i. Generators							
ii. Vehicles/Trailers							
III. System Documentation							
i. Letter of Agreement	0.75	0.50					
ii. Outline Development Plan	0.50	0.50					
iii. Development Plan			0.50	0.25			
iv. Required Operational Capability	0.25	0.50	0.75	0.50			
v. In-Process Reviews				0.50	0.25	0.50	0.25
vi. Technical Data Package					0.75	1.00	0.25
Total Man Years	2.00	2.00	2.00	2.00	2.00	2.00	2.00

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS (Cont'd)

OPERATIONS RESEARCH AND SYSTEMS ANALYSIS OFFICE (ORSA)

Tasks	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
I. Concept Evaluation Tests	2.0	2.0					
i. Test Organization and Management							
ii. Operational Evaluation							
iii. Analysis and Reporting of Results							
II. System Development	2.0	1.0	1.0	0.5			
i. Evaluation of Alternatives							
ii. Trade-off Studies							
iii. Cost-Effectiveness Analyses							
III. System Testing			1.0	1.5	2.0	1.0	1.0
i. Engineering Tests							
ii. DT/OT							
Total Man Years	4.0	3.0	2.0	2.0	2.0	1.0	1.0

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS (Cont'd)

FOOD ENGINEERING LABORATORY (FEL)  
Food Systems Equipment Division

Tasks	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
<b>I. Food Service Unit</b>							
i. Tray Pack Configured Components	1.0	1.0	1.0	1.0	1.0	1.5	1.5
ii. Fluid Tanks and Dispensers	1.0	0.5	0.25	0.5	0.5		
iii. Sanitation	0.5	0.5	0.25				
iv. Ancillary Items	0.5	0.25					
<b>II. Modular Field Kitchen</b>							
i. Heat Source Control Equipment	0.75	1.0	1.0	1.0	1.0	2.0	2.0
ii. Food Preparation and Serving Equipment	0.50	1.0	1.0	1.0	1.0		
iii. Ancillary Items	0.25	0.25					
<b>III. Field Sanitation Unit</b>							
i. Washer and Plumbing Accessories	0.85	0.85	1.0	1.0	1.0		
ii. Serving Ware	0.15	0.15					
<b>IV. Combat Vehicle Ration Heater</b>							
i. MRE Individual Ration Heater	0.5	0.5	0.5	0.5	0.5	0.5	0.5
<b>Total Man Years</b>	<b>6.0</b>	<b>6.0</b>	<b>5.0</b>	<b>5.0</b>	<b>5.0</b>	<b>5.0</b>	<b>5.0</b>

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS (Cont'd)

FOOD ENGINEERING LABORATORY (FEL)  
Food Technology Division

Tasks	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
<b>I. Menu Development</b>							
i. Define and Evaluate Menus	0.5						
ii. Recipes and Methods	0.5						
<b>II. Product Development</b>							
i. New Items Development	3.0	5.0	5.0	3.0	3.0	2.0	2.0
ii. Storage Studies and Other Product Evaluations	1.0	0.5	0.5	0.5	0.5	0.5	0.5
<b>III. Packaging</b>							
i. Tray Pack Shipping Containers	1.0	0.5	0.5	0.5	0.5	0.5	0.5
<b>Total Man Years</b>	<b>6.0</b>	<b>6.0</b>	<b>6.0</b>	<b>4.0</b>	<b>4.0</b>	<b>3.0</b>	<b>3.0</b>

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS (Cont'd)

FOOD SCIENCES LABORATORY (FSL)  
Behavioral Sciences Division

Task	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
I. Concept Evaluation Tests							
i. Food Acceptance	1.25	0.5					
ii. Human Engineering	0.5						
iii. Microbiological Assessments	0.25						
II. System Testing							
i. Engineering Tests				0.5	0.5	0.5	0.5
ii. DT/OT							
Total Man Years	2.0	1.0	0.5	0.5	0.5	0.5	0.5

TABLE J-2

ESTIMATED MANPOWER REQUIREMENTS (Cont'd)

AERO-MECHANICAL ENGINEERING LABORATORY (AMEL)  
Shelters Division

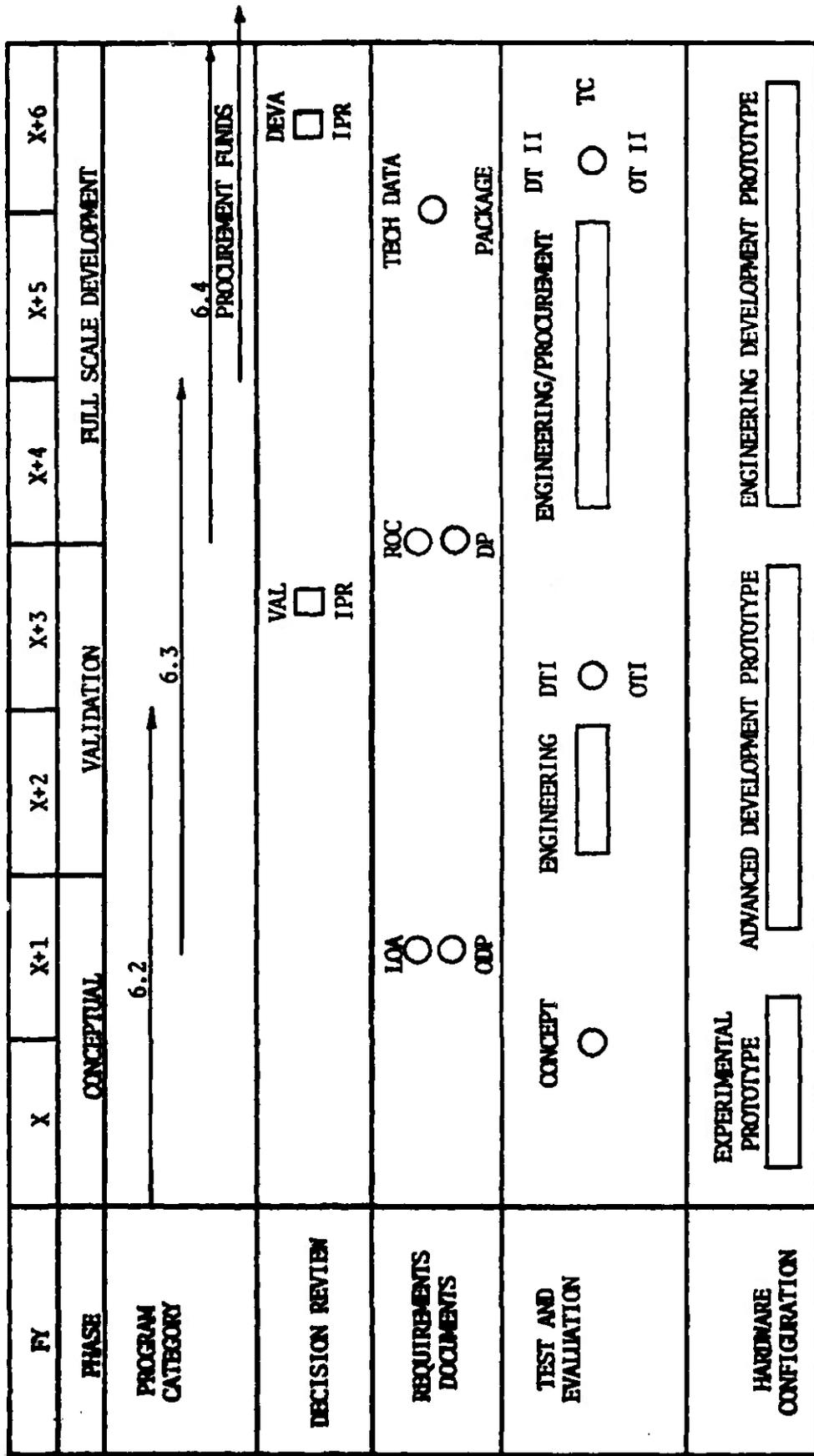
Task	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6
I. Diesel Fired Boiler	1.5	1.5	0.75	0.5	0.5	0.5	0.5
II. Shelters							
i. Kitchen Shelter	0.5	0.25					
ii. Food Service Unit Covering		0.25					
Total Man Years	2.0	2.0	1.0	1.0	1.0	1.0	1.0

TABLE J-3

FUNDING REQUIREMENTS (\$1000)

ACTIVITY	FY X	FY X+1	FY X+2	FY X+3	FY X+4	FY X+5	FY X+6	Total
<b>OPERATIONS RESEARCH AND SYSTEMS ANALYSIS OFFICE</b>								
	212	171	122	132	140	75	80	932
<b>FOOD ENGINEERING LABORATORY</b>								
Food Systems Equipment Division	438	468	415	445	475	510	545	3,296
- Food Service Unit*	110	100	60		84			354
- Modular Field Kitchen*	265	230	412	386				1,293
- Field Sanitation Unit*	150	150						300
- Combat Vehicle Ration Heater*	18	18		8	10			54
<b>FOOD ENGINEERING LABORATORY</b>								
Food Technology Division	438	468	498	356	380	306	327	2,773
- New Items Development*			300	200				700
<b>AEROMECHANICAL ENGINEERING LABORATORY</b>								
Shelters Division	142	152	81	87	93	99	105	759
- Diesel Fired Boiler*	12	158	255	5	35	5	5	475
- Shelters*	5	80		5	35	5	5	135
<b>FOOD SCIENCES LABORATORY</b>								
Behavioral Sciences Division	90	48	26	28	30	32	34	288
<b>Total Annual Funding</b>	<b>1,880</b>	<b>2,043</b>	<b>2,169</b>	<b>1,652</b>	<b>1,482</b>	<b>1,032</b>	<b>1,101</b>	<b>11,359</b>

\*Contract and procurement costs for development and testing.



- NOTES:
- VAL - VALIDATION
  - DEVA - DEVELOPMENT ACCEPTANCE
  - IPR - IN-PROCESS REVIEW
  - LOA - LETTER OF AGREEMENT
  - ODP - OUTLINE DEVELOPMENT PLAN
  - ROC - REQUIRED OPERATIONAL CAPABILITY
  - DP - DEVELOPMENT PLAN
  - OT - OPERATIONAL TEST
  - DT - DEVELOPMENT TEST
  - TC - TYPE CLASSIFICATION

FIGURE J-1. SYSTEM ACQUISITION CYCLE FOR ARMY COMBAT FOOD SERVICE SYSTEM

Design and development of the shelters for the Modular Field Kitchen and sanitation unit, a cover for the Food Service Unit, and the boilers, controls and circulating pumps to operate the tray pack heaters and sanitation devices will be undertaken by the Shelters Division, Aero-Mechanical Engineering Laboratory.

Technical support for food acceptance, human engineering and microbiological assessments during concept evaluation and system development will be provided by the Behavioral Sciences Division, Food Sciences Laboratory.

## APPENDIX K

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