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A SYSTEMS ANALYSIS OF ARMY FIELD BREAD AND BAKERY REQUIREMENTS

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BY
HARRY J. KIREJCZYK
WILLIAM CHEVALIER
BARBARA EDELMAN
ROBERT V. DECAREAU

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The systems analysis addresses alternatives to satisfy the Army's field bread product requirement, including fresh bread from mobile bakeries and host nation support, shelf-stable end products (canned bread, crackers, British-type biscuits), and shelf-stable mixes (cornbread, biscuit mix, sweet/quick breads). Each alternative was evaluated relative to a variety of criteria, including peace and wartime cost impacts, logistical impacts, field bakery requirements, continued on reverse		

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and consumer acceptance. Based on the systems analysis, the following recommendations were made:

- ° The Army should adopt a mix of products to satisfy its field bread requirement. The mix should be approximately:

- 50% fresh bread
 - 33% shelf-stable mixes
 - 17% British-type biscuits.

- ° The above mix provides a projected 10.6 and 22.3 million dollar annual cost savings in a wartime and peacetime environment, respectively.
- ° The fresh bread requirement should be satisfied by host nation support sources to the maximum extent possible.
- ° The Army has sufficient M-45 field mobile bakeries, if deployed at the general support company level.
- ° The Army should consider the development of a 300-400 pound per hour mobile bakery for deployment at the direct support company level.

SUMMARY

This systems analysis addresses a variety of alternatives to satisfy the Army's field bread requirement, including: fresh bread from mobile bakeries and host nation support, shelf-stable end products (canned bread, crackers, British-type biscuits), and shelf-stable mixes (cornbread, biscuit mix, sweet/quick breads). Each alternative was evaluated relative to a variety of criteria, including peace and wartime cost impacts, logistical impacts, field bakery requirements, and consumer acceptance. Based on the systems analysis, the following recommendations were made:

° The Army should adopt a mix of products to satisfy its field bread requirement. The mix should be approximately:

50% fresh bread;
33% shelf-stable mixes;
17% British-type biscuits.

° The above mix provides a projected 10.6 and 22.3 million dollar annual cost savings in a wartime and peacetime environment, respectively.

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° The Army should consider the development of a 300-400 pound per hour mobile bakery for deployment at the direct support company level.

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PREFACE

This project was conducted by the Directorate for Systems Analysis and Concept Development of the U.S. Army Natick Research and Development Center as part of the Department of Defense Food and Nutrition Research and Engineering Program under Military Service Requirement A85-4 - Systems Analysis of Field Bread/Bakery Requirement.

The authors extend a special appreciation to Ms. Maura Severance and Ms. Maureen Savage who endured and provided superb secretarial support throughout the development of this report.

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A SYSTEMS ANALYSIS of ARMY FIELD BREAD and BAKERY REQUIREMENTS

INTRODUCTION

This systems analysis defines the optimum alternative to satisfy the Army's field bread product requirement for 1987 and beyond. The Army's field bread requirement, as established by the Office of the Surgeon General (OTSG), is set at one half pound per bulk ration. Bulk rations (A, B, or T Ration) are those utilized for group rather than individual feeding situations. This requirement has normally been satisfied by fresh bread produced from the Army's M-45 field mobile bakery. Based on current allocation criteria, the Army requires about 85 M-45 size mobile bakery plants. However only about 36 M-45 mobile field bakeries presently exist. In addition, OTSG has stated that there are substitutes for fresh bread. However, due to questions regarding troop acceptability, the OTSG and the Academy of Health Sciences (AHS) concur in recommending that bread substitutes not replace the fresh bread product entirely.

ALTERNATIVES

The systems analysis addressed eight different bread product alternatives. These alternatives are grouped into three major categories as listed below:

<u>Category</u>	<u>Alternative</u>
Fresh Bread	Field Mobile Bakery Host Nation Support
Shelf-Stable Products	Canned Bread Crackers British-Type Biscuits
Shelf-Stable Mixes	Cornbread Mix Biscuit Mix Sweet/Quick Bread Mix Assorted Mixes

The fresh bread category includes both product produced by field mobile bakeries and product provided by the host nation based on host nation signed support agreements. Relative to the systems analysis, the cost and manpower impacts of fresh bread from mobile bakeries is based on the performance and staffing characteristics of the current M-45 field mobile bakery. Whether host nation fresh bread is viable depends on the theater of operations. For example, there are signed host nation support agreements for fresh bread in the European theater but no such agreement exists for the Southwest Asia theater.

The shelf-stable product category represents bread alternatives that are canned, shelf-stable, require no preparation labor, and are consumed as is. The three alternatives included in this category are canned bread, crackers, and British-type biscuits. Canned bread is a Natick R&D Center research and development effort. Program objectives are to develop an acceptable three-year minimum shelf life canned bread product by 1987. The cracker alternative represents a saltine or similar type cracker product. However, the crackers are assumed to be canned to extend their shelf life to the three to five year range. The British-type biscuit represents a product which is the same or similar to the British biscuit, a shelf-stable bread substitute used by the British military when fresh bread is not possible. The product is currently bulk packed - 39 pounds per can, nitrogen flushed, and has a 10-year shelf life.

The shelf-stable mix category represents dry, canned mixes, which can be readily prepared at the tactical field kitchen level with minimal labor, no special skills, and no special equipment. These mixes are intended to require only sufficient hand mixing with water to wet the product prior to panning and baking in a field kitchen oven. Alternatives included in this category are cornbread mix, biscuit mix, sweet/quick bread mix, and an assortment of these mixes. The sweet bread and biscuit mix are standard B Ration menu items. Cornbread and quick bread mixes are not in the B Ration but represent commercially available items. As currently marketed, these products (for example, banana bread, date-nut bread, etc.) have more of a cakelike texture and flavor than a breadlike texture or flavor. However, based on conversations with industry, the technology exists to develop these types of products with a more breadlike texture or flavor.

ASSUMPTIONS

The systems analysis of bread product alternatives was based on the following major assumptions.

1. The field bread product requirement is set by OTSG at 0.50 pounds per bulk operational ration (A, B, or T). This requirement is equivalent to 1/6 pound per A, B, or T Ration meal.
2. The field bread product requirement can be satisfied by fresh or shelf-stable breadlike products, or any combination thereof.
3. Nonfresh bread products can be formulated to be nutritionally equivalent to fresh bread.
4. The overall theater ration mix is 60% bulk rations (A, B, or T) and 40% individual rations, Meal, Ready-to-Eat (MRE's).
5. Individual rations (MRE's) have no field bread product requirement since crackers are included in the ration.

6. The bread product requirement exists from mobilization day to demobilization day.

7. The size and deployment location of field bakeries is not set at 11,000 pounds per 12-hour shift and the General Support Company as stated in the "Operational and Organizational Plan - Provision of Bread to Army Forces in the Field," dated April 1982.

8. Bread product will be maintained in the pre-position war reserve material stocks based on current stockage objectives.

9. The viability of host nation support fresh bread as an alternative depends on the theater of operations.

10. Any required field bakery equipment must be field operational by 1987.

METHODOLOGY and EVALUATIVE CRITERIA

The wartime and peacetime cost, manpower, and logistical impacts of each bread product alternative were established based on each product satisfying 100% of the Army's wartime field bread product requirement. However, the analysis was conducted and the necessary results are provided in a form such that the impact of any mix of alternatives can be readily established by simply weighting and summing the impact of each alternative appropriately.

Each bread product alternative was analyzed relative to the evaluative criteria listed in Table 1. Wartime cost, manpower, and logistical impacts of each alternative are projected based on the daily bread product requirement generated by a simultaneous two theater conflict to include Europe and Southwest Asia. Daily bread product requirements are established for each theater based on each theater's mature population strength. The European and Southwest Asia theater mature population troop strengths, for a simultaneous two-theater conflict, are based on the units included in the programmed peacetime FY88 force structure (M-day force). Peacetime cost impacts are projected based on the programmed FY88 peacetime force structure and current prepositioned war reserve material stock objectives. The mature two theater and the programmed FY88 force troop strengths are summarized in Table 2. As shown, about 95% of the programmed peacetime combat force structure is deployed. Troop acceptance of the various bread product alternatives was evaluated based on a consumer study conducted with U.S. Army personnel stationed at Ft. Devens.

TABLE 1. Evaluative Criteria

Wartime Costs

Product/Ingredients
 Intertheater Transportation
 Intratheater Transportation
 Bakery Units

Wartime Logistical Impacts

Intertheater (20 foot containers/day)
 Intratheater (34 Ton and 5 Ton truckdays)
 In-theater Storage (20 foot containers)

Wartime - Manpower Impacts

Bakery Units
 Transportation Units

Peacetime Costs

Pre-position War Reserve Material Stocks (PWRMS)
 - inventory cost
 - warehousing/handling cost
 - rotation costs
 Bakery Units
 Transportation Units

Troop Acceptance

TABLE 2. Troop Populations and Bread Product Requirements (Lb/Day)

Data Element	Theater			FY88 Force
	Europe	SW Asia	Total	
No. Troops	888,100	230,200	1,118,300	1,185,300
Bread Req't	266,500	59,100	335,600	355,600

FINDINGS

The detailed evaluations of each bread product alternative, including a description of the methodology and all assumptions relative to wartime and peacetime cost impacts, inter- and intratheater logistical impacts, mobile field bakery requirements and sizes, and troop acceptance are presented in Appendices A through D. The results and findings of these evaluations follow. The impacts associated with each bread product alternative are based on the product satisfying 100% of the Army's field bread product requirement. Based on these impacts, coupled with battlefield considerations, a mix of products is recommended to satisfy the Army's field bread product requirement.

WARTIME/PEACETIME COST IMPACTS

The wartime/peacetime cost impacts of the various bread product alternatives are summarized in Table 3. Wartime costs include product or ingredient costs; intertheater transportation costs; and required bakery and transportation unit costs, to include direct and general support maintenance impacts. Peacetime costs include the inventory, warehousing/handling, and rotation costs associated with required preposition war reserve material stocks; and the costs associated with required bakery and transportation units maintained in the peacetime active, National Guard, and reserve components of the Army.

TABLE 3. Annual Cost Summary By Alternative (\$1,000)

Alternative	Theater			FY88 Peace-time Force
	Europe	SW Asia	Total	
Fresh Bread				
Mobile Bakery ¹	\$70,607	\$20,464	\$91,071	\$33,697
Mobile Bakery ²	59,670	18,120	77,790	27,355
Host Nation Support(HNS)	59,855	17,378 ³	77,233	7,580
Shelf-Stable Products				
Canned Bread	192,109	56,474	248,593	30,354
	-258,254	-73,635	-331,889	-84,710
Crackers	161,240	54,308	215,548	29,366
British Type Biscuits	90,495	26,273	116,768	8,569
Shelf Stable Mixes				
Assorted	50,298	15,183	65,481	11,137

¹ Based on current M45 authorization: 1 Bakery/16,000 Troops, and 1 Bakery Team/Bakery.

² Based on proposed M45 authorization: 2 Bakeries/65,000 Troops, 1.5 Bakery Teams/Bakery.

³ No HNS available in SW Asia. Cost projected based on Europe HNS and Europe and SW Asia mobile bakery cost impacts.

The following information is provided relative to the cost impacts summarized in Table 3.

- ° Two cost impacts are provided relative to fresh bread from M-45 mobile field bakeries. The first cost impact is based on the current allocation of one M-45 mobile field bakery and one bakery team per direct support company (16,000 troops). The second cost impact is based on a proposed allocation of two M-45 mobile bakeries/three bakery teams per General Support Company (65,000 troops). The basis for the proposed allocation is presented in the following section of this report: "Mobile Field Bakery Requirements".

- ° There are signed agreements for host nation support (HNS) to provide fresh bread in the European theater. As of the date of this analysis, the price for the HNS-provided fresh bread had not been negotiated. The cost of HNS bread is projected based on the price of fresh bread charged by the Army Air Force Exchange System (AAFES) bakery in Gruenstadt, West Germany, to Army military dining facilities in West Germany. The ingredients for HNS fresh bread are supplied from the CONUS. Intra- and inter-theater transportation costs are projected and included in the total HNS cost impact as appropriate.

- ° No HNS bread agreements exist for the SW Asia theater (and none are expected). To facilitate direct comparison of total cost impacts of each alternative only, cost impacts for SW Asia HNS fresh bread are projected. This projection is based on the European HNS fresh bread and the European and SW Asia mobile bakery fresh bread cost impacts.

- ° A range of cost impacts is provided for the canned bread alternative. Canned bread represents a research and development item for which there has been no large-scale military procurement. The range in cost impacts is based on a projected cost of \$2.05 to \$2.90 per 20-ounce can with large-scale military procurements and a shelf life of one to three years.

- ° The wartime/peacetime cost impacts of the three shelf-stable mixes are similar. Therefore, only the average cost impact of the three products is presented.

Based on the wartime and peacetime cost impacts, the following conclusions regarding costs and preferences are noted.

- ° Relative to the fresh bread alternatives, based on peacetime cost impacts, HNS fresh bread is clearly the preferred alternative. The significantly reduced peacetime cost impact associated with this fresh bread alternative is due to the fact that bakery units would not need be maintained in the peacetime Army force structure. Relative to fresh bread from M-45 mobile bakeries, costs associated with the proposed allocation are lower than those associated with the current allocation solely due to the fewer number of required bakery teams.

° The shelf-stable products, based on wartime cost impacts, are all more expensive than the fresh bread alternatives. Relative to the three shelf-stable products, the wartime cost impact of British-type biscuits is significantly lower than the cost impact of the canned bread or cracker alternatives. In addition, the peacetime cost impact of the canned bread alternative is more expensive, and possibly significantly more expensive, (a range of costs is given since the item is under development) than the associated peacetime cost impact of fresh bread from mobile bakeries (based on the proposed bakery allocation). The high peacetime canned bread cost impact is due to the high product cost, short shelf life, and resulting high rotation cost associated with the pre-position war reserve material stocks (PWRMS). On the other hand, the low peacetime cost impact associated with the British-type biscuit alternative is due to the product's long shelf life (10 years) and resulting low rotation costs.

° Based on wartime cost impacts, the shelf-stable mixes are the least expensive bread product alternative. In addition, with the exception of HNS fresh bread and British-type biscuits, these bread product alternatives have the lowest peacetime cost impact.

The wartime cost impact per 1,000 pounds of product is presented in Table 4 by cost element. As shown, the estimated cost per 1,000 lb of product ranges from \$517 for assorted mixes to \$1,975 to \$2,655 for canned bread.

TABLE 4. Relative Wartime Cost Per 1,000 Pounds of Product

Element	Alternative						
	Mobile Bakery ¹	Mobile Bakery ²	HNS	Can Bread	Crackers	British Type Biscuits	Ass't Mixes
Ingred/Product	\$170	\$170	\$490	\$1,640 -2,320	\$1,030	\$790	\$410
Transportation-To	54	54	54	231	434	97	74
Transportation-In	52	52	72	104	194	43	33
Bakery Personnel	446	329	-	-	-	-	-
Total	\$722	\$605	\$616	\$1,975 -2,655	\$1,658	\$930	\$517

¹ Current authorization, 1 bakery per 16,000 troops, 1 shift per bakery.

² Proposed authorization, 2 bakeries per 65,000 troops, average 1.5 shifts per bakery.

M-45 FIELD BAKERY REQUIREMENTS

M-45 field bakeries are currently assigned on the basis of one per direct support company. Each bakery is staffed for a single 12-hour shift operation and has a rated output of 8,000 pounds per 12-hour shift. In turn, direct support companies are all located on the basis of one per 16,000 troops. The bread product requirement per troop is a function of the proportion of bulk and individual rations consumed. As shown in Table 5, one M-45 mobile field bakery could support 32,000 division troops or 17,800 Echelon Above Corps (EAC) troops based on a single 12-hour shift operation. With a two-shift operation, each bakery could support twice as many troops. Based on the theater average of 60% bulk rations, each bakery can support 26,700 or 53,400 troops based on a single and two-shift operation respectively.

TABLE 5. Field Bakery Support Capacity (No. Troops)¹

Theater Region	% Bulk	Support Capacity (No. Troops)	
		1 Shift	2 Shift
Division	50%	32,000	64,000
Corps	67%	24,000	48,000
Echelon Above Corps	90%	17,800	35,600
Theater Average	60%	26,700	53,400

$$^1\text{No. Troops} = \frac{8,000 \text{ Lbs/12 Hr Shift} \times \text{Shifts/Day}}{0.5 \text{ Lbs/Bulk Ration} \times \text{Fraction Bulk Rations}}$$

The Army, based on the TRADOC Operational and Organization Plan (O&O Plan) titled, "Provision of Bread to Army Forces in the Field," dated April 1982, plans to reassign mobile field bakery plants to the General Support Company (GSC). This plan calls for three 11,000 pound (1,100 pounds per hour) bakery plants per General Support Company. This allocation would result in approximately the same excess capacity as that provided by one M-45 size mobile bakery plant per direct support company.

For M-45 size bakery plants, Table 6 summarizes the number of bakery plants required based on the current allocation of one per direct support company and a proposed allocation of two per General Support Company. The number of bakery teams assigned per GSC would range from two to four and depend on the ration mix and resulting bread demand of the troops supported. On average each GSC would be assigned three bakery teams, that is, one bakery would be staffed and operated on a two-shift, 24-hour per day basis, and the other bakery on a single shift 12-hour per day basis.

TABLE 6. M-45 Size Field Bakery Plant Requirements Based On Current and Proposed Allocation Criteria

Allocation Criteria	Current			Proposed		
Bakery Plant Allocation	1/Direct Support Company			2/General Support Company		
Unit Allocation	1/16,000 Troops			1/65,000 Troops		
Bakery Team Allocation	1/Bakery Plant			Average 1.5/Bakery Plant		
Force	Europe	SW Asia	Peacetime	Europe	SW Asia	Peacetime
Troop Strength	888,100	230,200	1,185,300	888,100	230,200	1,185,300
Daily Bread Reqt(Lbs)	266,500	69,100	355,600	266,500	69,100	355,600
No. Bakery Plants	56	15	74	28	8	38
No. Bakery Teams	56	15	74	42	12	57
Equipment Capacity(Lbs)	896,000	240,000	1,184,000	448,000	128,000	608,000
% Total Requirement	336%	347%	333%	168%	185%	171%
Staffing Capacity	448,000	120,000	592,000	336,000	96,000	456,000
% Total Requirement	168%	174%	166%	126%	139%	128%

Based on the information in Table 6, the following points are noted:

- ° The proposed allocation results in a requirement for 38 M-45 size bakeries compared to 74 based on the current allocation.
- ° The proposed allocation provides 171% of the required equipment capacity, and 128% of the required staffing to satisfy 100% of the Army's field bread product requirement.

INTERTHEATER TRANSPORTATION AND WITHIN-THEATER STORAGE IMPACTS

The intertheater transportation and within theater storage impacts of the various bread product alternatives are listed in Table 7 in terms of 20 foot ISO container loads. Theater storage impacts are based on a 40-day theater supply objective.

TABLE 7. Intertheater Transportation and In-Theater Storage Impacts of Alternatives

Alternative	Intertheater Transport. (20' ISO Containers/Day)			In-Theater Storage (20' ISO Containers)			Rel. Impact
	Europe	SW Asia	Total	Europe	SW Asia	Total	
Fresh Bread Ingr.	7.59	1.97	9.56	304	79	383	1.00
Canned Bread	32.66	8.47	41.13	1,307	339	1,646	4.30
Crackers	61.21	15.87	77.08	2,448	635	3,083	8.05
British-Type Bisc.	13.72	3.56	17.28	549	142	691	1.80
Biscuit Mix	11.33	2.94	14.27	454	118	572	1.49
Cornbread Mix	10.12	2.62	12.74	405	105	510	1.33
Sw/Quick Bread Mix	10.01	2.60	12.61	400	104	504	1.32
Assorted Mixes	10.49	2.72	13.21	420	109	529	1.38

Based on the impacts presented in Table 7, the following points regarding intertheater transportation and within-theater storage are noted:

- ° The smallest intertheater transportation and in-theater storage burden is associated with fresh bread ingredients, as generated by any of the fresh bread alternatives.
- ° The largest impacts are associated with the shelf-stable products. The impact associated with British-type biscuits is significantly less than that of the other shelf-stable products. Relative to fresh bread ingredients, the transportation burden for crackers, canned bread, and British-type biscuits are 8.05, 4.30, and 1.80 times as large, respectively.
- ° The impacts associated with the shelf-stable mixes are considerably less than those of the shelf-stable products and are somewhat larger than those generated by fresh bread ingredients.

INTRATHEATER TRANSPORTATION IMPACTS

The intratheater transportation impacts of the various bread product alternatives for the European theater are presented in Table 8. Impacts for the SW Asia theater are included in Appendix A. However, the relative impact of the various alternatives is about the same for each theater.

TABLE 8. European Theater Intratheater Transportation Impact of Alternatives

Alternative	Truck Days (34T & 5T)				Tr. Days (Equiv. 34T)	
	34T	5T	Tot l	Rel Impact	34T	Rel Impact
Ingred/Bread (Mob. Bkry)	7.37	28.89	36.26	1.83	13.56	1.16
Ingred/Bread (HNS)	6.21	45.14	51.35	2.59	15.88	1.36
Canned Bread	32.05	32.58	64.63	3.26	38.17	3.26
Crackers	60.00	61.04	121.04	6.11	71.46	6.11
British Type Biscuits	13.40	13.68	27.08	1.37	15.97	1.36
Biscuit Mix	11.14	11.29	22.43	1.13	13.26	1.13
Cornbread Mix	9.92	10.09	20.01	1.01	11.81	1.01
Sweet/Quick Bread Mix	9.82	9.99	19.81	1.00	11.70	1.00

The following information is provided relative to the transportation impacts summarized in Table 8.

- ° All impacts are expressed in terms of truck-days. An impact of 10 truck-days translates into a dedicated requirement of 10 trucks daily for the movement of bread product.

- ° All impacts are calculated based on the Army's Class 1 resupply system objectives, average distances associated with the European theater, and appropriate transportation impact planning factors.

- ° The 34-ton truck (with two 20 foot ISO's) is assumed to be utilized over all transportation links, except between General Support Companies (GSC) and subordinate Direct Support Companies (DSC), for which 5-ton trucks are assumed to be utilized.

- ° Relative to the fresh bread alternatives, the intratheater transportation burden represents bread ingredients being transported from the port to the bread production point (GSC located mobile bakery or HNS bakery) via 34-ton truck, and fresh bread being transported from this point to the direct support companies by 5-ton trucks.

- ° Based on the TRADOC Operational and Organization (O&O) plan titled, "Provision of Bread to Army Forces in the Field," dated April 1982, mobile field bakery plants are assigned to the General Support Company.

Based on the intratheater transportation impacts presented in Table 8, the following points are noted:

- ° Shelf-stable mixes generate the smallest intratheater transportation impact.

- ° Fresh bread alternatives generate a larger intratheater transportation burden than the shelf-stable mixes. The larger

impact is due to the need to route all ingredients to a bread production point and to then transport a volume-intense fresh bread product forward to the direct support companies. As shown by Table 9, relative to the fresh bread ingredients, fresh bread generates 348% and 280% as many 34-ton and 5-ton truckloads, respectively.

TABLE 9. Relative Transportation Impact of Bread Ingredients and Fresh Bread Per 50,000 Pounds of End Product

Type Vehicle	Type Load	Ingredients	Fresh Bread	Impact
34T	Loads-Wt	0.712	1.125	--
	Loads-Ft ³	0.517	2.480	--
	Truck Loads	0.712	2.480	348%
5T	Loads-Wt	4.140	6.545	--
	Loads-Ft ³	2.753	11.574	--
	Truck Loads	4.140	11.574	280%

° HNS fresh bread generates a larger impact or burden than fresh bread from mobile bakeries because the estimated average distance between the bread production point and the supported direct support companies is longer. That is, with HNS the high volume final bread product is moved over a longer distance.

° The cracker and canned bread alternatives generate the largest impacts. In terms of total truck-days, British-type biscuits generates a smaller intratheater transportation impact than the fresh bread alternatives.

GENERAL VERSUS DIRECT SUPPORT LOCATED BAKERIES

As previously noted, the reassignment of mobile bakery plants from direct support to general support units has the major advantage that the number of M-45 size bakeries required is reduced from 74 to 38. However, there is at least one significant disadvantage. As summarized in Table 10 (based on the European theater) the total transportation impact generated by a bakery located with a general support company is 231% of that generated by a bakery located with a direct support unit.

TABLE 10. Relative Transportation Impact of General and Direct Located Bakeries (Division and Corps Troops)

Bakery Location	Truck Days (50,000 Lbs)			Relative Impact (%)
	34T	5T	Total	
Direct Support Company	1.54	1.74	3.28	100%
General Support Company	1.51	6.08	7.59	231%

The large increase is due to the need to first route all fresh bread ingredients to the general support company and to then transport a high volume fresh bread product from this location to the direct support units. In addition, the requirement to transport a highly perishable product over an additional transportation link results in a reduced product quality (and thus reduced troop acceptance) due to both increased product handling and increased product age at the time of consumption. The uncertainty associated with this final transportation link, at least for division troops, will result in both increased product loss and a reduced frequency at which fresh bread is available for issue.

DIRECT SUPPORT UNIT SIZE BAKERY

The required output capacity (lb/hour) of a direct support unit size bakery is a function of the proportion of bulk rations, of the percentage of the total bread requirement which is satisfied by fresh bread, and whether the bakery operates on a one or two shifts per day basis. Table 11 presents the required output capacity for various situations based on a single shift operation.

TABLE 11. Required Output Capacity of Direct Support Unit Size Bakery

Ration Mix (% Bulk)	Total Req't ¹ (Lbs)	Required Capacity (Lbs/Hr) ²			
		% Fresh Bread			
		100%	75%	67%	50%
100	8,000	800	600	533	400
90	7,200	720	540	480	360
67	5,333	533	400	356	267
60	4,800	480	360	320	240
50	4,000	400	300	267	200

¹ Direct Support Unit per 16,000 Troops.

² Based on 1 shift operation with 10 hours equipment output production.

As shown in Table 11, for the 100% bulk ration/100% fresh bread situation, the required output capacity is 800 pounds per hour. However, if a double shift operation were utilized, the required output capacity would drop to 400 pounds per hour. Assuming 100% of the bread product requirement is satisfied by fresh bread, then 400 pounds per hour represents the maximum required capacity of a direct support unit bakery. To support EAC troops (90% bulk) the bakery could be operated on a two shifts per day basis while to support division troops (50% bulk) the bakery would only need to be operated on a one shift per day basis.

If fresh bread satisfies less than 100% of the bread product requirement (the recommended alternative includes 33% shelf-stable mixes), then the required output capacity is lower yet. As shown by Table 11, if fresh bread satisfies only 67% of the total bread product requirement, then a bakery with less than 400 pounds per hour capacity can satisfy the fresh bread requirements of division or corps troops with a single shift operation only. Information about a smaller, highly mobile semi-trailer bakery which is made by Werner & Pfleiderer and which could satisfy this requirement is provided in Appendix D, along with a discussion of other field bakery alternatives.

TROOP ACCEPTANCE OF BREAD PRODUCT ALTERNATIVES

A consumer evaluation of various bread product alternatives was conducted with U.S. Army personnel stationed at Ft. Devens. Troop acceptance ratings of various bread product alternatives are presented in Table 12. The details of the entire evaluation are included in Appendix C. The following information is provided relative to the information presented in Table 12.

- ° All preference ratings are based on the nine point hedonic scale with nine representing LIKE EXTREMELY, five representing NEITHER LIKE NOR DISLIKE, and one representing DISLIKE EXTREMELY.
- ° The evaluation was conducted in a garrison environment. Personnel with no prior field experience were excluded.
- ° The canned bread utilized was eleven months old and had been stored at 70°F while the British biscuits were five years old. The Breakfast Bake is a Natick R&D Center developmental Tray Pack item which is composed mainly of flour and eggs.
- ° Evaluation of the 14 products were based on a single serving.

TABLE 12. Troop Acceptance Ratings

Alternative	Mean Rating	Std. Deviation
Fresh Bread Alternatives		
Raisin Bread	8.1	1.0
White Bread	6.9	1.2
Sprouted Wheat Bread	5.7	2.2
Pumpernickel Bread	4.9	2.6
Shelf-Stable Products		
Granola Bars	8.0	1.4
Breakfast Bake	6.8	1.5
MRE Crackers	6.6	1.7
British Biscuits	5.9	2.0
Rice Cakes	5.8	2.1
Canned Bread	4.8	2.3
Shelf-Stable Mixes		
Banana Bread	8.0	1.6
Corn Bread	7.8	1.1
Sweet Bread	7.4	1.0
B Ration Mix	5.3	2.4

Based on the troop preference ratings, the following points are noted.

- ° With respect to fresh breads, raisin bread (a sweet product) rated an 8.1 while white bread rated 6.9. Specialty whole grain breads rated considerably lower.
- ° With respect to shelf-stable product alternatives, crackers, British-type biscuits, and canned bread rated 6.6, 5.9, and 4.8 respectively. Canned bread (at 11 months old) therefore was generally neither liked nor disliked.
- ° Relative to the shelf-stable mixes, the sweet items were judged highly acceptable. The high ratings for these types of items indicate that they are more acceptable than shelf-stable products such as crackers, British-type biscuits, and canned bread.

CONCLUSIONS and RECOMMENDATIONS

Based on the systems analysis of the Army's field bread requirement, the constraints and conditions imposed by future battlefields, and the peacetime/wartime cost impacts, logistical impacts, and troop acceptance associated with various bread product alternatives, the following conclusions and recommendations are made.

1. The field bread product requirement should be satisfied with a mix of products approximately as follows: 50% fresh bread, 33% shelf-stable mixes, and 17% British-type biscuit. Use of a British-type biscuit product is recommended for 17% of the total requirement based upon the fact that bakery plants relocate once every six days (17% of the time). Each move results in a one day loss of production. Relative to the other shelf-stable products, British-type biscuits were selected because of the reduced cost and logistical impacts. The percent of British-type biscuits included in the mix should be minimized to those situations where fresh bread is not available and the unit cannot produce a shelf-stable mix type of product. From a consumer acceptance viewpoint, the fresh bread and shelf-stable mixes are clearly more preferred than the British biscuit and should thus be used more often. The percent of shelf-stable mixes was set at 33%, which reflects use of these products at one meal per day (maximum) so as to minimize the labor impact at the tactical field kitchen level. Fresh bread, at 50%, makes up the remainder of the recommended mix. The mix of products provides the flexibility to satisfy the Army's field bread product requirement with the lowest cost, least logistically demanding, and highest preference product possible, given battlefield constraints and conditions.

2. Based on peacetime cost impacts, Host Nation Support sources should be depended upon to the maximum extent possible to satisfy the field fresh bread requirement.

3. To increase the quality and frequency of field fresh bread, especially for division troops, a smaller (360 to 400 lb/hour) highly mobile bakery should be developed and assigned to operate at the Direct Support Company level.

4. If mobile bakeries are assigned to and operated at the General Support Company level (as stated in the "Operational and Organization Plan - Provision of Bread to Army Forces in the Field", dated April 1982), then two M-45 size bakeries per GSC are more than sufficient.

Based on the recommended mix, Table 13 presents the daily product requirement and M-45 bakery requirement by theater and for the programmed FY88 force structure. If the recommended mix is adopted and if HNS fresh bread is depended on to the maximum extent possible (based on USA QMS planning factors), then the programmed FY88 force structure generates an estimated total requirement of only 12 M-45 size bakery plants.

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TABLE 13. Annual Cost Impact and M-45 Size Mobile Bakery Requirement for Recommended Mix

Population (Troop Strength)	Theater			Peacetime Force (1,185,300)
	Europe (888,100)	SW Asia (230,200)	Total (1,118,300)	
Recommended Mix-Lbs(%)				
Fresh Bread-HNS	101,100 (38%)	- (0%)	101,100 (30%)	101,100 (28%)
Fresh Bread- Mobile Bakeries	32,200 (12%)	34,600 (50%)	66,800 (20%)	76,800 (22%)
Shelf Stable Mixes	88,800 (33%)	23,000 (33%)	111,800 (33%)	118,500 (33%)
British Type Biscuits	44,400 (17%)	11,500 (17%)	55,900 (17%)	59,200 (17%)
Total Bread Requirement	266,500 (100%)	69,100 (100%)	335,600 (100%)	335,600 (100%)
No. Mobile Bakeries	5	6	11	12
No. Bakery Teams	5	6	11	12
Annual Cost (\$1,000)	\$61,888	\$118,537	\$180,425	\$11,361

Table 14 summarizes the annual peacetime and wartime cost impact of the current and proposed field bread product system. As shown, the proposed mix (50% fresh bread, 33% mixes, and 17% British-type biscuits) can result in a system which provides a projected 10.6 and a 22.3 million dollar savings in wartime and peacetime environments, respectively.

TABLE 14. Annual Cost Savings of Recommended Mix

System	Wartime			Peacetime Force
	Europe	SW Asia	Total	
Current	\$70,607	\$20,464	\$91,071	\$33,697
Proposed	61,888	18,537	80,425	11,361
Savings	\$ 8,719	\$ 1,927	\$10,646	\$22,336

This document reports research undertaken at the US Army Natick Research and Development Command and has been assigned No. NATICK/TR-857012 in the series of reports approved for publication.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAFFS	Army Air Force Exchange System
AHS	Academy of Health Sciences
CONUS	Continental United States
DS	Direct Support
DSC	Direct Support Company
EAC	Echelons Above Corp
GS	General Support
GSC	General Support Company
HNS	Host Nation Support
ISO	International Organization for Standardization
NRDC	Natick Research and Development Center
O&O Plan	Operational and Organizational Plan
OTSG	Office of the Surgeon General
PWRMS	Pre-position War Reserve Material Stock
QMS	Quartermaster School
SWA	Southwest Asia
TOE	Table of Organization and Equipment
TRADOC	U.S. Army Training and Doctrine Command
TRASANA	U.S. Army TRADOC Systems Analysis Activity



APPENDICES

- APPENDIX A Wartime Cost, Manpower, and Logistical Impacts
 of Alternatives
- APPENDIX B Peacetime Cost Impact of Alternatives
- APPENDIX C Troop Acceptance of Bread Product Alternatives
- APPENDIX D Alternative Bakery Systems



Appendix A

Wartime Cost, Manpower, and Logistical Impacts of Alternatives

This appendix documents the systems analysis of bread product alternatives relative to wartime cost, manpower, and logistical impacts.

The alternatives are grouped into three major categories. The fresh bread category includes both product produced by field mobile bakeries, or product provided by the host nation based on signed support agreements. Host nation support fresh bread is a viable alternative in some theaters, for example, Europe; but not in others such as Southwest Asia (SWA). Alternatives which are both shelf-stable and consumed as is (canned bread, crackers, British-type biscuits) are grouped into the shelf-stable product category. The shelf-stable mix category includes those items which are shelf-stable and require only sufficient hand mixing with water so as to wet the product prior to panning and baking in a field-type oven. Alternatives in this category include cornbread mix, biscuit mix, sweet/quick bread mix, and an assortment of mixes.

In this appendix, each alternative is evaluated relative to the following factors:

Cost Impacts:	Product/Ingredients Intertheater Transportation Intratheater Transportation Field Bakery Units
Manpower Impacts:	Bakery Units Transportation Units
Logistical Impacts:	Intertheater (20' ISO containers/day) Intratheater (34 ton and 5 ton truck/days) In-theater Storage (20' ISO containers)

Each alternative is evaluated relative to satisfying 100% of each theater's total bread requirement. By conducting and presenting the analysis in this manner, the cost, manpower, and logistical impacts of any mix of alternatives can be readily established by simply weighting the cost of each alternative by the proportion of the total requirement to be met by that alternative.

BASIS OF THE ANALYSIS

The wartime cost, manpower, and logistical impact of each bread product alternative was established upon the basis of a simultaneous two-theater conflict: Europe and Southwest Asia. Bread product requirements (pounds per day) per theater were estimated based upon

the mature theater population strengths, the Army class 1 theater planning factor of 60% bulk rations (A, B, or T) and 40% individual rations, and the OTSG established bread product requirement of 0.5 pounds per bulk-type ration. Based on the theater class 1 planning factor, the percentage of bulk rations by region was estimated at 50%, 67%, and 90% for Division, Corps, and Echelon Above Corps (EAC) troops, respectively.

The wartime cost, manpower, and logistical impacts of each alternative were established based upon the resulting bread product requirements (pounds/day) developed in Table A1 by theater and region. As shown, the European theater bread product requirement is estimated at 266,500 pounds, to include 115,000, 119,000, and 32,500 pounds for division, corps, and EAC troops, respectively; while the SWA theater requirement is 69,100 pounds, to include 26,200, 39,600, and 3,300 pounds for division, corps, and EAC troops, respectively.

PRODUCT/INGREDIENT COSTS

The cost, gross and net weight, and cube per 50,000 pounds of product is presented in Table A2. The net weight of the canned bread, crackers, and British-type biscuit products is 50,000 pounds, since they are shelf-stable products served as is. On the other hand, the net weight of the bread ingredients and mixes are less than 50,000 pounds since these items require the addition of water prior to yielding the final product as served. For these items, the net weight of ingredients required per 50,000 pounds of product weight as served is developed in Table A3.

Based on the information summarized in Table A2, the annual product cost per alternative by theater is developed in Table A4. The product costs for canned bread are based on price estimates of \$2.05 to \$2.90 per 20-ounce can, given large-scale military procurements. Current costs are considerably higher since canned bread is still a developmental item and purchases have been under small-scale contracts.

INTRATHEATER TRANSPORTATION IMPACT

The intratheater transportation impact of alternatives is a function of several factors to include: product requirements by region and theater; type of vehicle utilized, product gross weight and volume parameters and the class 1 supply system.

The intratheater transportation impact of alternatives is established in terms of truck-days by type of vehicle, where a truck-day, per FM 55-15¹, is defined as 20 operational hours per day.

¹See Bibliography to body of Report.

Initially, the transportation impact per alternative is calculated on the basis of 50,000 pounds of product per theater region. The resulting impact is then scaled by the region's bread requirement and summed across regions to yield the total theater impact by alternative.

TRUCK LOADS PER 50,000 POUNDS

The intratheater transportation impact is established based on the assumed use of the 34-ton (with 2-20' ISO's) and 5-ton vehicles to move each product through the theater class 1 supply system. For each type vehicle, the maximum gross product weight and cube per load is developed in Table A5. The 20' ISO containers are through shipped from CONUS to their destination within the theater of operations. The intratheater maximum gross product weight per 20' ISO container represents the binding weight constraint since it is lower than the intertheater weight constraint.

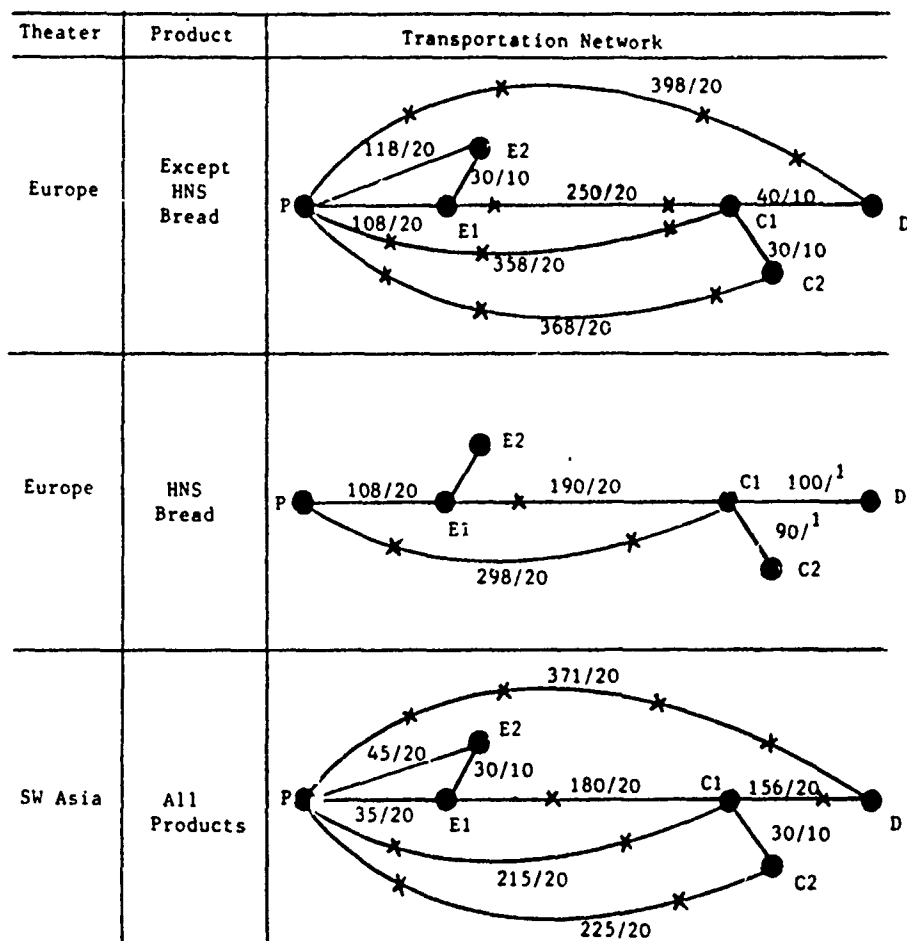
As shown in Table A5, the 34-ton vehicle can transport a maximum gross product load of 55,660 pounds or 1,534 cubic feet, while the 5-ton vehicle's maximum gross product load is 9,550 pounds or 288 cubic feet.

The number of truck loads per 50,000 pounds of product is developed in Table A6 by alternative and type of truck. The gross weight and volume per 50,000 pounds of each alternative is taken from Table A2. The number of truck loads generated is the larger of two figures based upon the products' weight and cube parameters and the vehicles' gross product weight and cube constraints. For example, relative to the 34-ton vehicle, bread ingredients generate 0.712 truck loads based on product gross weight ($39,541/55,560$); and 0.517 truck loads based on product cube ($793/1534$). Therefore, fresh bread ingredients for 50,000 pounds of bread generate 0.712 34-ton vehicle truck loads.

Referring to Table A6, bread ingredients are the only alternative for which truck loads are established based on weight: that is, the vehicle weight constraint is reached before the vehicle is full. For all other alternatives, truck loads are established based on volume; that is, the vehicle is full before its weight constraint is reached.

TRUCK-DAYS PER LOAD

To calculate the truck-days per 50,000 pounds of product per theater region, the class 1 supply system must be defined and the truck-days per load calculated for each transportation link over which bread product alternatives may flow. The class 1 supply system and resulting transportation networks for Europe and SWA are depicted in Figure A1.



¹ First 60 miles at 20 mph, remainder at 10 mph.

	Node	Definition
	P	Port
	E1	EAC, General Support Company
	E2	EAC, Direct Support Company
The labeled nodes represent supply points and are defined as follow..	C1	Corps, General Support Company (except HNS fresh bread)
	C2	Corps, Direct Support Company
	D	Division, Direct Support Company

Between node numbers represent average highway miles between nodes/
average vehicle speed(mph).

Figure A1. European and SW Asia transportation networks

On Figure A1, the lines connecting nodes represent transportation links over which product may flow. The first number on each link represents the estimated average highway mileage between the two connected nodes and the second number represents the estimated average vehicle speed over the transportation (mph) link. Mileages were established based upon a review of the port locations and the Division and Corps rear boundry lines for the European and SWA theaters, and the typical or average placement of GS and DS supply units within the EAC, Corps, and Division (DS only) areas. In addition, vehicles normally travel a maximum of about 90 miles from their unit locations. For line haul operations, transfer points, denoted by X on Fig. A1, are located about every 90 miles. At these points, an incoming driver with a loaded 34-ton trailer would unhook and rehook to an empty 34-ton trailer and return to his unit. If necessary, the loaded 34-ton trailer would then be hauled up to 90 miles further forward by a driver from another unit.

Host nation support fresh bread is available in the European theater but not in the SWA theater. For HNS bread only, C1 corresponds to the source of the HNS bread rather than the typical placement of a Corps, General Support Company location. Based on the HNS agreements for fresh bread by military district, the C1 location for HNS fresh bread average about 60 miles further back than the C1 location for other products.

The truck-days per load by link is a function of the distance, vehicle speed, number of transfers, and the load/unload time per link. To calculate truck days, the following planning factors are provided per FM 55-15:

Time Element	Hours
Load-Unload Time per Link	2.5
Time Per Transfer	1.0
Time Per Truck-Day	20.0

Table A7 summarizes the truck-days per load by link for each theater based on the distances and average vehicle speeds provided in Figure A1 and the above planning factors. In the European theater, for example, transporting one truck load of a non-HNS bread product from the port (P) to a typical Corps, General Support Company location (C1) generates 2.065 truck-days. This truck-day impact is calculated as follows:

Distance - One Way	358 miles
Distance - Round Trip	716 miles
Average Vehicle Speed	20 mph
Vehicle Travel Time	35.8 hours
Transfer Time (3 Transfers)	3.0 hours
Load/Unload Time	2.5 hours
Total Time	<u>41.3 hours</u>
Hours per Truck-Day	20.0
Truck-Days	<u>2.065</u>

Truck-days for all other transportation links are calculated in a similar manner.

TRUCK-DAYS PER 50,000 POUNDS OF PRODUCT BY THEATER REGION

The truck-days generated per 50,000 pounds of product by theater region is a function of the truck loads per 50,000 pounds of product by type vehicle (Table A6), truck-days per truck load by transportation link (Table A7), type of vehicle utilized by transportation link, and product routing through the theater supply system to each theater region (Table A8).

Product routings for the fresh bread and nonfresh bread product alternatives are different as shown in Table A8. For example, 20% of any nonfresh bread product requirement for divisional troops would be routed directly from the port area to the division direct support unit. However, with the fresh bread alternatives, all ingredients are routed through a Corps-located General Support Company (C1) or a HNS bakery (C1) where they are transformed from ingredients into fresh bread, prior to being forwarded to the division direct support unit. Product routings for the nonfresh bread alternatives are based on the class 1 supply system objectives.

For establishing vehicle impacts, the 34-ton vehicle is assumed for all transportation links except between general support and subordinate direct support units where 5-ton vehicles are assumed. Based on Tables A6, A7, and A8, the transportation impact (truck-days) per 50,000 pounds of product by theater region was generated and is presented in Tables A9, A10, and A11 by theater and bread product alternative. For example (referring to Table A9) a requirement for 50,000 pounds of canned bread for divisional troops in a European scenario would generate a transportation impact of 6.62 34-ton vehicle truck-days and 6.85 5-ton vehicle truck-days. This requirement is established as follows:

Type Truck	Truck Route	Tr. Loads/ 50,000 Lbs.	% Prod.	Tr. Loads/ Route	Tr. Days/ Load	Truck Days
34T	P-D	3.064	20	0.613	2.315	1.42
	P-C1	3.064	20	0.613	2.065	1.27
	P-E1-C1	3.064	60	1.838	2.140	3.93
	Total	-	-	-	-	6.62
5T	C1-D	16.319	80	13.055	0.525	6.85

The transportation impact for all other bread product alternatives by theater region was established in a similar manner. For the fresh bread alternatives, the transportation impact was calculated on the basis of bread ingredients being transported to the bread production locations (E1 and C1) and fresh bread being transported from these locations to EAC, Corps, and Division direct support locations (E2, C2, and D).

TRUCK-DAYS PER THEATER REGION

For the European and SWA theaters, Tables A12 and A13 summarize the transportation impact per 50,000 pounds of bread product alternative by theater region and type vehicle. This impact is scaled up or down based on the region's total bread product requirement to establish the total transportation impact by region. The resulting impacts per region are summed to yield the total theater transportation impact per alternative.

Referring to Table A12 for the European theater, the transportation impacts range from about 10 34-ton and 10 5-ton vehicle truck-days for the shelf-stable mixes to about 60 34-ton and 60 5-ton vehicle truck-days for shelf-stable crackers. Relative to the mixes, fresh bread ingredients and product generate a smaller 34-ton vehicle requirement, but a much larger 5-ton vehicle requirement to transport the fresh bread from the production location (General Support Company or HNS bakery) to the issuing direct support units.

INTRATHEATER TRANSPORTATION COST AND MANPOWER IMPACT

The intratheater transportation cost and manpower impact per bread product alternative are established based on an estimated cost and manpower impact per 34-ton and 5-ton vehicle truck-day. These impacts are projected based upon the Medium Truck Company (55-018H610) and Light Truck Company (55-017H520), respectively.

Referring to Table A14, the total annual cost and manpower impacts per required Medium Truck Company and Light Truck Company are \$8,257,000 and 202 people and \$5,825,000 and 184 people, respectively. The total annual fuel cost per truck company is developed in Table A15 and is based upon the European scenario. Maintenance unit impact per truck company, to include people and dollars, represents the direct support and general support maintenance workload generated by the transportation unit. The external maintenance workload generated by each truck company is summarized in Table A16. This workload was converted into the maintenance unit impact, people and dollars, as reported in Table A17.

Per unit TOE, the Medium Truck Company has 60 authorized 34-ton vehicles while the Light Truck Company has 60 authorized 5-ton vehicles. However, based on transportation unit planning factors, only 75% or 45 vehicles per unit are available for use on any given day. Thus a requirement of 45 truck-days (and not 60) generates a requirement for 1 truck company with 60 authorized vehicles. Based on 45 available vehicles per unit, the resulting manpower and total annual cost impact is: 4.49 people and \$183,000 per required 34-ton vehicle truck-day, and 4.09 people and \$129,000 per required 5-ton vehicle truck-day.

The total intratheater transportation annual cost and manpower impact are developed in Table A18 by theater and bread product alternatives. These total impacts are based on the vehicle requirements developed in Tables A12 and A13, and the cost and manpower impacts per required truck-day developed in Table A14.

INTERTHEATER TRANSPORTATION IMPACTS AND COSTS

The intertheater transportation impact and associated annual cost per alternative are presented in Table A19 by theater. Intertheater transportation impacts are established in terms of 20' ISO container loads per day with the containers being CONUS source loaded with throughput shipment to the theater of operations. The intratheater maximum gross product weight per 20' ISO container, 27,830 pounds, represents the binding weight constraint since it is lower than intertheater weight constraint of 40,000 pounds. Since there are two 20' ISOs per 34-ton vehicle truckload, the number of 20' ISOs per 50,000 pounds of product (Table A19) is simply two times the number of 34-ton vehicle truckloads per 50,000 pounds of product (Table A6). As shown in Table A19, the number of 20' ISOs containers per day range from 7.59 to 61.21 for Europe, and 1.97 to 15.87 for SWA both for fresh bread ingredients (low) and crackers (high) respectively.

Intertheater transportation costs are established on the basis of the product being routed in 20' ISO containers from Chicago to a CONUS east coast port (truck) and then on to the theater port (ship) via commercial container transportation. Commercial transportation costs are established per MTON (measurement ton-40 cubic feet) of container space. Based on the average number of MTONs of space per container

and the established rate per MTON of container space, the costs per 20' ISO container from Chicago to the European and SWA theater ports are \$1,888.62 and \$4,076.35, respectively. The resulting annual costs per alternative and theater are presented in Table A19.

IN-THEATER STORAGE IMPACTS (20' ISO CONTAINERS)

The in-theater storage of each bread product alternative is expressed in terms of 20' ISO container loads. Table A20 presents the class 1 stockage objective (days of supply) by theater region for division, corps, and EAC troops. The total stockage objectives for all theater troops is 40 days of supply. Total storage quantities (1,000 pounds) in each theater region are developed in Table A21. In Table A22, these quantities are converted into 20' ISO containers. The conversion is based on the number of 20' ISO containers per 50,000 pounds of product established in Table A6.

FIELD BAKERY UNIT IMPACT

The number of field bakeries required per theater is a function of the theater's daily fresh bread requirement, the availability of HNS fresh bread, mobile bakery output capacity (pounds per hour), and the unit to which and the basis on which field bakeries are allocated. Tables A23 and A24 develop the number of M45-type bakeries required to support the European and SW Asia theater based on the current allocation criteria, a proposed allocation criteria without HNS fresh bread, and a proposed allocation criteria with HNS fresh bread (Europe only).

The M-45 mobile bakery has a rated capacity of 8,000 pounds (10 hours equipment output at 800 pounds per hour) per 12-hour shift or 16,000 pounds per two shifts or 24-hour per day operation. The current allocation for M-45 mobile bakeries is one per direct support company, which are in turn authorized on the basis of one per 16,000 troops. Each bakery is staffed for a single shift, 12-hour per day operation.

The current allocation generates a requirement for 56 bakeries/56 bakery teams for Europe and 15 bakeries/15 bakery teams for SWA. This bakery plant authorization for Europe and SWA, based on equipment capacity (two shifts per bakery), can satisfy 336% and 347% of each theater's bread requirement respectively. Based on actual staffing (one 12-hour shift per bakery), the 56 bakery teams for Europe and the 15 bakery teams for SWA can produce 168% and 174% of each theater's bread requirement.

As shown in Tables A23 and A24, the proposed bakery allocation without HNS fresh bread is two per General Supply Company, which are authorized on the basis of 1 per 65,000 troops. The number of bakery teams assigned per GSC would range between two and four and would depend on the ration mix and resulting bread demand of the troops

supported. On an average, each GSC would be assigned three bakery teams: one bakery would be staffed and operated on a two shift, 24-hour per day basis and the other bakery on a single shift, 12-hour per day basis.

The proposed bakery/bakery team allocation criteria generates an allocation of 28 bakeries and 42 bakery teams for Europe, and 8 bakeries and 12 bakery teams for SWA. From an equipment capacity standpoint, the number of bakeries allocated can satisfy 168% of the European and 185% of the SWA theaters daily bread requirements. Based on actual staffings, the 42 bakery teams for Europe and 12 for SWA, can produce 126% and 139% of each theater's bread requirement.

These figures indicate that even though the proposed allocation criteria generate a significantly lower bakery/bakery team requirement than the current allocation criteria, there is still excess production capability based on equipment capacity and actual staffing. For Europe and SWA, based on theater bread requirements and the number of bakery teams allocated, each bakery team produces (on average) less than 6,400 pounds of bread which is less than 80% of the rated capacity (8,000 pounds per 12-hour shift).

For Europe, Table A25 summarizes the quantity of fresh bread available from the AAFES bakery or host nation sources by German military district. In total, these sources could provide 216,000 pounds of fresh bread per day. The maximum percent of the theater bread requirement that the Army will accept from HNS sources is developed in Table A26. This percent is a function of the location of the HNS source and is 0, 17%, 51%, and 66% for Division, Corps-forward, Corps-rear, and EAC located sources, respectively. The German military districts for which there are host nation support agreements are spread over the Corps-forward and Corps-rear regions of the theater. Therefore, the maximum percent of the division and Corps bread requirement from these HNS sources is assumed to be 34% (average of 17%, 51%). Based on these percents, the maximum quantity of fresh bread from HNS sources for the European theater is calculated at 101,000 pounds.

With host nation support, bakeries would be assigned to GSC's on an as-required basis with zero to two bakeries per GSC depending on the availability of fresh bread from host nation sources for the troops supported. The total number of bakeries/bakery teams required is estimated based on one bakery per 9,600 pounds of bread required, and an average of 1.5 bakery teams per bakery or 6,400 pounds per bakery team. Based on these criteria, with host nation support, the number of bakeries/bakery teams required is calculated at 18 and 27 respectively. As shown in Table A23, this allocation provides excess production capability based on equipment capacity and actual staffing.

BAKERY UNIT COST AND MANPOWER IMPACT

Table A27 summarizes the annual cost and manpower impact per required M-45 type bakery unit. All cost and manpower impacts are

based on the M-45 bakery section assigned to the Supply and Service Company (TOE 29-147H520). The cost and manpower impact per bakery section comprises the bakery section itself, company overhead, and the direct support and general support maintenance impact generated by the bakery section. Actual direct and general support maintenance hours generated by the bakery section are detailed in Table A28. These maintenance hours are converted to a maintenance unit manpower and cost impact in Table A29.

Based on the Resource Analysis Program Printouts, personnel costs for the bakery section represent over 85% of the total sections costs. For cost analysis purposes, all bakery teams (with or without equipment) are costed at 100% of the total bakery section cost.

TOTAL WARTIME COST AND MANPOWER IMPACT

The total annual wartime cost and manpower impact per alternative by theater is summarized in Table A30. As of the date of this analysis the price of the HNS fresh bread for Europe was under negotiation but no price had been established. The cost of HNS fresh bread was therefore projected based on the current price charged for fresh bread by the AAFES bakery to enlisted dining facilities: \$0.49 per pound. This price covers all of the AAFES costs (ingredients, facilities, utilities, labor) and includes a profit margin and distribution in peacetime to the garrison dining facilities. Relative to wartime costs of the HNS bread alternative, an additional inter and intratheater cost impact of bread ingredients to the HNS bakery and fresh bread from the HNS bakeries to the direct supply companies was estimated and added.

Although HNS is not currently available in the SW Asia theater, cost and manpower impacts were projected (as if available) to facilitate direct comparison of the cost and manpower impacts of each alternative for the SW Asia and European theaters combined. The impacts for SW Asia HNS are projected based on the European theater HNS and mobile bakery fresh bread alternative impacts, and the SW Asia theater mobile bakery fresh bread alternative impact.

For each alternative, the figure denoted "total cost (100%)" represents the total annual cost to satisfy 100% of a theater's bread requirement on a daily basis. To establish this figure for fresh bread from mobile bakeries, the annual cost of mobile bakery units is established as follows:

$$\text{No. Mobile Bakeries} \times \$651,000/\text{Bakery} \times 1.2$$

The rationale for the multiplicative factor of 1.2 is as follows. Based on current planning factors, Corps locator GSC companies, to which bakery units will be attached, move on average once every six days. With each move, one day of production is lost. On average for each six-day period, a bakery operates and outputs only five days' production. Therefore, on a theoretical basis, six bakeries are

necessary if the output of five bakeries is required on a daily basis. Thus, the multiplicative factor is $6/5$ or 1.2 . Then, on average, each day five bakeries would be operational while one was being moved. The resulting "total cost (100%)" figure for mobile bakeries represents a theoretical figure only to facilitate direct cost comparison with the "total cost (100%)" figure for all other alternatives.

Based on the number of bakeries actually allocated, the figure "total cost (83%)" represents the total projected annual cost of the mobile bakery alternatives to satisfy 83% (five days output per six-day period) of the theater's bread requirement. The "total cost (83%)" is established by taking $5/6$ of the "total cost (100%)" figure. As a result of the two multiplicative factors ($5/5 \times 5/6$), 100% of bakery unit costs are allocated against 83% of the theaters bread requirement. That is, six days of bakery unit costs are charged against five days of actual bakery unit output.

TABLE A1. Mature Two Theater Population Strengths and Bread Product Requirements (Lb/Day)

Theater	Region	No. Troops ¹	% Bulk Rations	No. Bulk Rations/Day	Lbs. Bread Product/Day
Europe	Division (LR1)	459,000	50	230,000	115,000
	Corp, Non-Div (LR2, LR3)	356,600	67	238,000	119,000
	EAC (LR4, LR5)	72,500	90	65,000	32,500
	Theater (LR1-LR5)	888,100	60	533,000	266,500
SWA	Division (LR1)	104,700	50	52,400	26,200
	Corp, Non-Div (LR2, LR3)	118,100	67	79,200	39,600
	EAC (LR4, LR5)	7,400	90	6,600	3,300
	Theater (LR1-LR5)	230,200	60	138,200	69,100

¹ Troop strengths provided by DCSOPS and are based on Total Army Analysis-88 (FY88 Force)

TABLE A2. Gross Wt (Lbs), Volume (Ft³), and Cost (\$) Per 50,000 Pounds of End Product by Alternative

	Unit of Issue	No. Units Req.	Case Data		Logistical Impact			Cost Impact (\$)		
			No. Units	Gross Wt(Lbs)	Cube (Ft3)	Net Wt (Lbs)	Gross Wt (Lbs)	Cube (Ft3)	Per Unit1	Total
Alternative Bread Ingredients	50.0 lb bag	650.0	1	51	0.98	32,500	33,150	637.0	\$9.13	\$5,935
	5.5 lb can	348.9	6	39	1.10	1,919	2,268	64.0	2.81	980
	10.0 lb bag	129.6	6	61	1.16	1,296	1,318	25.1	3.07	398
	5.0 lb bag	135.2	12	61	1.02	676	687	11.5	0.60	81
	2.0 lb can	112.9	24	65	1.81	226	310	8.5	3.52	397
	25.0 lb can	51.8	2	57	1.62	1,295	1,476	42.0	8.18	424
	50.0 lb bag	6.5	1	51	0.75	325	332	4.9	45.00	293
						38,237	39,541	793.0		8,508
Canned Bread	1.25 lb can	40,000.0	12	23	1.41	50,000	76,667	4,700	2.05- 2.902	82,000- 116,000
Crackers	13.0 lb can	3,846.2	1	23	2.29	50,000	88,463	8,808	13.39	51,500
British Type Bisc.	39.0 lb can	1282.1	1	49	1.54	50,000	62,823	1,974	30.803	39,487
Biscuit Mix	4.5 lb can	8889.0	6	33	1.10	40,000	48,889	1,630	2.14	19,023
Corn Bread Mix	4.5 lb can	7937.0	6	33	1.10	35,714	43,651	1,455	2.62	20,794
Quick/Sweet Bread Mix	5.0 lb can	7859.1	6	36	1.10	39,295	47,154	1,441	2.75	21,612

1 Except as footnoted, unit prices from Federal Supply Catalog, Price List, FSC Group 89, Subsistence:

1 October 1982.

2 Natick R&D Center price estimate, large scale military buy.

3 Actual price as of 1 October 1982, based on foreign exchange rates.

TABLE A3. Net Weight (Lb) of Ingredients per 50,000 Pounds of Finished Product

Factor	Fresh Bread	Biscuit Mix	Corn Bread	Sweet/Quick Bread
Recipe Dry Ingredient Weight (Lbs)	764.80	18.00	13.50	14.50
Recipe Water Weight (Lbs)	384.20	7.00	7.50	6.00
Recipe Total Weight (Lbs)	1149.00	25.00	21.00	20.50
Baking Loss Factor	13%	10%	10%	10%
Recipe Finish Product Weight (Lbs)	1000.00	22.50	18.90	18.45
Ratio: Finish Product to Dry Ingredient Weight	1.3077	1.2500	1.4000	1.2724
Net Weight of Ingredients Per 50,000 Pounds Product	38,237	40,000	35,714	39,295

TABLE A4. Annual Product Cost per Alternative by Theater (M\$)

Alternative	Cost (\$)/ 50,000 Lbs	Annual Cost (M\$) By Theater (Daily Requirement - Lbs)	
		Europe (266,500)	SWA (69,100)
Fresh Bread Ingredients	\$ 8,508	\$ 16,552	\$ 4,292
Canned Bread ¹	82,000-	159,527-	41,363
	116,000	225,672	58,514
Crackers	51,500	100,191	25,978
British Type Biscuits	39,487	76,820	19,918
Biscuit Mix	19,023	37,008	9,596
Corn Bread Mix	20,794	40,454	10,489
Quick/Sweet Bread Mix	21,612	42,045	10,902
Assorted Mixes	20,476	39,836	10,329

¹ Based on cost estimates of \$2.05 - \$2.90 per 20 oz. can, or \$1.64 - \$2.32 per pound.

TABLE A5. Maximum Gross Product Weight and Volume per Load
(Except Fresh Bread)

Factor	Type Vehicle	
	34 Ton	5 Ton
Maximum Weight Load	68,000 Lbs	10,000 Lbs
No./Type Containers	2-20' ISO	-
Average Container Weight	4,970 Lbs	-
No. Pallets	32	6
Pallet Weight	75 Lbs	75 Lbs
Max. Gr. Prod. Wt./Load	55,660 Lbs	9,550 Lbs
Max. Gr. Prod. Wt./20' ISO	27,830 Lbs ¹	-
Load (Ft ³)/Pallet	47.94 Ft ³	47.94 Ft ³
Max. Gr. Product Volume/Load	1,534 Ft ³	288 Ft ³

¹ Intertheater weight constraint - 40,000 Lbs/20' ISO Container.

TABLE A6. Truck Loads per 50,000 Pounds of Product (Product Weight as Served)

Type Vehicle	Item	Bread Ingrid	Fresh Bread	Canned Bread	Crackers	British Type Biscuits	Biscuit Mix	Corn Bread Mix	Sw/Quick Bread Mix
34T Semi with 2-20' ISO ¹	Gr. Wt. (Lbs)	39,541	62,500	76,667	88,463	62,823	48,889	43,651	47,154
	Volume (Ft ³)	793	4,550	4,700	8,808	1,974	1,630	1,455	1,441
	Loads - Wt	0.712	1.125	1.380	1.592	1.131	0.880	0.786	0.849
	Loads - Ft ³	0.517	2.480	3.064	5.742	1.287	1.063	0.949	0.939
Truck Cargo 5-Ton ²	Truck Loads	0.712	2.480	3.034	5.742	1.287	1.063	0.949	0.939
	Loads - Wt	4.140	6.545	8.028	9.263	6.578	5.119	4.571	4.938
	Loads - Ft ³	2.753	11.574	16.319	30.583	6.854	5.660	5.052	5.003
	Truck Loads	4.140	11.574	16.319	30.583	6.854	5.660	5.052	5.003

1 Maximum product loads: except fresh bread - 55,560 lbs, 1,534 Ft³ (see Table A5).

fresh bread - 55,560 lbs, 1,835 Ft³

2 Maximum product load: except fresh bread - 9,550 lbs, 288 Ft³ (see Table A5).

fresh bread - 9,550 lbs, 393 Ft³

TABLE A7. European and SW Asia Theater Truck-Days
per Load by Transportation Link

Theater	Product	From	To				
			E1	E2	C1	C2	D
Europe	Except	P	0.665	0.715	2.065	2.115	2.315
	HNS	E1	-	0.425	1.475	-	-
	Bread	C1	-	-	-	0.425	0.525
	HNS	P	0.665	-	1.715	-	-
	Bread	E1	-	0.425	1.125	-	-
	Only	C1	-	-	-	0.725	0.825
SWA	All	P	0.300	0.350	1.300	1.350	2.180
	Products	E1	-	0.425	1.075	-	-
		C1	-	-	-	0.425	0.955

TABLE A8. Product Flow By Final Destination

Product Destination	Type Vehicle	Vehicle Route	% Tot.	Requirement
			Non-Bread ¹	Fresh Bread
Division	34T	P-D	20%	-
	34T	P-C1	20	20
	34T	P-E1-C1	60	80
	5T	C1-D	80	100
Corps	34T	P-C2	20	-
	34T	P-C1	20	20
	34T	P-E1-C1	60	80
	5T	C1-C2	80	100
EAC	34T	P-E2	20	-
	34T	P-E1	80	100
	5T	E1-E2	80	100

¹Product routings per Logistic Concepts, Office of the Deputy
Chief of Staff for Logistics, June 1978

TABLE A9. European Theater - Transportation Impact (Truck Days) per 50,000 Pounds of Product by Theater Region
(Except Fresh Bread Ingredients/Fresh Bread)

Destin- -ation	Type Tr.	Route	%	Truck Days/ Load	Canned Bread			Crackers			British Biscuits			Biscuit Mix			Corn Bread			Sweet/Quick Breads		
					Truck Loads	Truck Days		Truck Loads	Truck Days		Truck Loads	Truck Days		Truck Loads	Truck Days		Truck Loads	Truck Days		Truck Loads	Truck Days	
Div.	34T	P-D	20	2.315	0.613	1.42		1.148	2.66		0.257	0.59		0.213	0.49		0.190	0.44		0.188	0.44	
		P-C1	20	2.065	0.613	1.27		1.148	2.37		0.257	0.53		0.213	0.44		0.190	0.39		0.188	0.39	
		P-E1-C1	60	2.140	1.838	3.93		3.445	7.37		0.772	1.65		0.638	1.37		0.569	1.22		0.563	1.20	
		Total	-	-	-	6.62		-	12.40		-	2.77		-	2.30		-	2.05		-	-	2.03
Corps	5T	C1-D	80	0.525	13.055	6.85		24.466	12.84		5.483	2.88		4.528	2.38		4.042	2.12		4.002	2.10	
		P-C2	20	2.115	0.613	1.30		1.148	2.43		0.257	0.54		0.213	0.45		0.190	0.40		0.188	0.40	
		P-C1	20	2.065	0.613	1.27		1.148	2.37		0.257	0.53		0.213	0.44		0.190	0.39		0.188	0.39	
		P-E1-C1	60	2.140	1.838	3.93		3.445	7.37		0.772	1.65		0.638	1.37		0.569	1.22		0.563	1.20	
EAC	5T	Total	-	-	-	6.50		-	12.17		-	2.72		-	2.26		-	2.01		-	-	1.99
		C1-C2	80	0.425	13.055	5.55		24.466	10.40		5.483	2.33		4.528	1.92		4.042	1.72		4.002	1.70	
		P-E2	20	0.715	0.613	0.44		1.148	0.82		0.257	0.18		0.213	0.15		0.190	0.14		0.188	0.13	
		P-E1	80	0.665	2.451	1.63		4.594	3.06		1.030	0.68		0.850	0.57		0.759	0.50		0.751	0.50	
EAC	5T	Total	-	-	-	2.07		-	3.88		-	0.86		-	0.72		-	0.64		-	-	0.63
		E1-E2	80	0.425	13.055	5.55		24.466	10.40		5.483	2.33		4.528	1.92		4.042	1.72		4.002	1.70	

TABLE A10. SW Asia - Transportation Impact (Truck-Days) Per 50,000 Pounds of Product by Theater Region
(Except Fresh Bread Ingredients/Fresh Bread)

Destin- -ation	Type Tr.	Route	%	Truck Days /Load	Canned Bread		Crackers		British Biscuits		Biscuit Mix		Corn Bread		Sweet/Quick Breads	
					Truck Loads	Truck Days	Truck Loads	Truck Days	Truck Loads	Truck Days	Truck Loads	Truck Days	Truck Loads	Truck Days	Truck Loads	Truck Days
Div.	34T	P-D	20	2.180	0.613	1.34	1.148	2.50	0.257	0.56	0.213	0.46	0.190	0.41	0.188	0.41
		P-C1	20	1.300	0.613	0.80	1.148	1.49	0.257	0.33	0.213	0.28	0.190	0.25	0.188	0.24
		P-E1-C1	60	1.375	1.838	2.53	3.445	4.74	0.772	1.06	0.638	0.88	0.569	0.78	0.563	0.77
		Total	-	-	-	4.67	-	8.73	-	1.95	-	1.62	-	1.44	-	1.42
Corps	5T	CI-D	80	0.955	13.055	12.47	24.466	23.37	5.483	5.24	4.528	4.32	4.042	3.86	4.002	3.82
		P-C2	20	1.350	0.613	0.83	1.148	1.55	0.257	0.35	0.213	0.29	0.190	0.26	0.188	0.25
		P-C1	20	1.300	0.613	0.80	1.148	1.49	0.257	0.33	0.213	0.28	0.190	0.25	0.188	0.24
		P-E1-C1	60	1.375	1.838	2.53	3.445	4.74	0.772	1.06	0.638	0.88	0.569	0.78	0.563	0.77
EAC	5T	Total	-	-	-	4.16	-	7.78	-	1.74	-	1.45	-	1.29	-	1.26
		CI-C2	80	0.425	13.055	5.55	24.466	10.40	5.483	2.33	4.528	1.92	4.042	1.72	4.002	1.70
		P-E2	20	0.350	0.613	0.21	1.148	0.40	0.257	0.09	0.213	0.07	0.190	0.07	0.188	0.07
		P-E1	80	0.300	2.451	0.74	4.594	1.38	1.030	0.31	0.850	0.26	0.759	0.23	0.751	0.23
EAC	34T	Total	-	-	-	0.95	-	1.78	-	0.40	-	0.33	-	0.30	-	0.30
		EI-E2	80	0.425	13.055	5.55	24.466	10.40	5.483	2.33	4.528	1.92	4.042	1.72	4.002	1.70

TABLE A11. European and SW Asia Theater Transportation Impact (Truck-Days) per 50,000 Pounds Fresh Bread Ingredients/Fresh Bread by Theater Region

Destination	Type Truck	Route	Prod (%)	Truck Loads	Europe				SWA	
					Mobile Bakery		HNS		Mobile Bakery	
					Tr. Days /Load	Truck Days	Tr. Days /Load	Truck Days	Tr. Days /Load	Truck Days
Div.	34T	P-E1-C1	80	0.570	2.140	1.22	1.790	1.02	1.375	0.78
		P-C1	20	0.142	2.065	0.29	1.715	0.24	1.300	0.18
		Total	-	-	-	1.51	-	1.26	-	0.96
	5T	C1-D	100	11.574	0.525	6.08	0.825	9.55	0.955	11.05
Corps	34T	P-E1-C1	80	0.570	2.140	1.22	1.790	1.02	1.375	0.78
		P-C1	20	0.142	2.065	0.29	1.715	0.24	1.300	0.18
		Total	-	-	-	1.51	-	1.26	-	0.96
	5T	C1-C2	100	11.574	0.425	4.92	0.725	8.39	0.425	4.92
EAC	34T	P-E1	100	0.712	0.665	0.47	0.665	0.47	0.300	0.21
	5T	E1-E2	100	11.574	0.425	4.92	0.425	4.92	0.425	4.92

TABLE A12. European Theater - Transportation Impact of Alternatives by Theater Region

Destin- ation	Quantity (Lbs)	Type Truck	Alternative							
			Ingrd/ Bread (Bakery)	Ingrd/ Bread (HNS)	Canned Bread	Crackers	British Type Biscuits	Biscuit Mix	Corn Bread Mix	Sw/Quick Bread Mix
Division	50,000	34T	1.51	1.26	6.62	12.40	2.77	2.30	2.05	2.03
		5T	6.08	9.55	6.85	12.84	2.88	2.38	2.12	2.10
	115,000	34T	3.47	2.90	15.23	28.52	6.37	5.29	4.72	4.67
		5T	13.98	21.97	15.76	29.53	6.62	5.47	4.88	4.83
Corps	50,000	34T	1.51	1.26	6.50	12.17	2.72	2.26	2.01	1.99
		5T	4.92	8.39	5.55	10.40	2.33	1.92	1.72	1.70
	119,000	34T	3.59	3.00	15.47	28.96	6.47	5.38	4.78	4.74
		5T	11.71	19.97	13.21	24.75	5.55	4.57	4.09	4.05
EAC	50,000	34T	0.47	0.47	2.07	3.88	0.86	0.72	0.64	0.63
		5T	4.92	4.92	5.55	10.40	2.33	1.92	1.72	1.70
	32,500	34T	0.31	0.31	1.35	2.52	0.56	0.47	0.42	0.41
		5T	3.20	3.20	3.61	6.76	1.51	1.25	1.12	1.11
Theater	266,500	34T	7.37	6.21	32.05	60.00	13.40	11.14	9.92	9.82
		5T	28.89	45.14	32.58	61.04	13.68	11.29	10.09	9.99

TABLE A13. SW Asia - Transportation Impact of Alternatives by Theater Region

Destination	Quantity (Lbs)	Type Truck	Alternative						Corn Bread Mix	Sw/Quick Bread Mix
			Ingrd/ Bread (Bakery)	Canned Bread	Crackers	British Type Biscuits	Biscuit Mix			
Division	50,000	34T	0.96	4.67	8.73	1.95	1.62	1.44	1.42	
		5T	11.05	12.47	23.37	5.24	4.32	3.86	3.82	
	26,200	34T	0.50	2.45	4.57	1.02	0.85	0.75	0.74	
		5T1	5.79	6.53	12.25	2.75	2.26	2.02	2.00	
Corps	50,000	34T	0.96	4.16	7.78	1.74	1.45	1.29	1.26	
		5T	4.92	5.55	10.40	2.33	1.92	1.72	1.70	
	39,600	34T	0.76	3.29	6.16	1.38	1.15	1.02	1.00	
		5T	3.90	4.40	8.24	1.85	1.52	1.36	1.35	
EAC	50,000	34T	0.21	0.95	1.78	0.40	0.33	0.30	0.30	
		5T	4.92	5.55	10.40	2.33	1.92	1.72	1.70	
	3,300	34T	0.01	0.06	0.12	0.03	0.02	0.02	0.02	
		5T	0.32	0.37	0.69	0.15	0.13	0.11	0.15	
Theater	69,100	34T	1.27	5.80	10.85	2.43	2.02	1.79	1.76	
		5T	10.01	11.30	21.18	4.75	3.91	3.49	3.46	

¹ Due to large transit distance (156 miles) from Corp GS to Division DS, 34T trucks may be utilized. To convert from 5T to 34T, multiply 5t requirement as follows: fresh bread (0.2142), other alternatives (0.1877).

TABLE A14. Total Annual Cost and Manpower Impact Per Truck Company
and Per Available Vehicle

Data Element	Medium Truck Company 55-018 H610		Light Truck Company 55-017 H520	
	No. People	Cost (\$)	No. People	Cost (\$)
Transp. Unit Impact ¹	186	\$5,291,000	173	\$4,513,000
Annual Fuel Cost	-	2,503,000	-	994,000
Maintenance Unit Impact	16	463,000	11	318,000
Totals	202	8,257,000	184	5,825,000
Avail. Vehicles/Unit	(45)	-	(45)	-
Annual Cost & Manpower Impact/Available Vehicle	4.49	\$183,000	4.09	\$129,000

¹Unit annual recurring investment and operating cost represents average cost of European and CONUS based units. From Resource Cost Analysis Program printouts (FY83 \$) - TRASANA.

TABLE A15. Annual Fuel Cost Per Truck Company

Data Element	Medium Truck Company 55-018H610	Light Truck Company 55-017H520
Type Vehicle	Truck Tractor, 10 Ton(M915) with Semi-Trailers, 34 Ton(M872)	Truck Cargo, 5 Ton (M925)
Vehicles/Unit	60	60
% Availability ¹	75%	75%
Avail. Vehicles/Unit	45	45
Daily Mileage ² / Avail. Vehicle	340	150
Miles/Gallon	2.7	3.0
Cost(\$)/Gallon	\$1.21	\$1.21
Annual Fuel Cost/Unit	\$2,503,000	\$994,000

¹ Per unit TOE

² Projected based on European theater, distances, and class 1 supply system.

TABLE A16. Maintenance Worker-Hours Generated Per Transportation Unit

	Annual Maint. Hrs Per Item ²		Trans. Medium Truck Co. (55-018H610)				Light Truck Co. (55-017H520)			
	DS	GS	No. Items	Total DS	Total GS	Total	No. Items	Total DS	Total GS	Total
Major Items ¹										
Truck Tractor, 10 Ton	115	86	61	7,015	5,246	12,261	-	-	-	-
Semi-Trailer, 34 Ton	33	6	120	3,960	720	4,680	-	-	-	-
Truck Cargo, 5 Ton	100	83	-	-	-	-	60	6,000	4,980	10,980
Truck Wrecker, 5 Ton	132	155	1	132	155	287	1	132	155	287
Truck Cargo, 2½ Ton	78	71	2	156	142	298	2	156	142	298
Truck Utility, ½ Ton	70	37	5	350	185	535	5	350	185	535
Water Trailer, 400 Gal.	22	4	1	22	4	26	1	22	4	26
Cargo Trailer, 1½ Ton	22	4	1	22	4	26	3	66	12	78
Cargo Trailer, ½ Ton	22	4	5	110	20	130	4	88	16	104
Gen 3.0 KW AC	176	104	1	176	104	280	-	-	-	-
Gen 3.0 KW DC	176	104	1	176	104	280	2	352	208	560
Gen 1.5 KW AC	73	49	1	73	49	122	4	292	196	488
Gen 1.5 KW DC	73	49	1	73	49	122	-	-	-	-
Vech - Subtotal	-	-	-	11,767	6,476	18,243	-	6,814	5,494	12,308
Gen - Subtotal	-	-	-	498	306	804	-	644	404	1,048
Total	-	-	-	12,265	6,782	19,047	-	7,458	5,898	13,356

¹ Major items authorized per unit TOE

² Per AR 570-2

TABLE A17. Maintenance Unit Impact (\$, People) by Transportation Unit

Maintenance Unit Data				Transportation Unit					
				Medium Truck Company 55-018H610			Light Truck Company 55-017H520		
Unit	(A) Annual Cost (\$) ¹	(B) No. People ²	(C) Avail Maint-Hrs	(D) Maint-Hrs Req ³	(E) No. People (BxD)/C	(F) Annual Cost (\$) (AxD)/C	(G) Maint-Hrs Req ³	(H) No. People (BxG)/C	(I) Annual Cost (\$) (AxG)/C
Light Mnt Co (DS) 29-209H900	6,112,000	210	237,600	12,265	10.8	316,000	7,458	6.6	192,000
Mnt Co (Light Eqpt) (GS) 29-134H200	5,799,000	198	375,300	306 (Gen)	0.2	5,000	404 (Gen)	0.2	5,000
Mnt Co (Heavy Eqpt) (GS) 29-137H200	6,679,000	226	305,100	6,476 (Vech)	4.8	142,000	5,494	4.1	120,000
Total Impact				19,047	15.8	463,000	13,356	10.9	318,000

¹ Average cost of European and CONUS based units. From Resource Analysis Program Printouts (FY83 \$) -

TRASANA

² Per maintenance unit TOE's

³ From Table A16

TABLE A18. Cost and Manpower Impacts of Intratheater Transportation
By Theater

Alternative	Type Truck	Europe			SW Asia		
		Trucks	Cost/Yr (\$1,000)	No. People	Trucks	Cost/Yr (\$1,000)	No. People
Bread Ingrid/ Fresh Bread (Mob. Bakery)	34T	7.37	\$1,349	33	1.27	\$ 232	6
	5T	28.89	3,727	118	10.01	1,291	41
	Total	-	5,076	151	-	1,523	47
Bread Ingrid/ Fresh Bread (HNS)	34T	6.21	1,136	28	-	-	-
	5T	45.14	5,823	185	-	-	-
	Total	-	6,959	213	-	-	-
Canned Bread	34T	32.05	5,865	144	5.80	1,061	26
	5T	32.58	4,203	133	11.30	1,458	46
	Total	-	10,068	277	-	2,519	72
Crackers	34T	60.00	10,980	269	10.85	1,986	49
	5T	61.04	7,874	250	21.18	2,732	87
	Total	-	18,854	519	-	4,718	136
British Type Biscuits	34T	13.40	2,452	60	2.43	445	11
	5T	13.68	1,765	56	4.75	613	19
	Total	-	4,217	116	-	1,058	30
Biscuit Mix	34T	11.14	2,039	50	2.02	370	9
	5T	11.29	1,456	46	3.91	504	16
	Total	-	3,495	96	-	874	25
Corn Bread Mix	34T	9.92	1,815	45	1.79	328	8
	5T	10.09	1,302	41	3.49	450	14
	Total	-	3,117	86	-	778	22
Sweet/Quick Bread Mix	34T	9.82	1,797	44	1.76	322	8
	5T	9.99	1,289	41	3.46	446	14
	Total	-	3,086	85	-	768	22
Assorted Mixes	34T	10.29	1,884	46	1.86	340	8
	5T	10.46	1,349	43	3.62	467	15
	Total	-	3,233	89	-	807	23

TABLE A19. Intertheater Transportation Impacts and Costs by Theater

Alternative	20' ISO's/ 50,000 Lbs Product	Theater (Lbs/Day)			
		Europe (266,500)		SW Asia (69,100)	
		No. 20' ISO's/Day	Cost/Year ¹ (\$1,000)	No. 20' ISO's/Day	Cost/Year ² (\$1,000)
Bread Ingredients	1.424	7.59	5,232	1.97	2,931
Canned Bread	6.128	32.66	22,514	8.47	12,602
Crackers	11.484	61.21	42,195	15.87	23,612
British Type Biscuits	2.574	13.72	9,458	3.56	5,297
Biscuit Mix	2.126	11.33	7,810	2.94	4,374
Corn Bread Mix	1.898	10.12	6,976	2.62	3,898
Sw/Quick Bread Mix	1.878	10.01	6,900	2.60	3,868
Assorted Mixes	1.967	10.49	7,229	2.72	4,047

¹ Average cost per container - \$1,888.62 (\$65.35/MTON Container Space x 28.90 MTON Container Space/Container)

² Average cost per container - \$4,076.35 (\$141.05/MTON Container Space x 28.90 MTON Container Space/Container)

TABLE A20. Stockage Objectives (Days of Supply)

Storage Location	Troop Population		
	Division	Corps Non-Division	EAC
User	2	2	2
Division (DS)	3	-	
Corps (DS)	-	3	
Corps (GS)	7	7	
EAC (DS)	-	-	3
EAC (GS)	30	30	37
Total	40	40	40

TABLE A21. Storage Quantities of Product by Theater Region (1,000 Lbs)

Theater	Product Destin- ation	Req't (Lbs/ Day)	Storage Location and Quantities (1,000 Lbs)							
			Division		Corps		EAC		Theater	
			Days	Total	Days	Total	Days	Total	Days	Total
Europe	Division	115,000	3	345.0	7	805.0	30	3,450.0	40	4,600.0
	Corp	119,000	0	0.0	10	1,190.0	30	3,570.0	40	4,760.0
	EAC	32,500	0	0.0	0	0.0	40	1,300.0	40	1,300.0
	Total	266,500	-	345.0	-	1,995.0	-	8,320.0	40	10,660.0
SWA	Division	26,200	3	78.6	7	183.4	30	786.0	40	1,048.0
	Corp	39,600	0	0.0	10	396.0	30	1,188.0	40	1,584.0
	EAC	3,300	0	0.0	0	0.0	40	132.0	40	132.0
	Total	69,100	-	78.6	-	579.4	-	2,106.0	40	2,764.0

TABLE A22. In-Theater Storage Impact of Alternatives by Region
(20' ISO Containers)

Theater	Region	Alternati (20' ISO'S/50,000 Lbs of Product)						
		Fresh Bread Ingred. (1.424)	Canned Bread (6.128)	Crackers (11.484)	British Type Biscuits (2.574)	Biscuit Mix (2.126)	Corn Bread Mix (1.898)	Sw/Quick Bread Mix (1.878)
Europe	Division	10	42	79	18	15	13	13
	Corps	57	245	458	103	85	76	75
	EAC	237	1,020	1,911	428	354	316	312
	Total	304	1,307	2,448	549	454	405	400
SWA	Division	2	10	18	4	3	3	3
	Corps	17	71	133	30	25	22	22
	EAC	60	258	484	108	90	80	79
	Total	79	339	635	142	118	105	104

TABLE A23. European Theater - Field Bakery Requirement (100% Fresh Bread)

Total Troop Strength			888,100
Daily Bread Requirement			266,500 Lbs
Host Nation Support: Avail 216,000 Lbs Util			101,100 Lbs
Field Bread Requirement (Non HNS)			165,400 Lbs
Authorization Criteria	Current	Proposed W/O HNS	Proposed W HNS
Bakery Allocation	1/DSC (16,000 Troops)	2/GSC (65,000 Troops)	Per GSC, As Required ¹
No Bakeries Required	56	28	18
Bakery Team Allocation	1/Bakery	Ave 1.5/Bakery	Ave 1.5/Bakery
No Teams Required	56	42	27
Equipment Capacity (Lbs)	896,000	448,000	288,000
% Total Requirement	336%	168%	174%
Staffing Capacity (Lbs)	448,000	336,000	216,000
% Total Requirement	168%	126%	131%

¹Average 1 bakery per 9,600 lbs of bread.

TABLE A24. SW Asia Theater - Field Bakery Requirement
(100% Fresh Bread)

Total Troop Strength	230,200	
Daily Bread Requirement	69,100 Lbs	
Host Nation Support	0 Lbs	
Field Bread Requirement	69,100 Lbs	
Authorization Criteria	Current	Proposed (No HNS)
Bakery Allocation	1/DSC (16,000 Troops)	2/GSC (65,000 Troops)
No Bakeries Required	15	8
Bakery Team Allocation	1/Bakery	Avg 1.5/Bakery
No Teams Required	15	12
Equipment Capacity (Lbs)	240,000	128,000
% Total Requirement	347%	185%
Staffing Capacity (Lbs)	120,00	96,000
% Total Requirement	174%	139%

TABLE A25. European Theater HNS¹/AAFES Bread Availability

Source	Quantity (Lbs)
HNS - MD III	66,000
HNS - MD IV	40,000
HNS - MD V	29,000
HNS - MD VI	14,000
AAFES Bakery ²	67,000
Total	216,000

¹ Source, HNS bread availability by military district, letter from DALO-PLF, dated 23 March 1983; Subject: "Host Nation Support in Germany."

² Bakery Location; Gruenstadt, near Kaiserlautern. Quantity based on current single shift eight-hour operation.

TABLE A26. European Theater Maximum Host Nation Support Fresh Bread

Product Destination	Req't (Lb/Day)	Product Source	Max HNS ¹	
			%	Lb
Division	115,000	Corp - Fwd	17%	19,600
		Corp - Rear	51%	58,700
		Average	34%	39,100
Corps	119,000	Corp - Fwd	17%	20,200
		Corp - Rear	51%	60,700
		Average	34%	40,500
EAC	32,500	EAC	66%	21,500
Theater	266,500	Theater	38%	101,100

¹Source: Combat Service Support Mission Area Analysis - July 1982.

TABLE A27. Total Annual Cost and Manpower Impact Per Bakery Section¹

Element	No. People	Annual Cost ²
Bakery Section	20.0	\$557,000
Bakery Unit Overhead	1.9	53,000
Maintenance Impact (DS&GS)	1.4	41,000
Total	23.3	\$651,000

¹Personnel and cost impacts based on M45 bakery section assigned to S&S Company, TOE 29-147H520.

²Average cost of European and CONUS based units. From Resource Analysis Program Printouts (FY 83 \$) - TRASANA.

TABLE A28. Maintenance Hours (DS + GS) Per Bakery Section

TOE Equipment Per Bakery Section	Annual Mnt Hrs/Item ¹		Supply & Service Co(DS) 29-147H520			
	DS	GS	No. Items	Total DS	Total GS	Total
Bakery Plant (B18848)	216	70	1	216	70	286
Pump Dispensing (G21472)	42	0	1	42	0	42
Pump Centrifugal (B92030)	98	56	1	98	56	154
Heater, 250,000 BTU (K24862)	36	18	2	72	36	108
Gen, Diesel, 30 KW (J36383)	199	122	2	398	44	642
Gen, Gas, 1.5 KW (J43918)	73	49	1	73	49	122
Trailer, Cargo 1½T (W95811)	22	4	1	22	4	26
Water Trailer, 400 Gal (W98825)	22	4	1	22	4	26
Truck Cargo, 2½T	78	71	1	78	71	149
Truck Cargo, 5 T	100	83	1	100	83	183
Sub-Total (Gen)	-	-	-	471	293	764
Sub-Total (Other)	-	-	-	650	324	974
Total	-	-	-	1,121	617	1,738

¹Per AR 570-2.

TABLE A29. Maintenance Unit Personnel and Annual Cost Impact Per Bakery Section

Unit	Maintenance Data Unit			Bakery Unit Impact		
	Annual Cost(\$) ¹	No. People ²	Avail Worker-Hrs ²	Mnt Hrs Req ³	No. People	Annual Cost (\$)
Light Mnt Co. (DS) 29-209H900	6,112,000	210	237,600	1121	1.0	29,000
Mnt Co. (Light Eqpt)(GS) 29-134H200	5,779,000	198	375,300	293 (Gen)	0.2	5,000
Mnt. Co. (Heavy Eqpmt)(GS) 29-137H200	6,679,000	226	305,100	324 (Other)	0.2	7,000
Total Impact	-	-	-	1,738	1.4	41,000

¹Average cost of European and CONUS based units. From Resource Analysis Program Printouts (FY 83 \$) - TRASANA.²Per maintenance unit TOE.³From Table A28.

TABLE A30. Theater Cost and Personnel Impact Summary By Alternative

Theater	Impact	Element	Alternative						
			Mobile Bakery (Current)	Mobile Bakery (Propose)	HNS Bread	Canned Bread	Crackers	British Type Biscuits	Assorted Mixes
Europe	Cost (\$1,000)	Ingredients/Product	16,552	16,552	47,664	159,527 - 225,672	100,191	76,820	39,836
		Intertheater Transp	5,232	5,232	5,232		42,195	9,458	7,229
		Theater Transp	5,076	5,076	6,959	10,068	18,854	4,217	3,233
		Bakery Sections (X1.2)	43,747	32,810	-	-	-	-	-
		Total (100%)	70,607	59,670	59,855	192,109 - 258,254	161,240	90,495	50,298
SWA	Cost (\$1,000)	Total (83%)	58,839	49,725	-	-	-	-	-
		Bakeries	1,305	979	213	277	519	116	89
		Transportation	151	151	213	277	519	116	89
		Total	1,456	1,130	213	41,363	25,978	19,918	10,329
		Ingredients/Product	4,292	4,292	12,359	58,514	23,612	5,297	4,047
	Personnel	Intertheater Transp.	2,931	2,931	2,931	12,602	4,718	1,058	807
		Theater Transp.	1,523	2,523	2,088	2,519	-	-	-
		Bakery Sections	11,718	9,374	-	-	-	-	-
		Total (100%)	20,464	18,120	17,378	56,484 - 73,635	54,308	26,273	15,183
		Total (83%)	17,053	15,100	-	-	-	-	-
	Personnel	Bakeries	350	280	-	-	-	-	-
		Transportation	47	47	66	72	136	30	23
		Total	397	327	66	72	136	30	23

Appendix B

Peacetime Cost Impact of Alternatives

This appendix details the development of the peacetime cost impact of each bread product alternative. This impact represents the cost incurred in a peacetime environment to maintain a specific wartime capability. The peacetime cost impact comprises a PWRMS (Pre-position War Reserve Material Stock) cost component and a personnel or unit cost component. The PWRMS cost component represents the cost to inventory, warehouse/handle, and rotate required PWRMS's; while the unit cost component represents the cost to maintain required bakery, transportation, and maintenance units in the Army's programmed peacetime force structure.

The peacetime cost impact for each alternative is established based on the product satisfying 100% of the Army's wartime bread product requirement. However, the results are provided in a manner so that the cost impact of a mix of alternatives can be established by simply weighting and summing the cost impact of each alternative appropriately.

PRE-POSITION WAR RESERVE MATERIAL STOCK (PWRMS) COSTS

The PWRMS requirement for bread products is presented in Table B1. This requirement is established based on the PWRMS requirement for B Rations (the Army's current bulk operational ration) and the OTSG-established guideline of 0.5 pounds of bread product per bulk operational ration. As shown in Table B1, the PWRMS requirement for bread products is estimated at 29,322,500 pounds.

For each bread product alternative, the inventory cost is equal to 10% of the value of the PWRMS requirement. The 10% cost factor may be viewed either as the cost of borrowing to finance the PWRMS inventory; or conversely as an opportunity cost; that is, lost income when available funds are tied up in the PWRMS inventory rather than being invested at a 10% return rate.

The peacetime warehousing and handling requirement (pallet loads) and associated costs per bread product alternative are developed in Table B2. Warehousing and handling requirements are expressed in terms of pallet loads of product while the resulting cost impact is projected based on an estimated warehousing and handling cost per pallet load of product. For each alternative, the warehousing requirement is based on the PWRMS requirement of 29,322,500 pounds of product, the resulting product volume, and 47.94 cubic feet of product per pallet load. With the exception of fresh bread ingredients, all bread product alternatives consist of a single item (product or mix).

The development of the warehousing and resulting handling requirement for fresh bread ingredients is detailed in Table B3.



Annual warehousing costs are estimated at \$29.41 per pallet load. This figure represents the average of the estimated average annual cost per pallet load of PWRMS currently in Europe (\$22.82) and in CONUS based commercial warehouses (\$36.00).

The annual handling requirement per bread product alternative is established by dividing the alternative's PWRMS requirement in pallet loads by the product shelf life. Crackers, for example, with a three year shelf life (see Table B2) generate a PWRMS requirement of 107,748 pallet loads while the annual handling requirement is 35,916 (107,748/3) pallet loads. That is 35,916 pallet loads or 1/3 of the product must be moved out of the warehouse and replaced with fresh product on an annual basis to avoid the PWRMS from exceeding its shelf life.

Annual handling costs are projected based on an estimated average round-trip handling cost (one pallet load out, one pallet load in) of \$9.45 per pallet load. This figure represents the average of the estimated round-trip handling cost per pallet load of PWRMS currently in Europe (\$9.90) and in CONUS-based commercial warehouses (\$9.00).

For each alternative, the annual rotation cost is summarized in Table B2. These costs are based upon the quantity of product rotated from the PWRMS inventory, the peacetime demand, and the quantity condemned.

The annual peacetime demands for bread ingredients, biscuit mix, cornbread mix, and quick/sweet bread mix represents planned DPSC FY83 procurements. For cost analysis purposes the peacetime demand for canned bread or British-type biscuits was assumed to be zero, even though if adopted, a small quantity would probably be consumed during peacetime field training exercises.

As shown in Table B2, the rotation cost drops as the product shelf life increases. In addition, the rotation cost is zero provided the product shelf life is larger than the PWRMS requirement divided by the peacetime annual demand. It can also be seen from the data summarized in Table B2, that the rotation cost varies considerably and ranges from \$559,000 for assorted mixes with a four year shelf life to a minimum of \$48,090,000 for canned bread with a one year shelf life.

Table B4 summarizes the rotation cost of each bread product alternative for 1% of the total PWRMS requirement. For biscuit mix, the annual rotation cost is then \$0 if biscuit mixes constitute 12% or less of the total bread requirement and \$74,400 (per 1% of the total PWRMS requirement) when biscuits are used to satisfy between 12% and 100% of the total field bread product needed. In other words, if the total field bread requirement was met by using 10% biscuit mixes and 90% from other products, the rotation cost attributable to biscuit mix would be zero. That is the garrison peacetime annual demand would exceed the quantity removed from the PWRMS inventory due to shelf life considerations.

UNIT COSTS

The peacetime cost impact of required bakery and transportation units is projected assuming that these units are assigned to the active and National Guard/Reserve components in the same proportion as the total programmed FY88 force structure.

Relative to TOE units, the programmed FY88 force structure will consist of 507,795 active Army and 677,541 Reserve and National Guard personnel. The annual cost of a Reserve or National Guard unit is estimated to be 25% of the active unit cost. Based on this estimate and the FY88 programmed force structure, the weighted average peacetime unit cost is estimated to be 0.573 times the annual cost of an active Army unit (see Table B5).

Based on the current authorization criteria of one bakery plant with one bakery team per 16,000 troops, the FY88 programmed force generates a requirement for 74 bakery plants and 74 bakery teams. With the proposed allocation, two bakery plants with three bakery teams per General Support Company (1 General Support Company per 65,000 troops) the FY88 programmed force generates a requirement for 38 bakery plants and 57 bakery teams. The peacetime cost of bakery teams, based on an estimated cost of \$651,000 per Active Army bakery team (see Appendix A), is projected as follows:

$$\begin{aligned}
 \text{Current Auth.} &= 74 \times \$651,000 \times 0.573 \\
 \text{(74 teams)} &= \$27,602,000 \\
 \\
 \text{Proposed Auth} &= 57 \times \$651,000 \times 0.573 \\
 \text{(57 teams)} &= \$21,262,000
 \end{aligned}$$

In the European and SWA theaters, a total of 1,118,300 troops of the programmed FY88 force structure of 1,185,300 troops are deployed. The resulting peacetime cost impact (PCI) of required transportation is estimated as follows:

$$\text{PCI} = (\text{Europe} + \text{SWA Transportation Unit Cost}) \times 0.573 \times \frac{1,185,300}{1,118,300}$$

Crackers, for example, generate the following impact given that the European theater transportation unit cost is \$18,854,000 and the SW Asia theater transportation unit cost is \$ 4,718,000:

$$\begin{aligned}
 \text{PCI (crackers)} &= (18,854,000 + 4,718,000) \times 0.573 \times \frac{1,185,300}{1,118,300} \\
 &= \$14,316,000
 \end{aligned}$$

The peacetime cost impact of required transportation units for the other alternatives are established in a similar fashion.

Table B6 summarizes the annual peacetime cost impact of each bread product alternative to include both PWRMS costs and bakery and transportation unit cost impacts.

TABLE B1. Pre-positioned War Reserve Material Requirement¹

Region	B Rations (1000's)	Lbc, Bread (1000 lbs)	%Total
TR1(Europe)	26,398	13,199.0	45.0
TR4(Europe)	165	82.5	0.3
TR5(Europe)	323	161.5	0.6
TR3 ²	18,562	9,281.0	31.7
Korea	2,784	1,392.0	4.7
Hawaii	54	27.0	0.1
Panama	311	155.5	0.5
CONSTOCS	10,048	5,024.0	17.1
Total	58,562	29,322.5	100.0

¹ B-ration PWRMR's based on B Ration conference, July 82
US Army Support Activity

² CONUS-based stocks for European theater

TABLE 82. Peacetime Annual PWRMS Warehousing, Handling, and Rotation Cost by Alternative

	PWRMS Warehousing Req't			Item Shelf Life	Annual Handling Req't			Annual Rotation			Total Cost (\$1000)
	No. Pallets	Net Wt. (1000 Lbs)	Cost (\$1000)		No. Pallets	Net Wt. (1000 Lbs)	Cost (\$1000)	Quantity (1000 Lbs Net Wt)		Cost (\$1000)	
								Demand	Rotate		
Alternative											
Bread Ingredients	9,701	-	285	1.10	8,841	-	84	-	29,323	1,217	1,586
Canned Bread	57,945	29,323	1,691	1.00	57,495	29,323	543	0	29,323	48,090	50,324
	57,945	29,323	1,691	2.00	28,748	14,661	272	0	14,661	24,044	26,007
	57,945	29,323	1,691	3.00	19,165	9,774	181	0	9,774	16,029	17,901
Crackers, Canned	107,748	29,323	3,169	3.00	35,916	9,774	339	1,500	8,274	8,522	12,030
	107,748	29,323	3,169	5.00	21,550	5,865	204	1,500	4,365	4,496	7,869
Brit.-Type Biscuit	24,148	29,323	710	10.00	2,415	2,932	23	0	2,932	2,316	3,049
Biscuit Mix	19,940	23,458	586	1.50	13,293	15,639	126	1,825	13,814	6,570	7,282
Corn Bread Mix	17,799	20,944	523	1.00	17,799	20,944	168	1,026	19,918	11,597	12,288
Quick/Sw.Bread mix	17,628	23,045	518	1.50	11,752	15,363	111	1,723	13,640	7,502	8,131
Assorted Mixes	18,456	22,482	542	1.33	14,281	17,315	135	4,574	2,741	6,805	7,482
	18,456	22,482	542	2.00	9,228	11,241	87	4,574	6,697	3,577	4,206
	18,456	22,482	542	4.00	4,614	5,621	44	4,574	1,047	559	1,145

1 From Table B3

2 Estimate, not centrally procured

TABLE B3. Peacetime Handling and Rotation Costs of PWRMS Fresh Bread Ingredients

Ingredient	PWRMS		Shelf Life (Yrs)	Annual Replacement		Annual Demand	Annual Rotation		
	Lbs (1,000)	Pal- lets		Pal- lets	Lbs (1,000)		Lbs (1,000)	\$/Lbs	\$/Yr
Flour	19,060	8,133	1.00	8,133	19,060	15,624	3,436	0.1826	\$627,400
Shortening	1,125	557	2.00	279	562	12,856	0	-	0
Sugar	760	323	Indef	0	0	-	0	-	0
Salt	396	168	Indef	0	0	-	0	-	0
Yeast	132	75	1.00	75	132	0	132	1.7600	232,300
Milk	760	364	1.33	273	570	0	570	0.3272	186,500
Additive	190	81	1.00	81	190	0	190	0.9000	171,000
Totals	-	9,701	-	8,841	-	-	-	-	\$1,217,200

TABLE B4. Annual PWRMS Rotate/Condemn Cost Per 1% of Requirement

Alternative	Shelf Life	% Total Req't		Cost(\$)/ 1% Total Req't
		From	To	
Fresh Bread Ingredients	1.10	0	82	\$ 5,900
		82	100	40,700
Canned Bread	1.00	0	100	480,900 - 680,300
	2.00	0	100	240,400 - 340,100
	3.00	0	100	160,300 - 226,800
Crackers	3.00	15	100	100,700
	5.00	26	100	60,400
British-Type Biscuits	10.00	0	100	23,200
Biscuit Mix	1.50	12	100	74,400
Corn Bread Mix	1.00	5	100	121,900
Quick/Sweet Bread Mix	1.50	11	100	84,500
Assorted Mixes	1.00-1.50	26	100	92,500
	2.00	40	100	60,000
	4.00	81	100	30,000

TABLE B5. Average Peacetime Unit Costs
(% Active Unit Cost)

Unit Status (No. Troops)	Portion Total Force	% Active Unit Cost	Weighted Cost
Active (507,795)	0.43	100%	43.0%
Reserve, National Guard (677,541)	0.57	25% ¹	14.3%
Average Cost	-	-	57.3%

¹Estimate, per phone conversation with TRADOC Systems Analysis
Activity(TRASANA), White Sands, N.M.

TABLE B6. Annual Peacetime Costs By Alternative (\$1,000)

Alternative	Alternative/Shelf Life																		
	Fresh Bread					Canned Bread					Crackers		Br. Type Bisc.	Biscuit Mix	Corn Bread	Quick Mixes	Assorted Mixes		
	Mobile Bakery ¹		HNS			3.0	5.0												
	Current	Propose		1.0	2.0			3.0	3.0	5.0	1.0-1.5	2.0					4.0		
	Shelf Life	1.1	1.1	1.1	1.0	2.0	3.0	3.0	5.0	10.0	1.5	1.0	1.5	1.0-1.5	2.0	4.0			
PWRMS Inventory (10%)	499	499	499	4,809- 6,803	4,809- 6,803	4,809- 6,803	3,020	3,020	2,316	1,116	1,219	1,267	1,201	1,201	1,201				
Warehouse/ Handling	369	369	369	2,234	1,963	1,872	3,508	3,373	733	712	691	629	677	629	586				
Rotate (Excess Inv)	1,217	1,217	1,217	48,090- 68,029	24,044- 34,014	16,029- 22,676	8,522	4,496	2,316	6,570	11,597	7,502	6,805	3,577	599				
PWRMS(Sub-total)	2,085	2,085	2,085	55,133- 77,066	30,816- 42,780	22,710- 31,351	15,050	10,889	5,365	8,398	13,507	9,398	8,683	5,407	2,346				
Personnel Bakery Sections	27,604	21,262	0																
Transportation ²	4,008	4,008	5,495	7,644	7,644	7,644	14,316	14,316	3,204	2,653	2,366	2,341	2,454	2,454	2,454				
Total	33,697	27,355	7,580	62,777- 84,710	38,460- 50,424	30,354- 38,995	29,366	25,205	8,569	11,051	15,873	11,739	11,137	7,861	4,800				

¹Based on 74 and 57 bakery teams with the current and proposed bakery authorization criteria, respectively.²Peacetime transportation cost equals wartime transportation cost times 1,185,300/1,118,300 x 0.573.

Appendix C

Troop Acceptance Of Bread Product Alternatives

Bread has traditionally been a component of rations in the field. The Office of the Surgeon General (OTSG) has stated that breadlike products are necessary in the field to ensure morale and adequate nutrition (1982). Historically, this requirement has been satisfied by fresh bread produced from basic ingredients by the Army's M-45 field mobile bakery.

In the TRADOC Operational and Organization Plan titled "Provision of Bread to Army Forces in the Field", several areas of concern about future military operations and their impact on the availability and delivery of fresh bread were delineated (1982). Fresh bread is a major nutritional component of current field rations. However, given battlefield conditions, mobile bakery bread baking operations will undoubtedly be curtailed on occasion. Thus, fresh-baked bread will not always be available.

In 1980, OTSG stated that there are acceptable substitutes for bread that can be prepared entirely from B Ration components. However, both OTSG and the Academy of Health Sciences (AHS) also mention questions about acceptability of bread substitutes as a reason not to rely on bread substitutes completely at every meal. If the product is not acceptable, troops might not consume it in sufficient quantities to ensure the nutritional adequacy of the ration. The following study was conducted to assess troop acceptance of a variety of breads and bread-like alternatives.

A representative group of 14 bread and bread-like products was chosen for testing. These products, through consultation with persons at the Food Engineering Laboratory, were chosen to represent typical available fresh bread products and bread substitutes. This group included fresh bread and shelf-stable products, as well as products that could be readily and entirely prepared from B Ration-type shelf-stable mixes. Attitudes about the importance of bread in the field were measured to learn more about what type of products would be most compatible with field requirements.

Ideally, the bread product alternatives should have been evaluated during a field exercise in which B Rations were used. However, no such field exercises could be identified within the time constraints of this study. The present study was therefore conducted in garrison with subjects who had previously participated in field exercises. The extrapolation of data collected in garrison to a field situation has to be done carefully since the differences between the two situations in terms of food acceptance and consumption often have a significant impact on food needs and acceptance evaluations. Thus conclusions of this study should be interpreted with this caveat in mind.



METHOD

A total of 128 active duty enlisted personnel stationed at Ft. Devens participated. All were students at the U.S. Army Intelligence School. The study consisted of three parts: an acceptance test, a written questionnaire and a structured interview. All testing was done in a dining facility at Ft. Devens. The questionnaire data from three subjects who reported never having been on a field exercise longer than 24 hours were excluded from the analysis.

At each of the six sessions, 14 subjects were chosen at random to be interviewed. A total of 84 subjects participated in the in-depth interviews about bread consumption in the field.

Because patterns of bread consumption have been found to vary on the basis of age and geographical area,¹ some demographic characteristics of the present sample should be mentioned. All but three subjects were male. The mean age of respondents was 20 with 75% falling between 18-21 years of age.

Most of the group had spent most of their lives in the eastern United States with 20% coming from the middle-Atlantic region (NY, NJ, PA). An additional 30% were divided evenly between the East, North Central Region and the South Atlantic Region. Thus, the findings of the present study may be more typical of 18- to 21-year old men who had spent most of their lives in the eastern United States than of other age and regional groups. Ninety-five percent of respondents lived on post (in bachelor quarters or barracks) and 95% were on Subsistence-in-Kind (SIK).

The written questionnaire was developed to assess: frequency of bread consumption both in general and during field exercises, types of bread and bread products commonly consumed, and the importance of bread as part of the overall diet. Questions were designed to measure the relative acceptability of various alternatives to fresh bread.

ACCEPTANCE TEST

The acceptance test covered 14 breads and bread alternatives. A standard nine point hedonic scale was used to measure troop acceptance of each item. In addition to acceptance, respondents were asked to rate each item on how frequently they would like it served as part of a field breakfast, midday or evening meal. The 14 items included were:

Fresh Breads

White Bread
Pumpnickel Bread

¹See Reference 1 to body of Report.

Sprouted Wheat Bread
Raisin Bread

Shelf-Stable Products

Canned White Bread--bread had been stored for 11 months at 70°F
at time of testing
Meal, Ready-to-Eat (MRE) Crackers
Breakfast Bake (component of Tray Pack breakfast rations)
British Biscuits (component of British Army Ration stored for five
years at time of testing)
Rice Cakes
Honey & Oats Granola Bars

Shelf-Stable Mixes

B Ration Biscuit Mix
B Ration Sweet Dough Bread Mix
Banana Bread Mix (commercial item prepared according to package
instructions)
Corn Muffins (commercial item prepared according to package
instructions)

Two daily testing sessions were run during a three-day period, one session in the morning after breakfast, the other session in the afternoon following lunch. Between 20-30 subjects participated in each session, which took approximately 10 minutes. Each group of subjects was assigned to test a different set of bread products. Subjects were seated four at a table; talking during the test was discouraged. The order of product presentation was randomized within each session.

The following combinations of products were tested:

Session 1: B Ration Sweet Dough Bread
Corn Muffins
Pumpernickel Bread

Session 2: B Ration Biscuits
Banana Bread
British Biscuits

Session 3: MRE Crackers
Raisin Bread
Sprouted Wheat

Session 4: Canned Bread
Rice Cakes
Granola Bars
Breakfast Bake

Session 5: White Bread

At each session, the purpose of the study was explained to participants and they were asked to complete the questionnaire.

Following completion of the questionnaire, each participant was given a sample of product to rate. After ratings were completed, the 14 randomly selected respondents participated in a short interview.

The interviews were conducted in two groups consisting of one investigator and seven subjects and were designed to provide an additional measure of attitudes about the role of bread in field rations. Interviews focussed on how important bread was perceived to be, why bread was eaten (e.g., in sandwiches or for snacks) and the ease of substituting fresh bread with other products all in the context of field feeding.)

RESULTS AND DISCUSSION

BREAD CONSUMPTION PATTERN

Patterns of bread consumption while in garrison and in the field are presented in Table C1. The amount of bread consumed at breakfast is similar in both situations. Between 25% and 33% of the respondents report eating no bread with the breakfast meal. The large percentage of respondents who report skipping this meal entirely should be noted. This figure (18-20%) is similar to findings of earlier studies on field and garrison feeding.²

Relatively few respondents report skipping the evening meal while in the field. It is impossible to tell, however, whether these meals are skipped in the field by choice or because of constraints of the field situation. Similarly while these figures suggest that somewhat less bread is consumed in the field than in garrison, it is impossible on the basis of these data to identify why less bread is eaten in the field.

Based on results summarized in Table C1, the average portion size per individual in the field is slightly less than 1.5 slices per meal.

Table C2 summarizes the frequency of consuming sandwiches in the garrison and in the field. Sandwiches are consumed less frequently during field exercises than at other times. Again, whether this pattern was due to individual choice, or what the field exercise menu offered cannot be determined from the results of the present study. (Field menus generally emphasize the provision of full conventional meals.)

While 46% of respondents report they are satisfied with the amount of bread they receive in the field, 41% want more and 10% want much more. In part, this suggests that if more bread were offered in the field then differences in bread consumption between field and garrison would probably disappear. However the reason more bread is wanted may be due to the other meal component portion sizes being too small rather than to the acceptance of bread itself.

²See Reference 2 to body of Report.

FREQUENCY OF CONSUMPTION BY TYPE BREAD

Based on Table C3, it is clear that white bread is consumed more often than other types of bread. Recent studies³ suggest that consumption levels for variety breads such as whole wheat may be increasing. Results from this study suggest that young enlisted men still consume more than twice as much white bread than whole wheat. In addition, when the troops were asked what type of bread they would rather receive when involved in a exercise, 47% report preferring white bread compared to 3% for whole wheat, 5% for cracked wheat and 8% for rye bread. Sweet breads such as raisin and banana were not included for consideration. Data which will be discussed later suggest that sweet breads are as, if not more, highly preferred, than white bread.

ACCEPTANCE RATINGS

The list of bread and bread product alternatives with the ratings they received are shown in Table C4. The sweet breads are clearly the most acceptable with the raisin bread alternative receiving the highest rating.

A post hoc statistical comparison among means (Newman-Keuls method) revealed no significant differences between the raisin bread, granola bars, banana bread, sweet dough bread, white bread and Tray Pack Breakfast Bake. The lowest ratings were given to the canned bread, pumpernickel, B Ration biscuits, sprouted wheat, rice cakes and British biscuits.

It is interesting to note that the MRE crackers rated significantly higher than the canned bread. In contrast, the results of a 1954 field test⁴ revealed that canned crackers were rated much lower (3.9) than canned bread which had been stored for 33 months (7.1). Different formulations of crackers and canned bread were compared in the 1954 study, which was conducted in the context of an actual field exercise. It is impossible to tell on the basis of the present data whether the ratings of current formulations of crackers and canned bread would be affected if they were served as part of a field meal rather than as part of a consumer test panel.

Respondents were also asked to rate each product in terms of how acceptable it would be if it were served as part of a field breakfast, midday or evening meal. The five least and most preferred items for each meal are listed in Table C5. As shown in Table C5, four of the five most acceptable items for all meals were raisin bread, sweet bread, corn bread, and white bread. The fifth item was granola bars for breakfast and banana bread for lunch and dinner.

³See Reference 3 to body of Report.

⁴See Reference 4 to body of Report.

For each meal, a Newman-Keuls test revealed no significant differences in acceptability among the five highest noted products. Products rated most acceptable, with the exception of white bread, are considered sweet products. The high rating for raisin bread supports findings of increased popularity of bread products containing raisins.³

There was more variability between meals for items rated least acceptable. In general the least acceptable items included the non-white, nonsweet fresh breads (pumpernickel, sprouted wheat), shelf-stable products (British biscuits, canned bread, MRE crackers, and rice cakes), and one nonsweet shelf-stable mix (B Ration mix).

In addition to rating these items for preference and acceptability many subjects included comments about individual products. The most consistent comments were on the dryness of the crackers; particularly the British biscuit. Respondents felt the crackers would make them thirsty and they would then need extra liquids, which in the field might present a problem.

INTERVIEWS

The oral interview sought opinions on two issues: Was bread necessary in the field and, if so, why was it considered necessary? Since all participants were encouraged to speak, detailed scoring of answers was impossible.

Several general trends emerged from the interviews. First, out of 84 respondents all but five stated that bread was a necessary part of field meals. The reason for this attitude seemed to be less a preference for bread than a dissatisfaction with the amount of food they received in the field. The quantity rather than quality of the food appeared to be the issue. Bread was considered important because it was a filler. As one respondent stated "Bread fills up the empty spots that other foods don't." Bread was generally eaten in the form of sandwiches or was used to soak up gravy, thus ensuring that no part of the meal would be wasted.

When asked what type of bread or bread alternatives would be acceptable in the field most respondents mentioned the freshness of products as critical. "Fresh baked anything is OK" was a typical answer. White or sweet breads were seen as most preferable. Many of the respondents suggested a variety of fresh baked products; if possible, different ones at different meals. Crackers were seen as acceptable if served occasionally. Major problems with crackers were seen as their dryness, their inability to be used for sandwiches, and their ineffectiveness in soaking up gravy.

CONCLUSIONS

The following conclusions are offered:

1. Bread is considered by young enlisted personnel to be an important component of field rations. It is unclear whether this is due to an actual preference for bread as a food or whether there are insufficient quantities of other food items.

2. Crackers are not considered to be an acceptable substitute for fresh bread in the field particularly because they are perceived to increase problems with thirst.

3. Existing shelf-stable bread products are less preferred than either fresh bread or crackers.

4. There is a range of highly rated alternatives to fresh white bread. Most are sweet and have a soft texture.

5. Sweet variety breads are judged to be an acceptable component of all three meals. They would provide an acceptable alternative for any and all meals when fresh white bread is not available.

TABLE C1. Bread Consumption Per Meal

Location/ Quantity	Meal			
	Breakfast	Midday	Evening	Snack
In General				
Never Eat Meal	20%	3%	1%	23%
Less than 1 slice	26%	14%	19%	36%
1-2 slices	48%	54%	60%	28%
3-4 slices	5%	25%	16%	10%
More than 4	1%	4%	4%	3%
In The Field				
Never Eat Meal	18%	11%	10%	59%
Less than 1 slice	31%	32%	27%	26%
1-2 slices	45%	49%	54%	11%
3-4 slices	5%	7%	8%	3%
More than 4 slices	1%	1%	1%	1%

TABLE C2. Frequency of Eating Sandwiches

Frequency	Field	Garrison
Everyday	7%	25%
2-3 Times/Week	16%	49%
Once a Week	12%	12%
Twice/month	4%	1%
Less than twice/month	58%	6%

TABLE C3. Frequency of Consumption by Type Bread

Type Bread	2-3 Times Each Week	Twice/Month Or Less
White bread	76%	10%
Whole wheat	32%	39%
Rye bread	4%	54%
Corn bread	9%	75%
Granola bars	6%	63%
Syrian bread	0%	39%

TABLE C4. Mean Preference Ratings

Alternative	Mean Rating	Standard Deviation
Fresh Bread Alternatives		
Raisin Bread	8.1	1.0
White Bread	6.9	1.2
Sprouted Wheat Bread	5.7	2.2
Pumpnickel Bread	4.9	2.6
Shelf-Stable Products		
Granola Bars	8.0	1.4
Breakfast Bake	6.8	1.5
MRE Crackers	6.6	1.7
British Biscuits	5.9	2.0
Rice Cakes	5.8	2.1
Canned Bread	4.8	2.3
Shelf-Stable Mixes		
Banana Bread	8.0	1.6
Corn Bread	7.8	1.1
Sweet Bread	7.4	1.0
B Ration Mix	5.3	2.4

TABLE C5. Most and Least Acceptable Products for Each Meal

Meal	Most Acceptable (in descending order)	Least Acceptable (in descending order)
Breakfast	Raisin Bread Sweet Bread Corn Bread White Bread Granola	Pumpernickel Bread British Biscuits Canned Bread Sprouted Wheat MRE Crackers
Midday Meal	Raisin Bread White Bread Sweet Bread Banana Bread Corn Bread	Pumpernickel Rice Cakes Canned Bread Sprouted Wheat B Ration Biscuits
Evening Meal	Sweet Bread Raisin Bread White Bread Banana Bread Corn Bread	Pumpernickel Bread British Biscuits Rice Cakes MRE Crackers B Ration Biscuits

Appendix D

Alternative Bakery Systems

The following bakery equipment systems were identified for evaluation:

1. Containerized bakery with commercial baking equipment;
2. Containerized automated bread baking system;
3. Commercial trailer bakery;
4. Commercial container bakery;
5. Commercial semi-trailer bakery;
6. Commercial tent bakery;
7. Continuous roll making bakery.

These alternatives were selected because they represent systems that could be fielded by 1987: a requirement of the TRADOC Operational and Organization (O&O) Plan. The alternatives are either "off-the-shelf" or require only a limited development effort.

The four commercial bakery systems are available from the West German baking equipment manufacturer, Werner & Pfleiderer of Stuttgart. This firm has sold field bakeries of all four types to a number of foreign governments to include: Greece, Saudi-Arabia, Belgium, France, Germany, Zaire, Nigeria, Algeria, and Libya.

A brief description of each alternative follows.

Alternative 1: Containerized baking system with commercial baking equipment (Figure D1)

The use of 8' x 8' x 20' ISO containers (or other hard shelters) makes it easier to protect against a CB threat and to decontaminate after a CB attack. Climate control can be provided and operation in dust and sand storms is possible.

Commercial mixers, dough dividers, moulders, proofers and ovens are available, off-the-shelf, in a variety of sizes to satisfy almost any output requirement. The use of roll-in racks is proposed as a means to reduce the labor burden. A pass-through version of a proofer and oven would require a development effort, but is not essential to the success of this approach.

A two-side, expandable, 8' x 8' x 20' ISO container can be erected by a crew of four in about 45 minutes. Containers with clam-shell expandable sides can be set-up in less than 30 minutes. Dough making can begin as soon as the baking oven is fired up and the proofer is at operational temperature and humidity conditions, or about an hour after erection of the system begins.

Alternative 2. Containerized automated baking system (Figure D2)

This alternative is included because of the extensive development effort that was carried out at Natick R&D Center, and because a functional prototype in containers is available.

Alternative 3. Commercial trailer bakery (Figures D3)

This bakery consists of three trailers carrying 23' x 8.2' x 12.5' expandable containers, that when in position, side by side, form a closed work space approximately 40 feet wide. In addition to mixing and make-up equipment this system contains two, five-level deck ovens. Production is rated at 1,056 pounds of dough per hour.

Alternative 4. Commercial container bakery (Figure D4)

This bakery is housed in a 40' container and is completely self-contained. It requires only 15 minutes to set-up for operation.

Alternative 5. Commercial semi-trailer bakery

This is a slightly smaller version of alternative 4. It is 36 feet long by 8.2 feet wide, and can be expanded on both sides, clam-shell fashion, to provide a working width of about 16 feet over about two-thirds of its length. Unlike alternative 4, it has a diesel generator in a closed space at the rear end of the container. The upper section of the expanded sides have canvas attached that drops down to enclose the expansion area. Alternatives 3 thru 5 have climate control.

Alternative 6. Commercial tent bakery (Figure D5)

This bakery is similar to the M1945 bakery plant in that trailer ovens are used and the system is operated in a tent. It differs in that it has two spacious trailers for dough making and proofing. This alternative is listed because of its similarity to the M1945 and because a recent cost is known. It also represents, essentially, a MACI version of the M1945.

Alternative 7. Continuous roll-making bakery

A continuous roll-making Bakery was developed at Natick Research and Development Center in the mid-1960's that consisted of a continuous mixing unit and a continuous oven unit. For this baking system, the dough is made from a chemically leavened mix that requires only the addition of water and mixing. The dough output is pumped to a multiple head dispensing device that automatically deposits five, 3 oz. pieces of dough on metal trays carried on an endless chain through the oven. As the trays move through the oven unit, the dough proofs first and is then baked. Following baking the trays are tipped automatically and the rolls are transferred to a conveyor belt. The conveyor carries the rolls out of the oven to a collecting point.

As developed, the bakery can be transported by a 2½ ton truck with a trailer; the oven travels in the truck and the mixer on the trailer. The bakery system could be mounted in an 8' X 8' X 20' ISO container. The production rate is about 125 pounds per hour and the production cycle is approximately 20 to 25 minutes. This short production cycle time is possible only with chemical leavening. Yeast leavening dough cannot be used in the unit as designed because of the longer proofing time required.

DISCUSSION

The production capabilities of the four commercial alternatives are given in Table D1. These values are based on production of European-type bread baked in a loaf pan. European bread is made with soft wheat flour, which means that the mixing time, proofing and baking times are shorter than with the U.S. Army dough formula. The ovens are also equipped with a steam generation means that is required in proofing the product.

Werner and Pfleiderer (W&P) of Stuttgart, West Germany, manufactures several bakeries that probably could satisfy the U.S. Army's field bread requirement with the least development effort. The W&P equipment is of high quality and probably as good as anything that could be obtained under a development contract. An In-house evaluation of spiral mixers, such as those used in the W&P bakeries, with U.S. dough formula indicated overheating of the gear box lubricant to well above design temperatures. The problem of mixing U.S. "no time" dough formula with spiral mixers would need to be addressed.

Relative to mobility, all three W&P mobile bakeries, in present or modified form, represent about the best available commercially. At the present time, none of the containers used in the W&P bakeries meets ISO standards. However, if essential, the equipment in the W&P container and semitrailer bakeries could be configured in 40 ft ISO containers.

Advantages of the single, semi-trailer, mobile field bakery alternative include the facts that the bakery

1. is operational in 15 minutes;
2. is completely self-sufficient to begin baking immediately as water and fuel resources are on board;
3. can close up and move out quickly;
4. can operate closer to customer;
5. requires a minimum number of prime movers;
6. requires a small crew (est. 5-6 men);
7. can be made chemical/biological tight in least time;
8. is easier to decontaminate than tentage;
9. can be climate controlled;
10. requires a minimal equipment investment;
11. is a commercially available item.

The costs of each of the alternatives are shown in Table D2. The first two were estimated based on information available on shelters and commercial and developmental equipment (see Tables D3 and D4). The last four (Table D2) are prices supplied by the West German manufacturer, Werner & Pfleiderer.

RECOMMENDATION

Based on the findings of the system analysis and the advantages of a single, semi-trailer, mobile field bakery, recommended the Army adopt a modified W&P type semi-trailer bakery at the direct support company level.

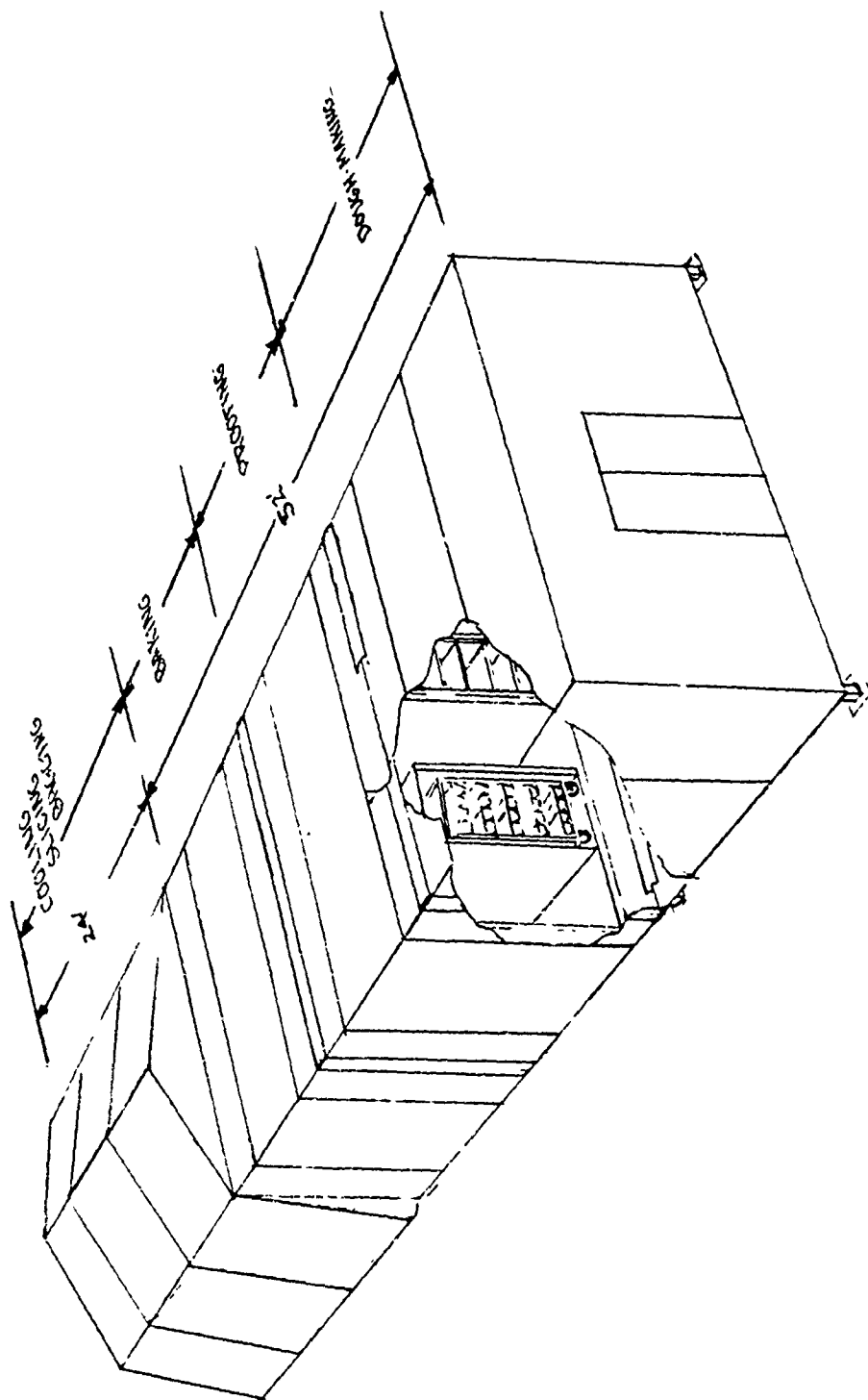


Figure D1. Containerized manual bakery

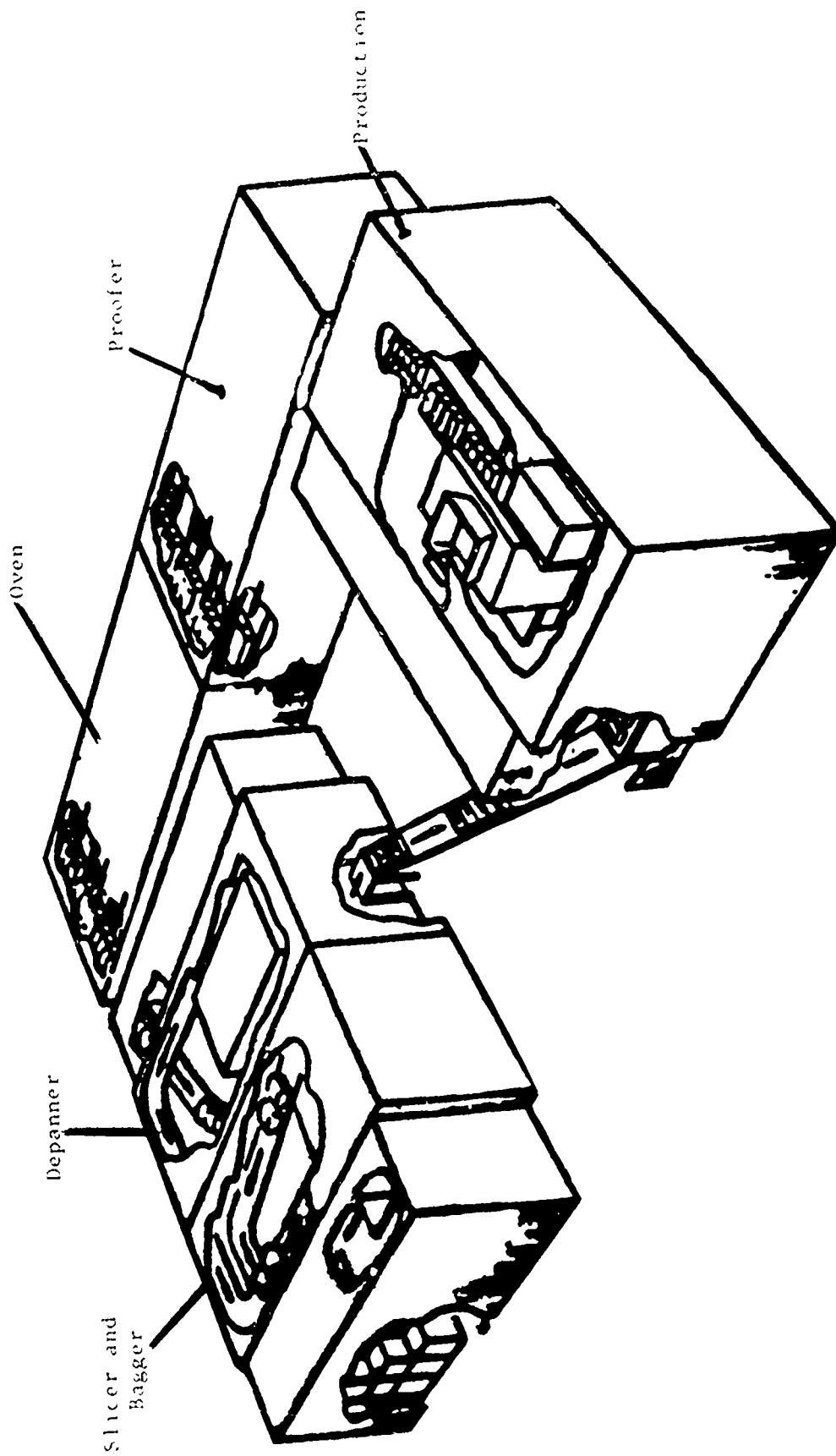


Figure D2. Containerized automated bakery

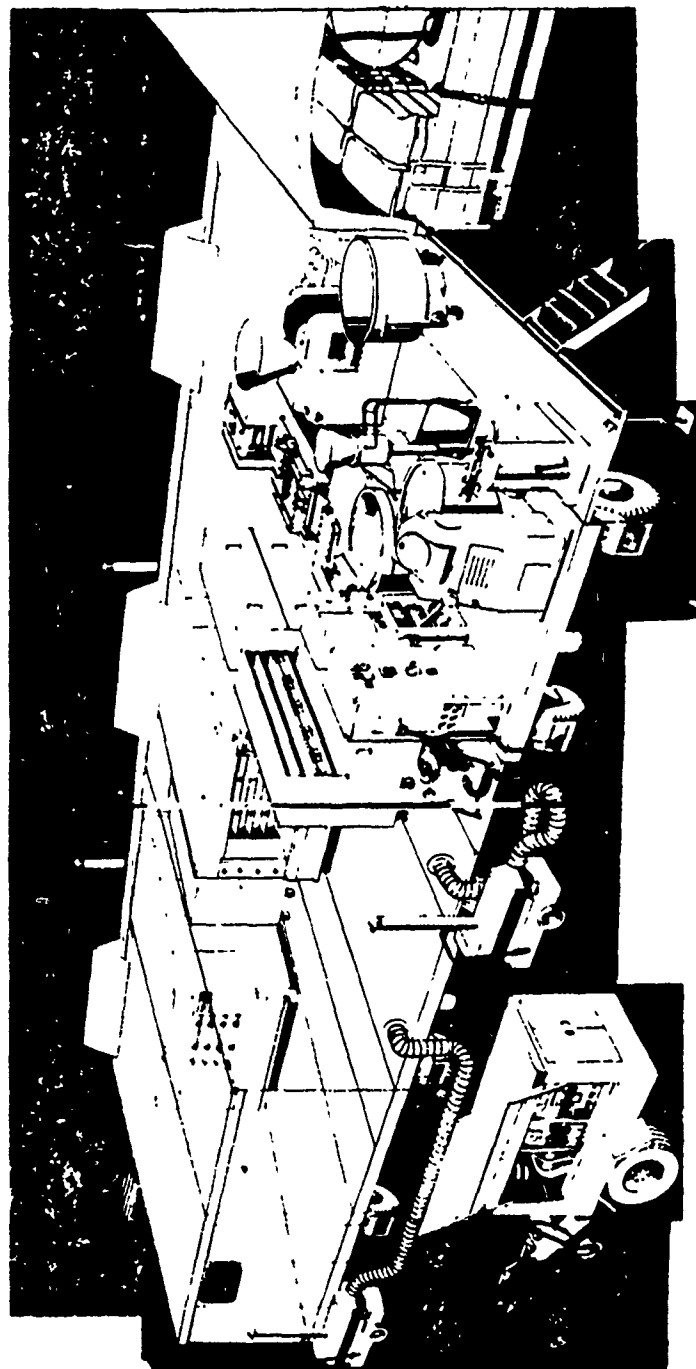


Figure D3. Commercial trailer bakery (Werner & Pfleiderer, West Germany)

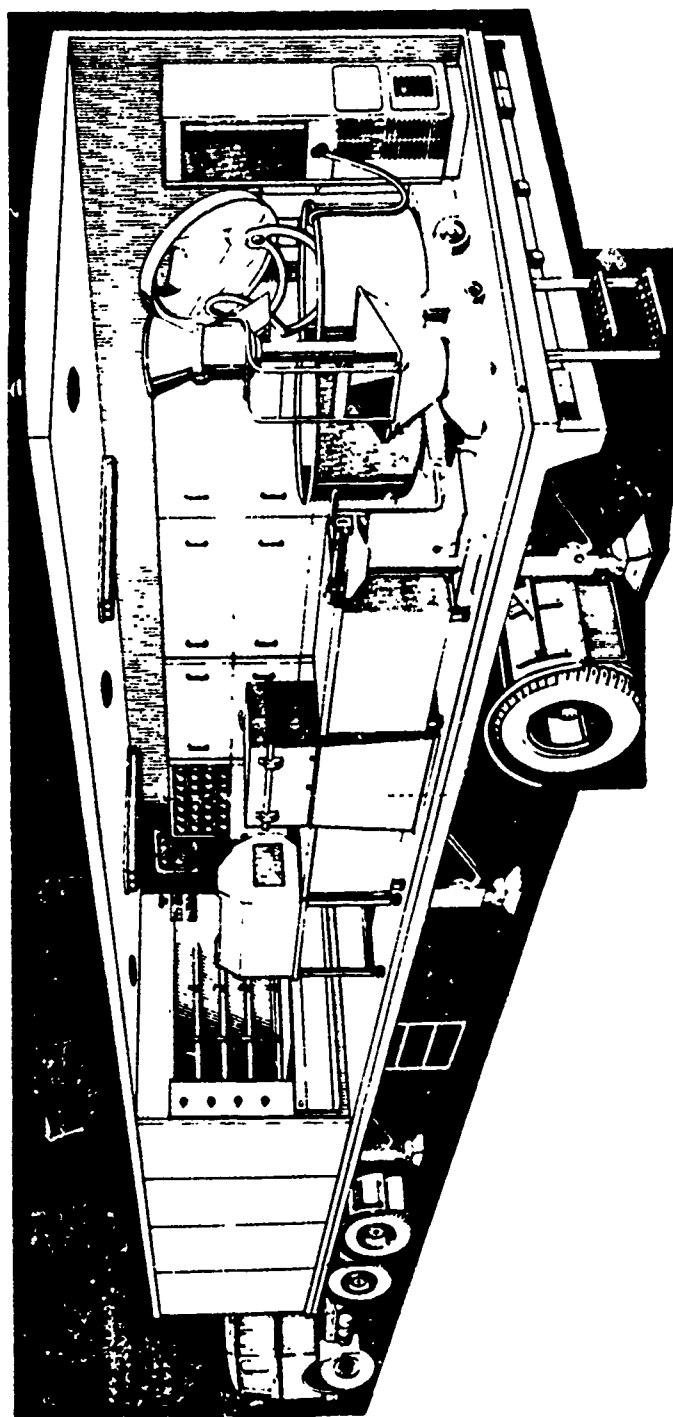


Figure D4. Commercial mobile container bakery (Werner & Pfleiderer, West Germany)

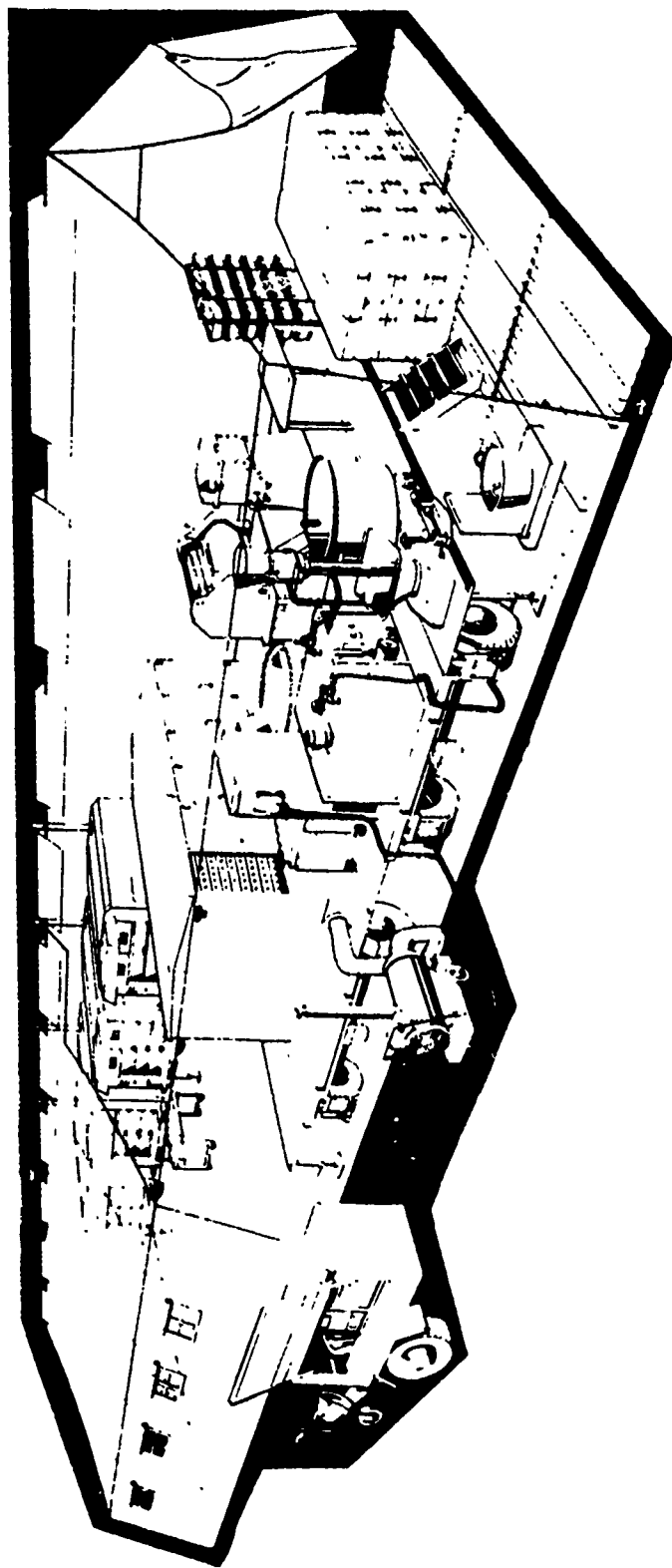


Figure D5. Commercial tent bakery (Werner & Pfleiderer, West Germany)

TABLE D1. Production Capacity of Field Bakeries Manufactured
by Werner & Pfleiderer, West Germany (21 oz. loaf)

Alternative	Lbs/Hr	Loaves
Trailer Bakery (Alt. 3)	1,056	800
Container Bakery (Alt. 4)	660	500
Semi-Trailer Bakery (Alt. 5)	384 (est)	293
Tent Bakery (Alt. 6)	1,584	1,200

TABLE D2. Equipment Cost Summary of Alternative Bakery Systems

Bakery System	Cost (\$)
Alt.1 Containerized Manual Bakery	537,267
Alt.2 Containerized Automated Bakery	891,950
Alt.3 Commercial Trailer Bakery	564,190
Alt.4 Commercial Container Bakery	419,318
Alt.5 Commercial Semi-Trailer Bakery	300,000
Alt.6 Commercial Tent Bakery	613,000

TABLE D3. Containerized Bakery System Equipment Cost (Alt. 1)

Equipment Items	Cost
Dough Making	
1-2 side expandable ISO container	\$100,000
Mixer-Champion	24,000
Dough Divider-Acme	16,670
Moulder-Champion	9,285
Water heater, electric	2,000
Water pump	300
Electrical Distribution Panel	2,000
Total	\$154,345
Proofing	
1-2 side clamshell ISO container	\$ 50,000
3-2 rack proofing cabinets	60,000
Total	\$110,000
Baking	
1-2 side clamshell ISO container	\$ 50,000
3-2 rack convection ovens	150,000
Total	\$200,000
Cooling/Bagging	
3-8 foot section temeri tent	\$ 7,500
Bagging machine	10,000
Fans/blowers (2)	5,000
Total	\$ 22,500
Miscellaneous	
15-5 tier, 4 wheel racks @ \$300	\$ 4,500
540-bake pans (strapped) @ \$10	5,400
2-diesel gen 60 kW @ \$18,725	37,450
2-heaters	2,372
Total	\$ 49,722

TABLE D4. Automated Baking System Equipment Cost (Alt. 2)

Equipment Items	Cost
Dough Making - Panning	
1-side expandable ISO container	\$100,000
1-continous dough maker/panner	
2-60-gallon kettles with mixers, pump, piping and valving	150,000
1-water heater with pump	2,000
2-SS sinks for clean up	500
1-transfer conveyor	2,000
Total	\$254,500
Proofing	
1-shelter, side opening conveying system, humidity temperature control transition to oven	\$ 50,000
Total	50,000
	\$100,000
Baking	
1-shelter, side opening oven, conveying system, heating systems, control	\$ 50,000
Total	200,000
	\$250,000
Power	
1-ISO frame open	\$ 50,000
2-Diesel 60 kW generator	37,450
Total	\$ 87,450

END