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Analysis of Alternative Means of Transporting Heavy Tracked Vehicles at Fort Hood, Texas

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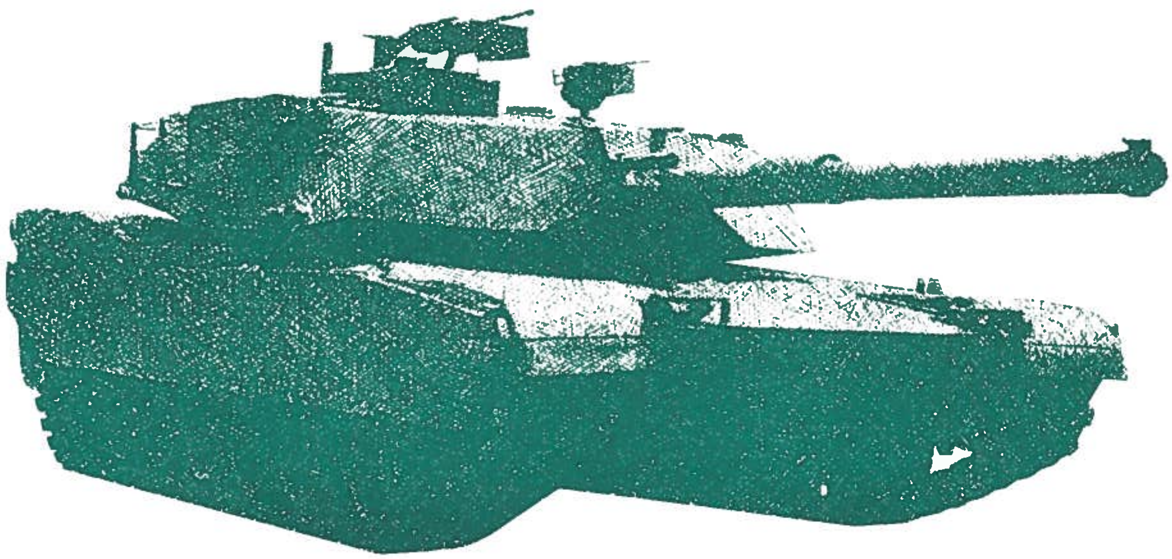

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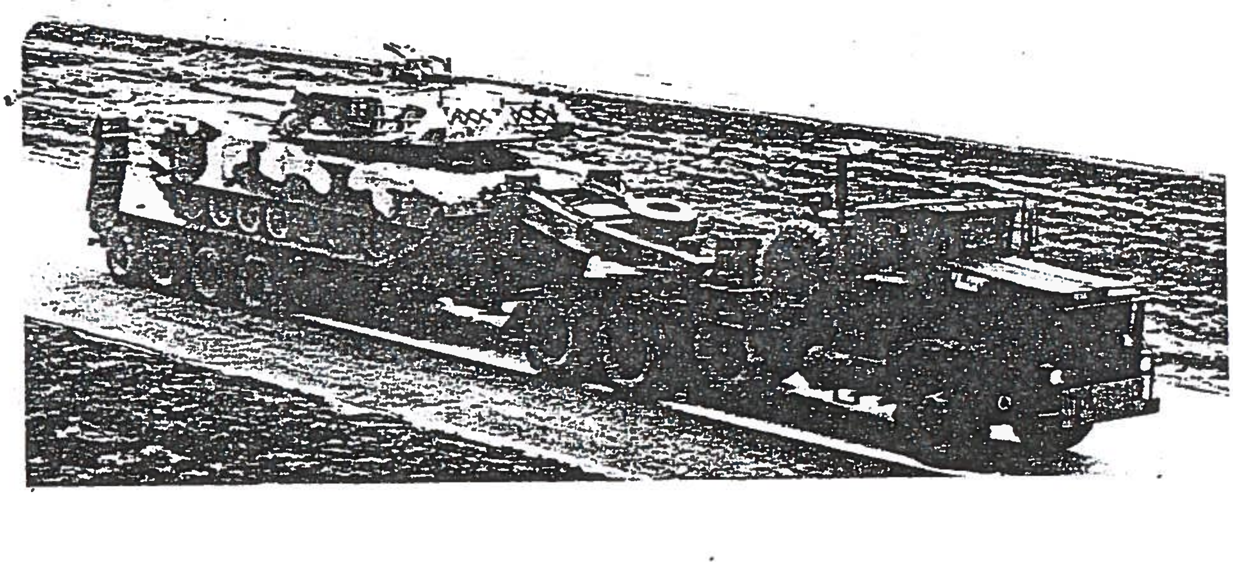
LIST OF ACRONYMS

AMC	Army Materiel Command
ARLF	Average Remaining Life Factor
ASB	Ammunition Storage Bunker
ATSF	Atchison, Topeka, and Santa Fe Railroad
AVLB	Armored Vehicle Launched Bridge
B/C	Benefit to Cost Ratio
COFC	Container-on-Flatcar
CRF	Capital Recovery Factor
DEH	Directorate of Engineering and Housing
DIVAD	Division Air Defense
DIVARTY	Division Artillery
DOL	Directorate of Logistics
DR	Discount Rate
DRM	Directorate of Resource Management
EAC	Equivalent Annual Cost
ESAL	Equivalent Single-Axle Load
FTX	Field Training Exercise
G3	Division Training Office
G4	Divsion Supply Office
HET	Heavy Equipment Transporter
MATES	Mobilization and Training Equipment Site
MLRS	Multiple Launch Rocket System
MTMC	Military Traffic Management Command
MTOE	Modification Table of Organization and Equipment
NTC	National Training Center, Ft. Irwin, CA.
O & M	Operating and Maintenance
OMB	US Office of Management and Budget
POL	Petroleum, Oil, and Lubricants
PV	Present value or present worth
ROW	Right-of-Way
SAM	Surface-to-Air Missle
SUPCOM	Support Command
TACOM	Transportation and Automotive Command
TOW	Tube-Launched, Optically-Sited, Wired-Guided Missle
TROSCOM	Troop Support Command
TXNG	Texas National Guard



EXECUTIVE SUMMARY

The problem addressed in this report is a transportation problem -- Given that a volume of heavy tracked vehicles must be moved from storage and maintenance locations to field training and other locations, what is the best way to move them? The options are to drive them, carry them by heavy equipment transporters (HETs), or carry them by railroad. Within each of these options are several variations, generating a total of roughly 10 alternatives for evaluation.

To facilitate comparison, as much as possible is held constant among the alternatives. Total vehicle mileage for training purposes, for example, is assumed to be the same for all alternatives. Those things which are affected by the choice of alternatives are labelled impacts, and separated into costs and benefits. For this analysis, costs include direct capital expenditures (new trucks, new rail construction), and transportation costs (operating costs, depreciation of existing facilities, maintenance of rights-of-way and structures); benefits consist of tracked vehicle operating cost savings and shipping cost savings.

This information -- most of which must be estimated, with at least some degree of error, and some of which is subject to several interpretations or is inherently elusive in magnitude -- is used as data for the evaluation of the alternatives. Decisions about discount rates, capital asset lifetimes, and opportunity costs are made during the evaluation phase. The results, inevitably, are sensitive to the values of the data and parameters, and a range of uncertainty is explored to determine the points at which one alternative succeeds another. The choice of investment, if any, depends upon which combination of data and assumptions is thought to reflect most closely the essence of the choices available.

The analysis suggests that tracked vehicles in general, and the M1 tank in particular, are so costly to operate in a self-powered mode that almost any method for transporting them will save enough in tracked vehicle operating costs and depreciation to be worthwhile. Whether the preferred mode is HET or rail may depend upon considerations lying outside this analysis, but the weight of evidence thus far tends to favor HETs as the more cost-effective alternative.

SUMMARY OF RESULTS

A summary of the study results is presented in Table 1. Ten transportation alternatives were explicitly examined:

- A Full Roadmarch alternative, in which all tracked vehicles are roadmarched to the field; this alternative served as the base against which other alternatives were measured.
- A partial HET alternative intended to replicate Current HET Operations at Ft. Hood.
- An Expanded Existing HET alternative designed to maximize the use of the 96th Transportation Company for transporting M1 tanks and M2/M3 Bradleys to and from training areas.
- Three Full HET alternatives, which require the equivalent of two full HET companies on post. Two of these alternatives utilize military HETs and differ only in where the HET companies are assigned organizationally. The third alternative utilizes HETs and drivers supplied by a civilian commercial hauler.
- A Full Rail alternative, in which a single-track rail loop would be constructed from South Ft. Hood, to the MATES facility at North Ft. Hood, and back to South Ft. Hood, along an alignment roughly parallel to the existing range roads, and including a spur to the existing Santa Fe Railroad mainline trackage.
- Three Partial Rail alternatives incorporating the main line spur and the segment from South Ft. Hood to North Ft. Hood along West Range Road, plus one or none of the following segments: MATES to Crittenberger tank range, or South Ft. Hood to the Curry ranges.

All of the project alternatives appear cost-effective relative to the Full Roadmarch alternative, due primarily to the high cost of roadmarching heavy tracked vehicles. On an annualized basis, rail operations are less costly to operate and maintain than HETs, but the Full HET alternatives achieve substantially greater reductions in tracked vehicle mileage, because HETs are able to transport tracked vehicles much closer to their final training destinations. In terms of net annualized benefits (annualized benefits less annualized costs), the Full HET alternatives in general, and the commercial HET alternative in particular, appear to be most cost-effective.

Brief discussions of specific cost elements and noteworthy differences among the transportation alternatives are presented below.

TABLE 1. SUMMARY OF RESULTS (In Millions of Dollars)

	Current HET Operation	Expanded Existing HET	- Full HET - Military	Commercial	Full Rail Loop	West Rail to Curry	West Rail to Critten.	West Rail Only
NEW CAPITAL COSTS								
Transportation Vehicles	0.0	0.0	7.800	0.0	2.750	2.750	2.750	2.750
Facilities and Equipment	0.0	0.0	1.950	1.020	0.344	0.344	0.344	0.344
Right-of-Way and Structures	0.0	5.000	5.000	5.000	77.502	56.002	51.681	42.683
TOTAL COSTS FOR NEW CAPITAL	$0.0	$5.000	$14.750	$6.020	$80.596	$59.096	$54.775	$45.777
ANNUALIZED TRANSPORTATION COSTS								
Annualized Costs for New Capital	0.0	0.472	1.830	0.568	5.840	4.280	3.973	3.321
Annualized Costs for Existing Capital	0.432	1.123	0.559	0.985	0.179	0.178	0.185	0.175
Transportation Systems Operations								
Vehicle Operations and Maintenance	0.872	2.557	5.031	3.722	0.409	0.408	0.417	0.328
Administration and Overhead	0.162	0.518	0.986	0.582	0.174	0.174	0.174	0.174
Crew Transportation Costs	0.051	0.152	0.295	0.295	0.212	0.198	0.189	0.145
Maintenance of Ways and Structures								
Pavement Damage to Range Roads	0.729	1.823	2.863	2.863	0.0	0.0	0.0	0.0
Maintenance of Railroad Trackage	0.0	0.0	0.0	0.0	0.185	0.174	0.173	0.101
Annualized Opportunity Cost of Land Used	0.0	0.0	0.002	0.002	0.025	0.019	0.017	0.014
TOTAL ANNUALIZED COSTS	$2.246	$6.645	$11.566	$9.017	$7.024	$5.431	$5.128	$4.258
ANNUALIZED TRANSPORTATION BENEFITS (Cost Savings)								
Tracked Vehicle Operating Costs								
On-Post Movement of Ft. Hood Units	5.931	18.071	29.339	29.339	16.684	15.313	15.172	11.593
On-Post Movement of Texas NG Units	0.0	0.0	0.0	0.0	1.182	1.147	1.054	0.995
Outloading of Ft. Hood Armor Units	0.0	0.0	0.0	0.0	0.487	0.487	0.487	0.487
Tank Trail Maintenance Costs	0.003	0.010	0.020	0.020	0.014	0.013	0.013	0.010
Shipment of Vehicles & Equipment to MATES	0.0	0.0	0.0	0.0	0.702	0.702	0.702	0.702
TOTAL ANNUALIZED BENEFITS	$5.934	$18.081	$29.359	$29.359	$19.069	$17.662	$17.428	$13.787
NET ANNUALIZED BENEFITS	$3.688	$11.436	$17.793	$20.342	$12.045	$12.231	$12.300	$9.529

New Capital Costs. Initial capital costs are those expenditures for guideway construction (railroad and highway), equipment (tractors, semitrailers, locomotives, flatcars, maintenance equipment), and facilities (shops, yards, buildings) required to support each alternative. As would be expected, initial capital costs for the rail alternatives are much higher than for the HET alternatives.

When annualized, new capital costs for the rail and HET alternatives are closer together: $2.4 million for the military Full HET versus $6.0 million for the Full Rail (a ratio of about 2.5 compared to almost 5.5 for the lump sum figures). These results are based on a discount rate of 7 percent and expected lifetimes of about 10 years for HETs versus 40 years for rail facilities. Thus, the large initial expenditure for rail buys a longer-lived asset, but one which is still more expensive on an annual basis when both depreciation and opportunity costs are included.

Transportation Systems Operations. Costs for operating HETs include repair parts, fuel and lubricants, drivers and maintenance labor, depreciation of existing tractors and semitrailers, administrative overhead for HET companies, and repair of damage to on-post highways. Using existing HETs does not eliminate either the capital depreciation or the opportunity costs of the vehicles from the costs of the HET alternative, but the costs appear as operating costs rather than as initial capital expenditures. HETs also produce substantial highway damage from carrying heavy loads on light-duty roads.

Operating costs for the commercial HET alternative are substanitally less than those for the military HET options, even after inclusion of a reasonable profit for the commercial hauler. These cost differences can be attributed to: 1) lower maintenance costs for commercial HETs; 2) a reduced number of drivers and mechanics; and 3) fewer supervisory personnel. The capital costs of commercial HETs are also less than those of military HETs because they do not need to operate in a combat environment.

Rail operating costs are substantially less than those for any of the HET alternatives due to the high load capacity and durability of the vehicles and guideway, and substantially lower labor requirements.

The opportunity cost for land at Ft. Hood taken from other purposes for use in transportation was valued at the price required to purchase additional land at the fringes of the post. Land costs represent less than one-half of one percent of the annualized costs of the alternatives.

Annual Transportation Benefits. All benefits are measured as cost savings for the transportation of tracked vehicles and other equipment, relative to the Full Roadmarch alternative. M1 tanks cost roughly $183 per mile in avoidable costs to operate, and the Bradley M2/M3 vehicles cost about $103 per mile. Most other tracked vehicles range downward from there in operating cost. These costs include replacement parts at all levels (battalion to depot), as well as civilian and military maintenance labor. Crew costs are not included.

Other benefits included in the evaluation are shipping and outloading cost savings for the rail alternative, and reduction in the maintenance costs of tank trails.

Current operations with existing HET vehicles already achieve a modest share of the potential tracked vehicle cost savings. Optimal use of the existing on-post HETs could more than triple these savings. The Full HET alternative realizes the greatest annual benefits -- $29.4 million per year -- a sum which would both cover its operating costs and repay its initial capital investment within one year. The rail alternatives also generate substantial cost savings, ranging from $13.8 million for the shortest rail segment to over $19 million for the Full Rail alternative. With these benefits, even the most expensive rail system would be able to repay its initial capital investment in 5.6 years.

<u>Net Annual Benefits</u>. Although the Full HET alternative yields the greatest benefits, it is also the most costly to operate and maintain, on an annual basis. Subtracting annual costs from annual benefits yields a net annual benefit of $17.8 million for the military Full HET alternatives and $20.3 million for the commercial HET alternative. Similar computations for the rail alternatives yield net annual benefits ranging from $9.5 million to $12.3 million.

Among the rail alternatives, the West Rail segment with an extension to the Crittenberger range generates the largest net benefits ($12.3 million), and at a lower initial and annualized cost than either the Full Rail ($12.0 million), or the West Rail segment plus Curry extension ($12.2 million).

All of the project alternatives that were considered are much better than the Full Roadmarch or current HET operations. The commercial HET alternative generates the largest net benefits, and is also the least risky, in that nearly all of the capital assets acquired under this alternative could be liquidated should the need to transport tanks on-post at Ft. Hood diminish.

<u>Other Impacts and Considerations</u>. A number of impacts could not be explicitly monetized, either because of uncertainty in their outcome or disagreement in their valuation. Nevertheless, they represent important considerations that should be addressed in selecting among the alternatives.

Construction of a railroad on post at Ft. Hood has the potential to reduce transportation costs for bulk shipments of fuel, ammunition, and repair parts, as well as the outloading of men and equipment. Based on the information made available to the study team, approximately $1.4 million in annual cost savings could be achieved from the proposed track configurations; these savings have been explicitly included as rail benefits. Further savings would require construction of additional trackage, not necessary for the on-post movement of tracked vehicles. These other rail construction efforts can and should be evaluated as independent projects.

The increased number of sidings and railheads available under the rail alternatives have the potential to significantly reduce the time required to outload large volumes of vehicles and equipment from Ft. Hood. The strategic value of this reduced time for mobilization (up to 3 days per armor division), depends on both the specific mobilization scenario and any downstream constraints in the mobilization network.

All of the transportation alternatives will significantly increase the time required to move tracked vehicles from their cantonment areas to field training areas. These travel time increases range from 1 to 12 hours per training mission under the HET alternatives, and from 3 to 18 hours per training mission under the rail alternatives. While the value of the extra travel time depends in large part on how it would otherwise be used, it is clear that this impact represents a decrease in the net benefits presented in Table 1.

Both the HET and rail alternatives provide division troops with additional training in loading and unloading tracked vehicles. While there is clearly some positive value in this training, it is not clear how much training is needed to maintain an acceptable level of proficiency among the units. The military Full HET alternatives also provide additional training for HET drivers, and establish at least one additional military HET company capable of providing combat support to the resident armor divisions.

A potential drawback to the military HET options is that fulltime utilization of military HET vehicles will accelerate their depreciation and decrease their state of combat readiness. While vehicle depreciation and replacement have been explicitly accounted for as costs in the analysis, combat readiness implies that the vehicle is available for service at any specific point in time. This problem does not apply to either the commercial HET or rail options, because they use equipment which would not be mobilized.

PRE-POSITIONING OF TRACKED VEHICLES AT TRAINING AREAS

As an alternative to transporting tracked vehicles to and from training areas, the vehicles could be stored in the field, closer to their training areas. The substitution of pre-positioning for some form of on-post transportation system does not appear to be cost-effective because pre-positioning would require substantially more tracked vehicles than are currently available at Ft. Hood, as well as additional facilities to store and maintain them. The capital costs to acquire the additional vehicles are greater, on an annualized basis than the potential cost savings.

A more modest pre-positioning option, implemented in conjunction with an on-post transportation system could provide additional cost savings in the range of $4 to $5 million per year through the reduction of inter-range travel for armor and infantry/cavalry units during gunnery qualification exercises. A potential issue related to pre-positioning concerns the willingness of M1 and Bradley crews to share their vehicles with other units.

CRITICAL ASSUMPTIONS AFFECTING THE CHOICE OF INVESTMENT

Evaluation of investment alternatives is based on assumptions and estimates; there are no absolute "true" assumptions or "correct" numbers. Assumptions are derived, in part, from theory, but many critical choices will always be left to judgment. For each set of assumptions, there are quantitative dollar magnitudes that represent the concepts of cost and benefit embodied in the assumptions. These magnitudes can be estimated, with varying degrees of accuracy, by acquiring data that provide relevant empirical evidence. It is almost never a matter of finding the right number, but of constructing the best number to represent the assumptions.

Obviously, some assumptions and estimates have greater impact on the evaluation than others. A fundamental purpose of good economic analysis is to direct attention to those particular assumptions -- varied within a plausible range of choice -- that are most likely to tip the apparent preferability of an alternative one way or another. Those assumptions that have emerged from the analysis as being the most critical are described below, in more or less descending order of importance.

Tracked Vehicle Operating Costs. Estimates on the unit costs of roadmarching M1 and M2/M3 vehicles are detailed in Chapter 4, and these costs are very large. The consequences of using these estimates are twofold: first, any of the proposed investment alternatives generate sufficient savings from reduced tracked vehicle mileage to easily pay for themselves; and second, the alternative that focuses most single-mindedly on carrying tracked vehicles instead of roadmarching them (the HET alternative) dominates the others. Benefits from other uses of the railroad are small compared to the HET benefits in reducing vehicle mileage for the M1 and M2/M3.

The operating and maintenance costs for the M1/M2/M3 tracked vehicles were obtained directly from the Army's Tank and Automotive Command (TACOM) and represent the most recent and complete empirical cost data available. Nevertheless, because of the influence these unit costs have on the study results, sensitivity tests were conducted. Substituting estimates for tracked vehicle unit operating costs equal to approximately half the TACOM values, for example, yields net annualized benefits of $4.4 million for both the military Full HET alternative and the Full Rail alternative. In other words, the two alternatives become virtually identical in terms of their net benefits and, although they still yield positive net benefits, those benefits are substantially reduced.

Thus, the most critical assumption in the analysis is that the Army will continue to use the M1/M2/M3 tracked vehicles, or ones equally costly to roadmarch, in the future. Procurement of tanks that are cheaper to operate, substitution of different vehicles for field training, or other actions that would reduce roadmarching costs, could significantly change the character and benefits of the alternatives.

Railroad Construction Costs. The single greatest cost item for any of the rail alternatives is the capital costs of constructing the mainline trackage and sidings. As with the tracked vehicle operating costs, these costs were carefully researched and represent the best available estimates, short of a firm construction bid price. There are, however, two major uncertainties in the construction cost estimates which could have a profound impact on the final cost: 1) the specific soil conditions found in the railroad alignment; and 2) possible delays in the overall track construction schedule.

The unit cost for earthmoving used in the study was based on a cursory examination of soil conditions in the Ft. Hood area. While it is unlikely that average earthmoving costs will be significantly lower than this estimate, they could be higher if unusual rock formations or unstable soil conditions were encontered. This would increase the total capital cost for the rail alternatives, which would translate into an increase in the annualized opportunity cost of new capital, and thereby decrease the net annualized benefits of rail relative to the other alternatives.

A major potential source of delay in rail construction comes from the possible discovery of archeological sites within the proposed rail alignment. These sites either would have to be fully excavated before construction could continue, or the alignment changed to circumvent the site. Given the number of archeological sites already uncovered at Ft. Hood, it is very likely that the two-year construction estimate assumed in the study might increase by a year or more. A one-year lag in construction would decrease the net annualized benefits of the Full Rail alternative by about $1.2 million.

The rail construction cost estimates presented in this study are based on the assumption that neither of the above problems will occur to any significant extent. Consequently, the net annualized benefits resulting from the rail alternatives reflect a somewhat optimistic construction scenario; any deviation from this scenario will likely decrease the overall attractiveness of rail relative to HETs.

Feasibility of Acquiring Division HET Companies. The military Full HET alternative is predicated on the assumption that one or two fully equipped, but partially staffed, HET companies can be assigned to Ft. Hood. While similar organizational changes have been proposed in the past, it is by no means certain that such a structure would be authorized by the Army, regardless of its economic merit. Some variations on the assumed organizational structure of the military Full HET alternative, and their implications with respect to net annualized benefits, are presented below.

If the military Full HET alternatives were implemented with fully staffed division-based HET companies, annual personnel costs would increase by approximately $1.5 million per company. While some of this increase in personnel costs might be offset by military readiness and training benefits, the Army would likely incur additional net costs above and beyond those stated in this study.

If division-based HET companies cannot be authorized, the HET alternative might be implemented by reassigning one or more HET companies from other posts to Ft. Hood. The suitability of such a move requires that the existing HET companies be so underutilized that the benefits foregone at their current posts plus the costs of moving them to Ft. Hood are less than the costs of starting new companies at Ft. Hood.

Highway Damage from Increased HET Use. A major cost associated with the HET alternative is the additional pavement damage resulting from the increased number of heavily loaded vehicles using the range roads. As discussed in Chapter 6, pavement damage is a function of the weight of the tracked vehicle being carried and the number of load-bearing axles on the HET. Throughout this study, it was assumed that the weight of an M1 tank was 59 tons and that this weight, plus the weight of the HET tractor and trailer, was distributed equally over the 7 axles of the M911/M747 HET unit. The resulting pavement stress for this weight and axle configuration is 36 equivalent single axle load (ESAL) miles per HET mile.

If the same tractor/trailer configuration were to carry the new 70-ton M1A1 tank being proposed for deployment at Ft. Hood, the resulting pavement stress would increase to 80 ESAL-miles per HET mile, and the equivalent annual highway depreciation would jump from $2.78 million to $5.14 million. However, it is virtually certain that introduction of the M1A1 tank to Ft. Hood will be accompanied by replacement of the M747 HET trailer with the XM1000, because the M747 is structurally unable to even support the weight of an M1A1 tank, let alone transport it over a paved road.

The load configuration of the XM1000 semitrailer will be distributed over a minimum of 6 axles instead of 4. Resulting pavement stress from an M1A1 tank on this trailer would be approximately 20 ESAL-miles per HET mile, and the equivalent annual highway depreciation would drop from $2.78 million to $1.4 million. Thus, the most likely scenario involving introduction of the M1A1 tank to Ft. Hood will result in a 50 percent decrease in highway depreciation and a corresponding increase in net annualized benefits for the Full HET alternative.

Use of Existing Resources. "Existing resources" mean capital equipment, facilities, materials, and labor already owned or employed by the Army. These include existing locomotives, flatcars, land, on-post highways, HET tractors and semitrailers, tracked vehicles, HET crews and other military personnel, and civilian labor. These resources could be either sold, released, or used for a purpose other than one of the proposed alternatives. In the analysis, each existing resource consumed was assigned a dollar value to reflect the opportunity cost of not employing the resource in its next best use. None of the existing resources was treated as "free" (i.e., an unrecoverable sunk cost).

Exclusion of the costs of existing resources from the calculations would reduce the annual costs and thereby increase the net benefits for all HET and rail alternatives, but the greatest increase in net benefits would accrue to the military HET alternatives.

Discount Rate. In almost any investment feasibility analysis, the discount or implicit real "interest" rate has a major quantitative effect on the results, within ranges of discount rates that are plausible values for the circumstances. Investments in long-lived assets (e.g., a railroad) compare more favorably to other alternatives or to the status quo when lower discount rates are used. This uncertainty cannot be eliminated, because there is no rigorous way to establish the correct discount rate.

For the Fort Hood study, 4 percent was judged to be the lowest acceptable rate and 10 percent the highest rate, with 7 percent chosen as the most suitable discount rate. Using these values and holding other assumptions constant, the annual net benefits for the commercial HET alternative varied from \$20.5 to \$20.1 million, while those for the Full Rail went from \$15.3 to \$8.7 as the discount rate went from 4 to 10 percent. The Full Rail alternative, being the one with the largest initial investment, is the most sensitive to the discount rate. Rankings within the rail alternatives change with these rate variations, but the Full HET alternatives always remain significantly higher in terms of net benefits.

CHAPTER 1. DESCRIPTIONS OF THE ALTERNATIVES

A total of ten transportation alternatives were investigated in this study. Four of the alternatives involve construction of a railroad on post at Ft. Hood and examine the costs and benefits of various proposed combinations of track segments. Another four alternatives investigate the expanded use of heavy equipment transporters (HETs) to move tracked combat vehicles to and from the field for training. A base case alternative in which all tracked vehicles are assumed to be roadmarched to and from training is provided as a common standard of comparison for the HET and rail alternatives. Finally, an alternative representing current HET operations is provided to compare the potential costs and benefits of proposed alternatives to a "do nothing" alternative. Each of these alternatives is discussed below.

1.1 THE BASE CASE (FULL ROADMARCH) ALTERNATIVE

Evaluation of a proposed project must necessarily be conducted as a comparison between two alternatives (i.e., the assessment of benefits and costs is always relative to something, rather than being an absolute measurement). All project alternatives are compared initially to a base alternative, and those projects whose net benefits exceed their costs may be compared to each other.

The function of the base alternative is to represent the null case or status quo. In that sense, it is treated as the most likely outcome if none of the project alternatives are implemented. For purposes of evaluation, however, the base case should constitute the best feasible use of the existing stock of capital resources, including vehicles, rights-of-way, guideways such as highways and railroad tracks, and other facilities. If the base alternative is not efficiently designed, a bias may be created in favor of one of the project alternatives.

Compromises with realism are sometimes acceptable if the clarity of the choices is improved. Current transportation of tracked vehicles at Ft. Hood includes some use of HETs, through the 96th Transportation Company in the 13th Support Command (SUPCOM), but this has been ignored in designing the base case. Instead, current HET operations are treated as a separate alternative. Thus, the clarity of the comparison between HETs and the base case is enhanced by designing the base alternative to exclude the use of HETs for carrying tracked vehicles.

Under the Base Case or Full Roadmarch alternative, it is assumed that all tracked vehicles are roadmarched (i.e., driven under their own power) to and from on-post field training missions. It is also assumed that tracked vehicles are roadmarched from their motor pool areas to the existing South Ft. Hood railhead for outloading. HET use by the 96th Transportation Company is assumed to be limited to recovery of disabled vehicles from the field.

Several factors are assumed to remain constant across all alternatives. First, it is assumed that the current number of tracked vehicle movements to and from training will remain the same across all alternatives into the future. Second, it is assumed that the tracked vehicle mileage consumed in actual training (i.e., in field training exercises) will be unaffected by the transportation alternative. Consequently, any savings in tracked vehicle mileage achieved under the proposed alternatives would be translated into reductions in tracked vehicle operating costs.

1.2 HET ALTERNATIVES

A HET consists of a 3-axle tractor (M911) and a 4-axle semitrailer (M747), as currently configured. One HET has the capacity to carry one tracked combat vehicle such as an M1 tank or an M110 howitzer. Thus loaded, a HET is not permitted on public highways because of the pavement stress resulting from the amount of weight on each axle.

The operating and maintenance costs of a loaded HET are substantially less than the costs of driving most tracked vehicles. Consequently, the economic benefits of the HET alternative depend upon the level of utilization of available HET vehicles, the capital costs of acquiring them, and purposes for which HETs would be used other than hauling tracked vehicles.

Full HET Alternatives. Under the Full HET alternative, it is assumed that each of the 2 armor divisions on post would have access to the equivalent of a full HET company of 22 to 24 vehicles, staffed with sufficient personnel to operate and maintain the HETs for the principal purpose of transporting tracked vehicles to and from the field for training. All tracked combat vehicles, except those belonging to the M113 family would be transported via HET.[1] Tracked vehicles would be loaded onto HETs in the motor pool areas in order to minimize travel distance. HETs would travel along paved or improved surface roads to an off-loading point as close as possible to the unit's final training destination. HETs would not routinely travel in areas which are only

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1 The assumption that M113 tracked vehicles would not be transported via HET is based on a comparison of the respective O & M costs and depreciation for the two modes of transortation. Including HET deadhead mileage, the average cost to transport an M113 by HET ($26.34/mile) is higher than the cost to roadmarch the vehicle ($17.94/mile).

accesible via tank trails. Consequently, access to certain training areas would require that the tracked vehicles be off-loaded and roadmarched a short distance to their final destination. Tracked vehicle crews, who typically ride in their vehicles under a roadmarch scenario, would have to be transported to the field by truck or, if space were available, in the roadmarched M113 personnel carriers.

Typical HET assignments would involve transporting company-sized units, requiring from 6 to 18 HETs per assignment. Battalion-sized units would require the HETs to make up to 4 round trips in order to transport all tracked vehicles to the field. Most company-sized HET assignments could be completed in 2 to 2.5 hours, including loading and off-loading the tracked vehicles and deadheading the empty HETs back to the motor pool area. Battalion-sized units would require up to 12 hours to get all tracked vehicles to the field.

Current estimates of on-post training at Ft. Hood indicate that each armor division conducts approximately 410 company-size training missions per year (see Table 2-2). This estimate includes battalion-level training multiplied by the number of company-sized units in each battalion. Approximately 390 of these training missions involve tracked vehicles which might be transported by HET. If each training mission involves an average of 15 tracked vehicles and requires 2 HET lifts per vehicle (one to bring the vehicles out to the field and the other to recover them at the completion of their mission), then the expected workload for a division HET company would be about 780 assignments or 11,700 total lifts per year. Based on a 250-day workyear, this translates into an average of 3 assignments per HET company or 2.1 lifts per HET per day.

The Full HET alternative could be implemented in a variety of ways. If military HETs were used, the necessary personnel and equipment could be acquired by assigning or establishing HET companies in the support commands of each armor division, or by assigning two additional HET companies to the 13th SUPCOM. This option will henceforth be referred to as the <u>2-Company</u> HET Option, and it is assumed that HET companies would be established within each armor division. Alternatively, under a <u>commercial</u> HET Option, vehicles and drivers could be acquired through a contract with a commercial heavy equipment hauler. The comparative costs of using military versus commercial HETs are examined in Chapter 5.

In order to realize the potential cost savings of a Full HET alternative, division training would require a more rigidly structured scheduling process and greater coordination among military unit commanders than presently exists. This increased structure is necessary in order to avoid peaking problems in which too many training missions are scheduled to begin and/or end on the same day, making it impossible for one HET company to transport all units. It is assumed that the extra level of effort needed to efficiently schedule and coordinate all division training requirements would be about one-half labor-year per division, centered principally in the division's G3 office.

The military HET and commercial HET options described above assume no significant contribution from the existing HET Company in moving tracked vehicles on post. If the 96th Transportation Company were also to provide on-post transportation service for both armor divisions, then the average number of company-level movements that could be handled per day would increase by up to 50 percent across the two divisions. This capacity would be sufficient to accomodate approximately 90 percent of current on-post training movements without the need for scheduling restrictions. It would enable each division to realize the full savings in tracked vehicle operating costs while sacrificing relatively little in terms of training flexibility.

The Full HET alternative could also be implemented with only one additional HET company if the existing HET company were used to transport tracked vehicles on a full time basis. This 1-company HET Option would require a significant change in the duties and perceived peacetime role of the 96th Transportation Company as well as recognition that full-time utilization will lead to more rapid depreciation and reduced combat readiness of the HET equipment.

Current HET Operations. Current operations at Ft. Hood represent a partial HET alternative in which one HET company (the 96th Transportation Company) provides on-post transportation for tracked vehicles of both armor divisions. HET transportation is requested independently by units (generally, at the battalion level) within each division, and is provided on a first-come, first-served basis by the HET company. When demand exceeds the available supply of HET's on a given day, the unit's request is denied and vehicles must be roadmarched to the field.

Based on information provided by the 13th SUPCOM, during FY 1985 the 96th Transportation Company conducted 3403 lifts of tracked vehicles on post at Ft. Hood. (A lift is defined as transporting one tracked vehicle either out to or back from the field via HET.) While the tracked vehicle makes only a one-way trip, the HET makes a round trip and must typically deadhead one way). Approximately 75 percent of the HET lifts involved M1 tanks, while the remaining 25 lifts were distributed among other heavy tracked support vehicles and artillery pieces (i.e., M2/M3, M88, M109, M110, M578). Furthermore, it was indicated that most HET operations involved battalion-level movements; relatively few company-level training missions or gunnery practices were transported via HET.

Expanded Existing HET Alternative. Current operational procedures do not represent the optimal use of existing HET capacity at Ft. Hood. With little or no coordination in training schedules between divisions, HET utilization is subject to severe peaking problems. The 96th Transportation Company may have no lifts requested for several consecutive days, and then have so many requests on a single day that it must deny service to some units. Moreover, units themselves may fail to request HET transportation because they feel it would be denied, when in fact, it may be available.

The number of lifts conducted by the 96th Transportation Company during 1985 represents only 29 percent of the potential number of lifts that could be handled by a dedicated division HET company. This suggests that considerable savings in tracked vehicle operating costs could be achieved with little or no capital investment through better utilization of the existing HETs on post.

Under the Expanded Existing HET alternative, it is assumed that the 96th Transportation Company could provide approximately 11,500 lifts per year. The lifts would be split between the two resident armor divisions, and would be prioritized to favor transportation of heavier, higher cost tracked vehicles. The substantial increase in the number of lifts provided through the 96th Transportation Company would be achieved principally through improved scheduling and coordination of division training movements and more stringent limitations on roadmarching. As with the one-company Full HET Alternative, this option would require a change in the perceived peacetime role of the 96th Transportation Company, and would result in more rapid depreciation of existing HET equipment.

1.3 RAIL ALTERNATIVES

A railroad offers the potential of low ton-mile operating costs but requires a large initial investment in fixed facilities and rolling stock. In contrast to HETs, the rail alternative depends heavily on scale economies and, hence, high utilization of capacity. Because railheads and sidings cannot be placed close to as many training destinations as HETs can travel to, the maximum feasible share of tracked vehicle mileage that can be carried by rail is less than for HETs. However, the low marginal cost of adding another railcar to a train enables the rail alternative to carry a number of lighter tracked vehicles (e.g., M113s) that cannot be transported efficiently by HETs.

The possible variations within the rail alternative consist of track segments. Obviously, the total share of mileage carried by rail will increase with the length of the railroad, other things being equal, but costs will also increase. By ranking the segments of the rail system from those with the least cost and highest usage potential to those with the highest cost per usage, the most efficient rail system can be designed for comparison to the base and HET alternatives. The factors making this optimization difficult are the interaction effects between segments that increase utilization of base segments with addition of other segments, and the need for connectivity. The following rail segments were specifically examined in this study:

1. A base segment extending from the South Ft. Hood motor pool area to North Ft. Hood along an alignment paralleling West Range Road, plus a spur to the Santa Fe Railroad (ATSF) trackage. (West Line)

2. A segment extending the West Line from the South Ft. Hood motor pool area to the Curry tank course just South of Cowhouse Creek along an alignment paralleling East Range Road. (West Line to Curry)

3. A segment extending the West Line from North Ft. Hood to the Crittenberger tank course along an alignment paralleling East Range Road. (West Line to Crittenberger)

4. A full loop around the live fire area, connecting the Curry and Crittenberger extensions with a track segment and bridge crossing the Cowhouse Creek on the eastern side of the live fire area. (Full Rail)

The physical configuration and general operation of the Full Rail alternative are described below. Briefer descriptions are provided for each of the partial rail alternatives, focusing principally on their key differences from the Full Rail alternative.

Full Rail Alternative. Under the Full Rail alternative, a single track, standard gauge railroad would be constructed on post at Ft. Hood. The railroad would be configured as a closed loop, extending from the cantonment area at South Ft. Hood, along the western perimeter of the live fire area to the Mobilization and Training Equipment Site (MATES) at North Ft. Hood, and then returning along the eastern perimeter of the live fire area to the South Ft. Hood cantonment area (see Figure 1-1). A segment of trackage would connect the on-post railroad to the ATSF railroad located south of the cantonment area. Seven sidings/railheads would be constructed at strategic locations along the main track, including a railhead and rail maintenance yard near the South Ft. Hood motor pool area, a railhead at the North Ft. Hood MATES facility, and five field sidings near major M1 and M2/M3 firing ranges. Each siding would consist of trackage parallel to the mainline track long enough to hold a 40-car train transporting a battalion-size unit of tracked combat vehicles. At one end of each siding would be a spur leading to four track segments with endramps for loading and off-loading tracked vehicles. Each track segment would be long enough to hold a 10-car consist. More detailed descriptions of the rail alignment and schematic layouts of the two major railheads, a typical field siding, and cross-section of the railroad right-of-way track are included in Appendix A.

As in the Full HET alternative, the principal function of the on-post railroad would be to transport tracked combat vehicles to and from the field for training missions. Additionally, the railroad would be used to transport tracked vehicles and heavy vehicle repair parts (e.g., tank tracks) to both the South Ft. Hood cantonment area and the North Ft. Hood MATES facility.

Typical on-post rail movements would involve one or more company-sized units, with each company requiring 6 to 10 railcars. Trains would generally be made up of company-sized consists, up to a maximum of 40 cars. This limit is imposed by the physical capacity of the proposed field siding. All tracked combat vehicles, including those belonging to the M113 family, would be eligible for transportation by rail, subject to a maximum limit of 80 vehicles per train. Units having more than 80 tracked vehicles either would have to roadmarch some of their vehicles or would require more than one train to complete their move. For the purposes of this study, it was assumed that all tracked vehicles would be transported to the field via train, regardless of the size of the military unit.

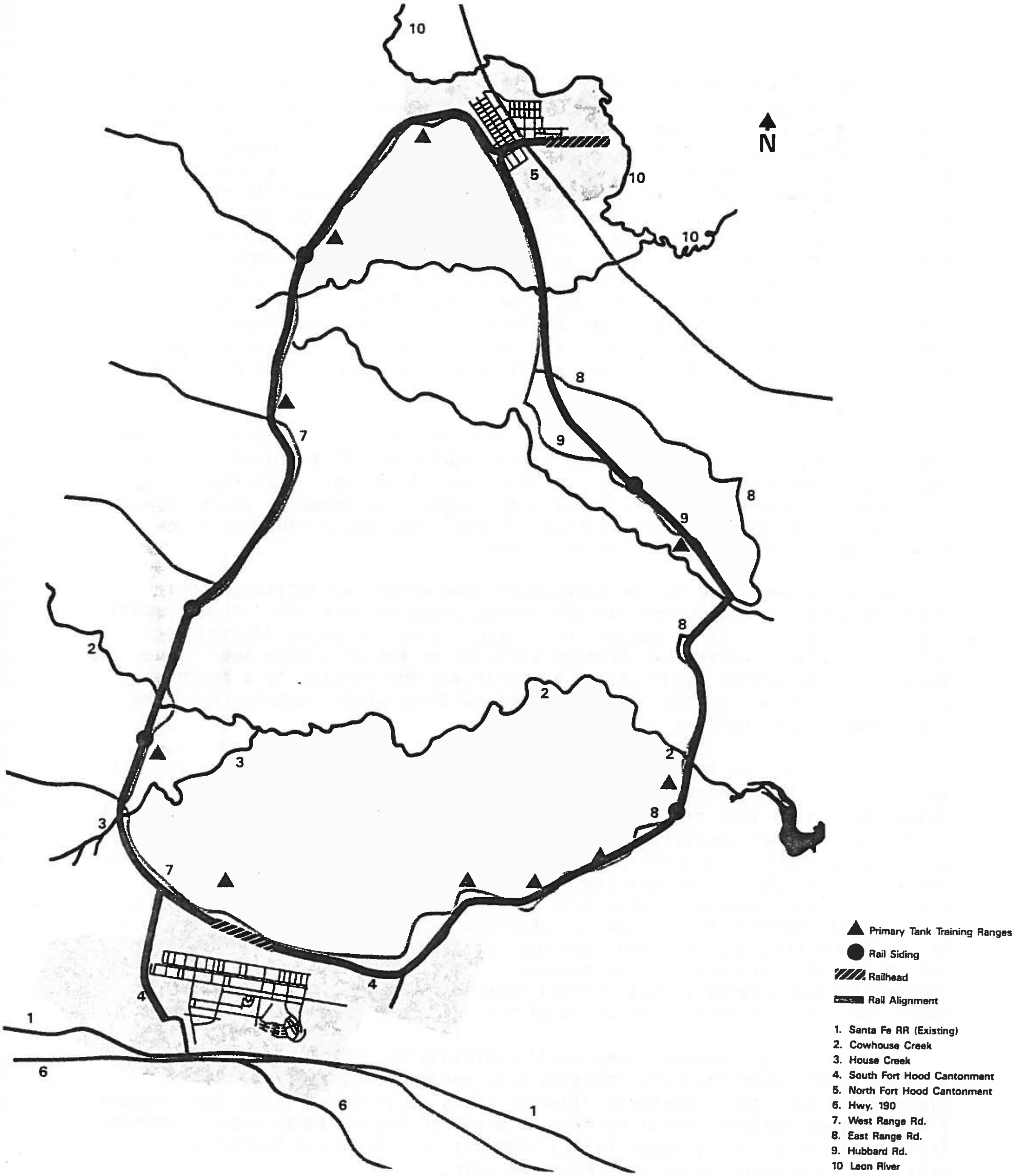

FIGURE 1-1. PROPOSED FT. HOOD RAIL ALIGNMENT

Tracked vehicles would be driven from their motor pools to the South Ft. Hood railhead (an average distance of 0.5 mile) where they would be loaded, "circus style" (i.e., loaded from one end of the consist and driven under their own power down the line of railcars) onto waiting DODX flatcars. Vehicles typically would be loaded 2 per railcar. When all railcars in a consist have been loaded and secured, locomotives would assemble the consists into a train and move it out onto the mainline trackage. Consists would be pulled to the siding closest to a unit's final training destination. A train might make from one to four stops per run, depending on the number of separate units it is carrying and the locations of their training missions. Upon reaching its siding, the consist would be moved into position on one of the end tracks, and vehicles would be off-loaded, circus-style. Once off-loaded, the unit would then roadmarch to its final destination. As with the HET alternative, tracked vehicle crews would have to be transported to the field siding by truck.

Since the proposed railroad forms a loop only around the live fire area, travel to many training areas would still require a unit to roadmarch its vehicles a significant distance. In fact, some locations (training areas 21-27 and the Pilot Knob and Blackwell M1 ranges, for example) would receive no benefit from the proposed railroad. These areas would continue to be accessible only via roadmarching or by HET.

For units returning to the cantonment area after completion of their training mission, transportation procedures would be reversed. A unit would roadmarch its vehicles to the nearest field siding and begin loading onto waiting railcars. After all tracked vehicles in the unit have been loaded and secured, a locomotive would assemble and/or add the consist to a train and pull the train back to the South Ft. Hood railhead where consists would be disassembled and vehicles off-loaded.

Estimates of the time required to transport a company-sized unit via rail to a training area depend on a number of parameters. These include: 1) the time required to load the tracked vehicles onto railcars and secure them (1.5 to 2 hr per 10-car consist); 2) the time required to assemble up to four 10-car consists into a train (0 to 1.5 hr); 3) travel time to the appropriate siding (.5 to 1.5 hr); 4) the time required to break off a consist from a train or to disassemble a train into 10-car consists at a siding (0 to 1 hr); 5) the time required to off-load a company-sized unit from the railcars (.5 hr); 6) and finally, the time required to roadmarch the unit from the rail siding to the final training destination (0 to .5 hr). Summing up these component times yields a total travel time per unit varying from 3.0 to 10 hours for a single train, and up to 19 hours if two trains are required.

Shorter overall travel times would typically be associated with trains pulling 10 or fewer railcars, because they would not have to assemble or disassemble consists. Moreover, loading times would probably be less because fewer tracked vehicles would have to be moved to the railhead simultaneously. Transportation of units requiring 10 flatcars or less would therefore generally be handled using one train per unit.

For larger units, the time required to assemble and disassemble consists (1 to 2.5 hr) is roughly comparable to the time required for a locomotive to make a round trip. On the basis of rail operating costs, it would be more efficient in these cases to run a single multiple-consist train rather than make two or more runs of a single consist train, assuming that all consists could be loaded simultaneously. For the purposes of this study, it was assumed that a unit requiring between 10 and 40 flatcars would be transported as a single, multiple-consist train. Units requiring more than 40 flatcars (e.g., armor or infantry battalions) would be transported to the field in two train movements.

Based on estimates of annual on-post training missions that could feasibly be transported via rail, the expected workload for a railroad at Ft. Hood would be approximately 1030 train movements per year for the two armor divisions. In addition, it is envisioned that a railroad would provide on-post tracked vehicle transportation for Texas National Guard units operating out of North Ft. Hood as well as on-post movement of vehicles and equipment being outloaded by rail. These duties could add another 100 train movements per year. Total on-post demand for the railroad could therefore be as high as 1130 train movements per year, or an average of about 4 movements per day during the week and 1 movement per day on weekends. To accommodate this demand, it is assumed that two locomotives operating on staggered 10-hour shifts during weekdays, and a single locomotive operating on weekends, would be required. The railroad would be operated either by civil service crews or through a long-term contract with a commercial railroad. A more detailed description of proposed operating strategies for the railroad, including train crew composition, is presented in Chapter 5.

Scheduling of transportation requests under the Full Rail alternative would be somewhat more complex than under the Full HET alternative. First, it would be necessary to develop and coordinate a transportation schedule among all units in both armor divisions, instead of just within a single division. Second, the timing of transportation requests will be constrained not only by the availability of a locomotive but also by the availability of an unoccupied field siding. For the purposes of this analysis, it is assumed that the extra level of effort needed to efficiently schedule training under the rail alternative would be about one-half labor-year per division (as under the Full HET alternative), plus one additional labor-year to coordinate schedules between the two divisions, to allocate railcars and locomotives to meet combined training requirements, and to oversee all on-post rail operations.

<u>West Line Alternative</u>. The West Line represents the shortest feasible rail alternative that would provide both access to North Ft. Hood and a limited amount of on-post transportation of tracked vehicles. Under the West Line alternative, both the Crittenberger and Curry sidings would be eliminated along with all trackage leading to them. Rail transportation would be unavailable to virtually all east side training areas and firing ranges, and units going to these areas would have to roadmarch their vehicles. This will result in a substantial increase in tracked vehicle operating costs over the Full Rail alternative. These costs are discussed in detail in Chapter 4.

The principal cost savings under this alternative result from the elimination of about 15 miles of mainline trackage and two field sidings. Although the number of annual train movements would be reduced by about 25 percent (from 1130 to 850), railroad operating costs would not decrease proportionately. This is because an on-post railroad would continue to require the equivalent of two train crews per weekday to handle the potential variation in daily demand and one crew on weekends to handle demand from North Ft. Hood.

West Line to Crittenberger. The addition of the Crittenberger extension to the West Line alternative would provide direct rail access to the most heavily utilized M1 tank course on post and would enable tracked vehicles some rail access to training areas northeast of Cowhouse Creek (TA 1-8). Units would still have to roadmarch to training areas and firing ranges located east of the cantonment area (TA 11-19), but this alternative would provide much greater savings in tracked vehicle operating costs than the West Line alone.

The principal cost savings in this alternative relative to the Full Rail alternative would result from elimination of relatively expensive trackage along East Range Road to the Cowhouse Creek and the Cowhouse Creek bridge. Rail operating costs under this alternative would not be substantially different from those incurred under the Full Rail alternative.

West Line to Curry. The addition of the Curry extension to the West Line provides limited rail access to all training areas and firing ranges along East Range Road without incurring the expense of building a railroad bridge across the Cowhouse Creek. However, elimination of the Crittenberger extension means that armor units going to Crittenberger would have to roadmarch their vehicles either 6 miles from the Curry siding or 10 miles from North Ft. Hood. Rail operating costs under this alternative would be essentially the same as those incurred under the Full Rail alternative.

CHAPTER 2. TRANSPORTATION DEMAND ESTIMATES

A heavy vehicle transportation system at Ft. Hood will be a worthwhile investment only to the extent that it is used and that the associated benefits and cost savings are greater than the costs required to build and operate it. This section identifies the potential sources of demand for a heavy vehicle transportation system at Ft. Hood, and estimates how much of this demand would be satisfied under each of the proposed alternatives. These demand estimates are used in subsequent analyses to determine transportation system operating costs and cost savings from reduced roadmarching of tracked vehicles.

It is expected that the principal source of demand for a heavy vehicle transportation system at Ft. Hood would come from the two resident armor divisions to transport tracked combat vehicles between motor pool storage areas and various firing ranges and field training areas on post. Additional demand for on-post transportation of tracked vehicles is expected to come from Texas National Guard (TXNG) units training out of the MATES facility at North Ft. Hood. A heavy vehicle transportation system may also facilitate the outloading of vehicles and equipment for off-post training (e.g., to and from the National Training Center (NTC) at Ft. Irwin, CA) or wartime mobilization. Furthermore, given that the transportation system provides a direct rail link between the local service railroad and vehicle maintenance facilities at Ft. Hood, additional cost savings could be achieved in the transportation of vehicles and heavy equipment parts between Ft. Hood and Army Materiel Command (AMC) depots. Each of these sources of demand is examined in detail below.

2.1 ON-POST MOVEMENT OF TRACKED VEHICLES FOR TRAINING

Each of the military units garrisoned at Ft. Hood participate in a variety of training activities. Most of these training activities involve the movement of heavy, tracked combat vehicles from the unit's motor pool area, located along North Avenue, to designated training areas and firing ranges located throughout the post. Because of the high operating and maintenance (O & M) costs associated with roadmarching tracked vehicles, significant cost savings could be achieved by transporting them to and from training areas by some other means.

The principal measure of demand for on-post movement of tracked vehicles used in this study is <u>annual vehicle-miles</u> traveled to and from training. In the Base Case alternative, all of this demand is assumed to be met by roadmarching. By comparing the roadmarch mileage under each alternative with that derived for the Base Case, an estimate of the potential savings in vehicle-miles is obtained. This number, in turn, is used as input in computing operating cost savings under each alternative.

Due to the large differences in O & M costs and annual mileage among the various tracked vehicles, separate mileage estimates were computed for each major vehicle type. For the purposes of this study, 3 major tracked vehicle categories were identified: M1 tanks, M2/M3 fighting vehicles, and all other tracked combat vehicles.

Tracked vehicle mileage was computed using the following procedure:

1. An inventory of all tracked combat vehicles on-post at Ft. Hood was obtained from III Corps. Vehicles were categorized and assigned to military units based on the most recent Modification Table of Organization and Equipment (MTOE). Only those units having a significant number of tracked vehicles were studied further.

2. For each military unit studied, estimates were obtained concerning the types and frequencies of training in which the unit typically participates.

3. Roadmarch distances from the motor pool area at South Ft. Hood to each major firing range, training area, and artillery firing emplacement were measured from a topographic map of the Ft. Hood area. Additional measurements were made to each of these areas from the nearest proposed rail sidings and improved surface roads in order to approximate roadmarch distances under each of the various alternatives. Rail and HET distances from the motor pool area to the respective drop-off points were also measured.

4. Based on available information regarding training frequencies and restrictions on the use of various training areas and firing ranges by certain unit types, estimates of average round-trip mileages were developed for each military unit/training mission combination identified in Step 2. Mileage estimates were stratified by roadmarch and transported mileage for each alternative studied.

5. The tracked vehicle inventory for each military unit/training mission combination (from Step 1) was multiplied by the appropriate mileage (from Step 4) to obtain average round-trip vehicle-mile estimates by vehicle type under each alternative. These estimates were, in turn, multiplied by average training mission frequencies (from Step 2) and by the number of units on post to obtain estimates of total annual vehicle-miles by vehicle for each military unit/training mission combination. Estimates were then summed across all military units, mission types, and vehicles for each of the three major tracked vehicle categories to obtain total annual tracked vehicle mileage for each of the alternatives studied.

The remainder of this section documents in greater detail the data sources and underlying assumptions used in the demand analysis.

Tracked Vehicle Inventory. An on-post inventory of tracked combat vehicles assigned to the 1st Cavalry and 2nd Armor Divisions was obtained from III Corps (G4). This inventory was last updated at the end of FY 1985, and represents the best available information about vehicles actually on post at Ft. Hood. It does not, however, reflect pending acquisitions of new tracked vehicles to meet full division authorizations, nor does it reflect the retirement and replacement of older weapon systems and support vehicles by new vehicle types.

A more detailed breakdown of the allocation of tracked combat vehicles among military units within each division was derived from the Army's most recent MTOE. As such, it represents what is authorized to each unit, not what is actually there. This information, presented in Appendix B, was used to create a tracked vehicle inventory by military unit that would form the basis for all subsequent vehicle mileage computations.

Table 2-1 compares the actual on-post vehicle inventory with the authorized inventory derived from the MTOE. The two lists are very consistent with respect to most vehicles, and identical with respect to the M1 and M2/M3 tracked vehicles which are of primary interest to this demand analysis.

Military Unit and Training Mission Type. Based on the unit allocations of tracked combat vehicles and discussions with III Corps and with the 2nd Armor Division (G3), 15 military unit types were identified which appeared to involve the movement of a significant number of tracked vehicles to and from the field for training purposes. The training missions that these units engage in fall into three major categories, distinguished principally by the location of the training: 1) gunnery or direct fire practices, which take place at one or more of the 11 tank ranges on post; 2) artillery or indirect fire practices, which take place at one or more of the 196 artillery emplacements on post; and 3) field training exercises and evaluation, which take place at one or more of the 43 designated training areas on post. Table 2-2 lists the military units that were included in the analysis, the number of these units currently on post, and the type and frequency of training in which each unit typically participates.

The training frequencies listed in Table 2-2 represent current "best estimates" of the average number of times that a company- or battalion-level unit travels to the field over the course of a year. They do not include training exercises undertaken by smaller units (e.g., platoons) which are typically spontaneous in nature, of short duration, and take place relatively close to the cantonment area. Furthermore, based on telephone conversations and documentation supplied by the 2nd Armor Division, it appears that the actual training activities for any specific military unit may deviate from these averages for a variety of reasons, including scheduling conflicts, off-post training activities, and priorities of individual unit commanders.

TABLE 2-1.

FORT HOOD TRACKED VEHICLE INVENTORY

ID#	Description of Vehicle	Vehicles Authorized in MTOE	Actual Vehicles on Post	Difference in Vehicle Inventory
M1	"Abrams" Combat Battle Tank	464	464	0
M2	"Bradley" Infantry Vehicle	216	216	0
M3	"Bradley" Cavalry Vehicle	152	152	0
AVLB	Armored Vehicle Launched Bridge	24	28	4
M88	Heavy Armored Recovery Vehicle	102	100	-2
M106	107mm Mortar Carrier	84	81	-3
M109	155mm Howitzer	72	72	0
M110	8" Howitzer	24	25	1
M113	Armored Personnel Carrier	418	449	31[1]
M163	"Vulcan" 20mm Anti-Aircraft Gun	48	48	0
M270	Multiple Launch Rocket System	18	9	-9[2]
M548	Ammunition Carrier	102	103	1
M577	Mobile Command Post	202	203	1
M578	Light Armored Recovery Vehicle	34	34	0
M728	Combat Engineer Vehicle	12	12	0
M730	"Chaparral" SAM Missle Launcher	48	48	0
M901	Improved TOW Missle Launcher	48	49	1
M1015	Electronics Equipment Carrier	8	9	1
		-----	-----	-----
	TOTAL VEHICLES IN INVENTORY	2076	2102	26

1. M113 armored personnel carriers are sometimes used as substitutes for other tracked carriers. This may account for the apparent excess in these vehicles over actual unit authorizations.

2. Although each armor division is authorized one MLRS batttery in its field artillery brigade, as of the end of FY 1985 only the 2nd Armor Division actually had an operational MLRS battery. It is expected that a MLRS battery will be assigned to the 1st Cavalry Division in FY 1986.

TABLE 2-2.

MILITARY UNIT TYPES AND ANNUAL TRAINING FREQUENCIES

Military Unit Type	Units on Post	On-Post Training Categories: Gunnery Practice	Field Training	Artillery Practice
Armor Brigade Units				
Armor Company	32	4	4	-
Infantry Company	16	4	4	-
Tank Destroyer (TOW) Co.	4	4	4	-
Armor Battalion	8	-	2	-
Infantry Battalion	4	-	3	-
Composite Battalion	8	-	2	-
Field Artillery (DIVARTY)				
155mm Howitzer Battery	12	2	-	2
8" Howitzer Battery	4	2	-	2
MLRS Rocket Battery	2	2	-	2
155mm Howitzer Battalion	4	-	-	4
8"/MLRS Battalion	2	-	-	4
Air Defense (DIVAD)				
Vulcan Battery	4	-	2	4
Chaparral Battery	4	-	2	4
Division Troop Elements				
Cavalry Troop	4	4	4	-
Engineer Company	6	-	6	-

Computation of Average Round-Trip Mileages to Training. Distances from the motor pools at South Ft. Hood to each major firing range, training area, and artillery firing emplacement were measured off a 1:50,000 scale topographic map of the Ft. Hood area provided by III Corps (DRM). The map (5-DMA, series V782S) depicts training areas and firing ranges as of 1982. A minimum of three sets of measurements were made for each training destination:

1. **Full Roadmarch** - distances were measured from the mid-point of the motor pool area to each destination along established tank trails.

2. **HET Alternatives** - HET distances were measured from the mid-point of the motor pool area along paved or improved surface roads to off-loading points as close as possible to each destination. Roadmarch distances were measured from these off-loading points to the final destinations along established tank trails.

3. **Full Rail Alternative** - Rail distances were measured from the proposed railhead at South Ft. Hood along the proposed rail right-of-way to the rail siding nearest each destination. An additional 0.5 mile was added to this rail distance to reflect terminal operations at the origin and destination sidings. Roadmarch distances were measured from the destination siding to each training destination along established tank trails. An additional 1.0 mile was added to this roadmarch distance to reflect travel from the motor pools to the South Ft. Hood railhead.

4. **Partial Rail Alternatives** - for those destinations where the nearest rail siding would be eliminated under a partial rail alternative, rail and roadmarch distances were measured to the next existing siding. The distance computations were the same as for the Full Rail Alternative.

The measured distances served as input data for calculations of average round-trip training mileages for the 24 military unit/training mission combinations identified in Table 2-2. These average mileage estimates are summarized in Table 2-3 for the base case and for each major transportation alternative. Assumptions and procedures used to compute the mileage for each combination are presented in Appendix C.

Computation of Annual Tracked Vehicle Mileage. Each of the military unit/training mission combinations identified in Table 2-2 has a specific set of tracked combat vehicles associated with it. These vehicle sets were multiplied by appropriate round-trip roadmarch mileages to obtain average tracked vehicle-miles by training mission type under each alternative for both the unit and for individual vehicle types within the unit. For the Full Roadmarch and rail alternatives, the computations involved multiplying each tracked vehicle in the unit by the corresponding roadmarch mileages presented in Table 2-3.

For the HET alternatives, it was assumed that all vehicles of the M113 family would be roadmarched from the motor pool area to training rather than transported via HET. Consequently, the following vehicle types were multi-

TABLE 2-3.

AVERAGE ROUND-TRIP VEHICLE MILES TO TRAINIING

Unit and Mission Type	Base	HET Alternative		Full Rail Alternative		West Line Only		West Line to Curry		West Line to Crittenberger	
	Roadmarch Distance	HET Distance	Roadmarch Distance	Rail Distance	Roadmarch Distance	Rail Distance	Roadmarch Distance	Rail Distance	Roadmarch Distance	Rail Distance	Roadmarch Distance
Armor Co to Firing Range	15.57	14.79	1.42	11.71	4.75	14.66	8.70	9.16	7.30	18.21	4.75
Infantry Co to Firing Range	19.89	19.79	0.93	19.39	5.21	17.83	7.23	18.75	5.85	18.71	6.24
TOW Co to Firing Range	19.89	19.79	0.93	19.39	5.21	17.83	7.23	18.75	5.85	18.71	6.24
Armor Co to Field Training	23.66	22.62	2.40	14.96	12.15	11.54	16.48	14.29	12.69	17.94	13.85
Infantry Co to Field Training	23.66	22.62	2.40	14.96	12.15	11.54	16.48	14.29	12.69	17.94	13.85
Tow Co to Field Training	23.66	22.62	2.40	14.96	12.15	11.54	16.48	14.29	12.69	17.94	13.85
Armor Bn to Field Training	25.82	25.10	2.15	17.48	11.86	15.39	15.18	17.31	12.36	20.72	13.06
Infantry Bn to Field Training	25.82	25.10	2.15	17.48	11.86	15.39	15.18	17.31	12.36	20.72	13.06
Composite Bn to Field Training	25.82	25.10	2.15	17.48	11.86	15.39	15.18	17.31	12.36	20.72	13.06
Cavalry Tp to Firing Range	19.89	19.79	0.93	19.39	5.21	17.83	7.23	18.75	5.85	18.71	6.24
Cavalry Tp to Field Training	24.74	23.86	2.28	16.22	12.01	13.47	15.83	15.80	12.53	19.33	13.45
Engineer Co to Training Area	22.87	22.63	0.98	18.09	7.95	5.13	19.33	18.04	8.12	6.91	16.62
155mm FA Bty to Firing Range	9.00	9.40	0.00	0.00	9.00	0.00	9.00	0.00	9.00	0.00	9.00
8" FA Bty to Firing Range	9.00	9.40	0.00	0.00	9.00	0.00	9.00	0.00	9.00	0.00	9.00
155mm FA Bty to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.56
8" FA Bty to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.56
MLRS Bty to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.56
155mm FA Bn to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.56
8" FA Bn to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.56
Vulcan Bty to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.36	9.55
Chaparral Bty to Artillery Range	22.52	22.18	1.89	19.53	7.70	14.42	14.18	18.44	8.80	25.35	9.56
Vulcan Bty to Field Training	25.82	25.10	2.15	17.48	11.86	15.39	15.18	17.31	12.36	20.72	13.06
Chaparral Bty to Field Training	25.82	25.10	2.15	17.48	11.86	15.39	15.18	17.31	12.36	20.72	13.06

plied by the Full Roadmarch distances: M106 (107mm mortar carrier), M113 (armored personnel carrier), M548 (ammunition carrier), M577 (mobile command post), and M901 (improved TOW vehicle).

Estimates of the number of HET-transported tracked vehicles were further reduced for the Current HET and Expanded Existing HET operations by the number of lifts which could be provided with existing equipment.

Based on information from 13th SUPCOM (180th Transportation Bn), the total number of HET lifts provided during FY 1985 was known (3403), as was the approximate percentage of those lifts which involved M1 tanks (75%). However, no information was available on the specific units or training missions carried via HET, or on the average annual mileage that the HETs traveled. Therefore, in order to obtain estimates of the tracked vehicle and HET mileage incurred under Current HET operations, it was necessary to construct a distribution of HET movements which conformed with available information.

Using the 3403 lifts per year as a control total and the relative shares of tracked vehicles transported via HET as guidelines, a hypothetical scenario of FY 1985 HET operations was constructed. It was assumed that 50 percent of all armor battalion training (including both "pure" armor battalions and composite battalions) was transported via HET. It was further assumed that 25 percent of armor company and division field artillery battalion training was transported via HET. Computation of the total number of lifts represented by these mission types is presented in Table 2-4.

Under this scenario, 2528 lifts or 74.3 percent of all HET lifts involved M1 tanks. Therefore, although the scenario may not precisely replicate the FY 1985 operations of the 96th Transportation Company at Ft. Hood, it is consistent with the information provided and provides a reasonable approximation of the tracked vehicle mileage currently being saved by using HETs.

A similar scenario was constructed for the Expanded Existing HET alternative, using 11,500 lifts as a control total. In order to maximize cost savings, it was assumed that only M1 and M2/M3 tracked vehicles would be transported via HETs. Highest priority would be given to gunnery and training missions involving M1 armor units; remaining HET capacity would be utilized for gunnery and training missions involving M2 mechanized infantry units. It was assumed that 75 percent of all armor company- and battalion-level training and 50 to 67 percent of all mechanized infantry training could be transported under the Expanded Existing HET alternative. Computation of the total number of lifts represented by these mission types is presented in Table 2-4.

The Expanded Existing HET scenario described above does not necessarily represent the optimal allocation of HET lifts to mission types. The maximum savings in tracked vehicle costs would be achieved if 100 percent of the missions involving M1 tanks were transported by HET, and any remaining HET capacity were allocated to transporting M2/M3 vehicles. Given likely scheduling conflicts and the difficulty of coordinating training between the two resident armor divisions, however, it does not appear reasonable to expect that all M1 training missions could be supported with only one HET company. Therefore a more realistic goal of 75 percent was used.

TABLE 2-4.

COMPUTATION OF HET USAGE UNDER PARTIAL HET OPERATIONS

Type of Mission	Missions per Post per Year	Vehicle Lifts per Mission	Share of Missions via HET	Total Lifts per Year
Current HET Operations				
Armor Co. Training	128	28	.25	896
Armor Bn. Training	16	142	.50	1136
Composite Bn. Training	16	140	.50	1120
155 mm Bn. Training	16	38	.25	152
8 inch Bn. Training	8	50	.25	100

				3404
Expanded Existing HET				
Armor Co. Gunnery	128	32	.75	3072
Armor Co. Training	128	28	.75	2688
Armor Bn. Training	16	128	.75	1536
Composite Bn. Training	16	126	.75	1512
Infantry Co. Gunnery	64	30	.50	960
Infantry Co. Training	64	26	.50	832
Infantry Bn. Training	8	120	.67	960

				11,560

Calculation of annual tracked vehicle mileage under the Current HET and Expanded Existing HET alternatives involved taking weighted averages of the Full Roadmarch and Full HET distances in Table 2-3 for each of the military unit/mission combinations identified in Table 2-4. For example, the average mileage estimate for armor company training under Current HET operations would be computed as:

$$.25 \times \text{Full HET mileage} + .75 \times \text{Full Roadmarch mileage}$$

Military unit/mission combinations not identified as being transported under the partial HET operations were assumed to incur the same average mileage as under the Full Roadmarch alternative.

Tracked Vehicle Mileage Results and Sensitivity Tests. The resulting round-trip mileage for each vehicle type were aggregated into the 3 major vehicle categories (M1, M2/M3, and other) for each military unit/training mission combination. These values were multiplied by the training mission frequency and the number of military units on post and summed over all military units and mission types to obtain total annual vehicle-miles by vehicle category (see Appendix D). Average annual vehicle-miles were obtained by dividing the total annual vehicle-miles by the number of vehicles in each category. Table 2-5 presents the total and average annual vehicle-miles to and from training for the three major vehicle categories under each of the alternatives.

The mileage estimates in Table 2-5 show that the Full HET alternative offers a substantially larger reduction in M1 and M2/M3 roadmarch mileage than any of the rail alternatives. The rail alternatives, on the other hand, offer a slightly greater reduction in roadmarch mileage for other tracked vehicles, specifically those in the M113 family. The principal reason for these differences is that although fewer tracked vehicles would be transported under the Full HET alternative, those vehicles which were transported could be taken closer to their final training destination. By loading vehicles having the highest operating costs onto HETs (i.e., the M1, M2/M3, and other heavy support vehicles), the HET alternatives can also provide greater average operating cost savings per vehicle transported.

As a check on the reasonableness of the demand estimation procedure, estimates of average annual mileage per vehicle were computed for the M1, M2, and M3 using Base Case roadmarch distances and stratifying the components of mileage by military unit and type of training. The results of this analysis are presented in Table 2-6. When travel between firing ranges is included, the estimated mileage for the M1 and M2 vehicle types is not significantly different than the estimate of 300 miles/year per vehicle used in the original Ft. Hood study (see Appendix H). The lower average mileage estimate for the M3 is attributable to the fact that the vehicle is used by battalion headquarter companies and by cavalry troops, both of which participate in field training less than either armor or infantry companies.

TABLE 2-5.

ANNUAL TRACKED VEHICLE MILEAGE TO AND FROM TRAINING

Transportation Alternative	M1	M2/M3	Other
Total Annual Tracked Vehicle-Miles (all vehicles)			
Full Roadmarch	113,435	84,573	125,023
Current HET Operations	84,596	79,839	119,773
Expanded Existing HET	36,193	46,071	125,023
Full HET Alternative	10,445	6,561	81,198
Full Rail Alternative	49,944	34,624	52,817
West Line to Curry	56,461	37,100	56,581
West Line to Crittenberger	54,949	39,141	63,546
West Line Only	70,453	46,450	79,202
Average Annual Tracked Vehicle-Miles (per vehicle)			
(Number of Vehicles)	(464)	(368)	(1052)[1]
Full Roadmarch	244.47	229.82	118.84
Current HET Operations	182.32	216.95	113.85
Expanded Existing HET	78.00	125.19	118.84
Full HET Alternative	22.51	17.83	77.18
Full Rail Alternative	107.64	94.09	50.21
West Line to Curry	121.68	100.82	53.78
West Line to Crittenberger	118.42	106.36	60.40
West Line Only	151.84	126.22	75.29

1. The number of vehicles in the "other" category includes only those vehicles which were assigned to the 15 military unit types studied in the demand analysis.

TABLE 2-6.

COMPONENTS OF AVERAGE ANNUAL TRACKED VEHICLE MILEAGE

	Average Annual Miles per Vehicle		
Military Unit/Mission Type	M1	M2	M3
Armor Battalion (vehicles/unit)	(58)		(6)
Gunnery Practice	62.28		62.28
Inter-Range Travel	40.20		40.20
Company Field Training	91.38		0.00
Battalion Field Training	90.82		103.28
Total Annual Mileage	284.68		205.76
Infantry Battalion (vehicles/unit)		(54)	(6)
Gunnery Practice		79.56	79.56
Inter-Range Travel		28.40	28.40
Company Field Training		115.99	0.00
Battalion Field Training		77.46	77.46
Total Annual Mileage		301.41	185.42
Cavalry Squadron (vehicles/unit)			(40)
Gunnery Practice			79.56
Interrange Travel			28.40
Troop Field Training			94.01
Total Annual Mileage			201.97
AVERAGE ANNUAL MILEAGE/VEHICLE	284.68	301.41	200.50

Computation of Annual HET and Rail Mileage. Estimates of the tracked vehicle mileage which would be carried via HET or rail under each of the alternatives were computed in a manner analogous to that used for computing tracked vehicle mileage. For each military unit/mission type, the corresponding HET or rail distance from Table 2-3 was multiplied by the number of tracked vehicles in the unit (excluding those vehicles which were assumed to be roadmarched). These mileage estimates were multiplied by training mission frequency and number of military units on post and summed over all military unit/training mission combinations to get total annual tracked vehicle-miles carried under each alternative.

For the HET alternatives, tracked vehicle mileages were grouped into two categories based on the weight of the tracked vehicle: vehicles weighing in excess of 50 tons (specifically, the M1, AVLB, M88, and M728), and all others. This stratification was used in subsequent analyses to estimate pavement damage to roads used by the HETs (see Chapter 6). It was also assumed that HETs would normally deadhead back to the motor pool area after off-loading their tracked vehicle, and would therefore incur additional operating mileage equal to the total loaded mileage.[1]

For the rail alternatives, tracked vehicle mileages were summed over all vehicle categories with no distinction by vehicle weight, and the resulting mileage divided by two, based on the assumption that tracked vehicles would be loaded two per railcar, to get total annual loaded railcar-miles.

An estimate was also made of the average annual locomotive-miles incurred under each rail alternative. Locomotive-miles were used in subsequent calculations to compute the O & M costs and depreciation on locomotives. For the purposes of these calculations, it was assumed that at least one locomotive would be required each time a military unit traveled to the field for training, regardless of the size of the unit. The average rail mileage for each military unit/training mission combination was multiplied by the annual mission frequency and number of units on post, and summed across all combinations to get total annual loaded train-miles. As with the HET alternative, it was assumed that locomotives would normally deadhead back to the South Ft. Hood railheads after dropping off their railcars, and would therefore incur additional mileage equal to the total loaded mileage.

The specific calculations of HET and rail mileage for each combination of military unit and training mission is presented in Appendix E. Table 2-7 summarizes the resulting annual mileages by transportation mode for the HET alternatives; Table 2-8 does the same for the rail alternatives.

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1 This assumption admittedly represents a "worst case" scenario with respect to total HET mileage. However, current training practices show a clear tendency for units to travel out to the field during the morning and back to the motor pool area during the afternoon, in order to get in a full day of training. Anticipated continuation of this practice will make it difficult for any of the transportation alternatives to avoid a significant amount of deadheading. To the extent that deadheading can be reduced, some additional cost savings would be realized.

TABLE 2-7.

HET ANNUAL VEHICLE MILEAGE SUMMARY

HET Alternative	Number of HET Lifts	Total HET Mileage	- HET Mileage Components - 50+ Ton	<50 Ton	Deadhead -	Average Mileage per HET
Current HET Operations	3,404	82,482	33,515	7,726	41,241	3,749
Expanded Exsiting HET	11,560	244,657	81,711	40,617	122,328	11,121
Full HET Alternative	21,027	475,893	123,119	114,828	237,947	10,816

TABLE 2-8.

RAIL ANNUAL VEHICLE MILEAGE SUMMARY

Rail Alternative	Number of Train Movements	- Total Mileage - Railcar	Locomotive	Total Ton-Miles Carried	- Average Mileage - Railcar	Locomotive
Full Rail	1,032	116,904	21,995	7,664,667	1,948	10,997
West Line to Curry	1,032	111,166	20,688	7,198,722	1,853	10,344
West Line to Crittenberger	832	140,214	25,809	9,340,875	2,337	12,905
West Line Only	764	100,635	18,632	6,775,119	1,677	9,316

2.2 OUTLOADING OF TRACKED VEHICLES FROM SOUTH FT. HOOD

In addition to the on-post training described in the preceding section, each military unit garrisoned at Ft. Hood travels off-post for training, on average, once a year. Off-post training exercises typically involve moving a battalion- or brigade-sized unit by rail to another post or to the NTC at Ft. Irwin, CA.

Currently, when a unit is outloaded from Ft. Hood via rail, all vehicles are roadmarched from their motor pool areas to the South Ft. Hood railhead. The average one-way distance for this trip is 2.75 miles. Under any of the proposed rail alternatives, a new railhead would be constructed near North Avenue, an average distance of 1.0 mile from the motor pools. Thus, the average savings in tracked vehicle mileage for units outloading under any of the proposed rail alternatives would be 1.75 miles per one-way vehicle trip, or 3.5 miles per round-trip.[2]

Multiplying the average savings in tracked vehicle mileage by the number of vehicles authorized to the two armor divisions on post (see Table 2-1), the total annual savings in tracked vehicle miles for each of the three major vehicle categories was computed to be: M1 tanks - 1624 miles; M2/M3 fighting vehicles - 1288 miles; all other tracked vehicles - 4354 miles.

The incremental mileage incurred by rail vehicles to provide this savings in tracked vehicle mileage is relatively insignificant -- an average of 45 miles per year per railcar and 85 miles per year per locomotive. This mileage is implicitly included in the total annual rail vehicle mileage used to compute annual O & M costs and depreciation (see Chapter 5).

2.3 ON-POST MOVEMENT OF TEXAS NATIONAL GUARD VEHICLES

The MATES facility at North Ft. Hood provides maintenance and storage for tracked vehicles belonging to the 49th Armor Division of the Texas National Guard (TXNG). Units from the TXNG use the firing ranges and training areas at Ft. Hood for their weekend drills and 2-week summer training camps. According to the superintendent of MATES, North Ft. Hood has the equivalent of six armor battalions and two cavalry squadrons using the facility and its equipment throughout the year.

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2 Comparable savings in vehicle mileage could also be achieved by transporting the tracked vehicles from their motor pool areas to the existing Ft. Hood railhead via HET. However, these savings in tracked vehicle mileage would be largely offset by the additional time and manpower required to load, transport, and off-load the vehicles from HETs. From a logistics standpoint, therefore, HETs do not appear to be a realistic alternative for outloading.

If a railroad siding were located at MATES and the railroad were operational on weekends, it is anticipated that TXNG units would use it to transport armor and cavalry units to and from firing ranges. Tracked vehicles scheduled for weekend gunnery practice would be loaded onto railcars prior to the arrival of TXNG soldiers using a skeleton crew of MATES personnel. The loaded railcars would be stored at the North Ft. Hood railhead until the units arrived, and then pulled to the appropriate field siding in time for gunnery practice on Saturday morning. Units would have to load the tracked vehicles back onto railcars at the conclusion of their gunnery practice, but the railcars could be off-loaded early the following week using MATES personnel. It has been suggested that TXNG units would be unable to utilize HETs in a comparable manner because there are not enough HET trailers to allow vehicles to be loaded in advance and stored until TXNG units arrive. TXNG units going on field training exercises would continue to roadmarch their vehicles to and from the field as part of their training.

Each armor and cavalry unit is required to take gunnery (firing range) twice a year. Both of these units are comprised entirely of M60 combat battle tanks when going for gunnery practice. Table 2-9 summarizes the computations used to estimate the number of annual M60 trips that would be carried by rail from North Ft. Hood.

Computation of the average annual mileage for tracked vehicles, railcars, and locomotives from MATES to TXNG firing ranges followed the same procedure as described in Section 2.1 and Appendix C. Table 2-10 presents a summary of the resulting mileage estimates for the Full Roadmarch and each of the four rail alternatives.

The difference in annual M60 mileage between each of the rail alternatives and the Full Roadmarch alternative was multiplied by the average operating and maintenance cost and depreciation per mile for the M60 to get an estimate of the average annual cost savings for on-post transportation of TXNG units (see Chapter 7). Average railcar and locomotive mileage for this transportation is implicitly included in the total rail vehicle mileage used to compute rail O & M costs and depreciation.

2.4 SHIPMENT OF EQUIPMENT AND SPARE PARTS

It was anticipated that an on-post railroad would enable both both the III Corps (DOL) maintenance facility at South Ft. Hood and the MATES facility at North Ft. Hood to benefit from lower transportation costs in shipping tracked vehicles and heavy equipment parts by rail instead of by truck. However, subsequent discussions with South Ft. Hood DOL personnel indicated that rail provides little or no cost savings for shipments weighing less than 45,000 lbs or for shipments of one railcar-load or less. Based on Military Traffic Management Command (MTMC) and Ft. Hood cost experience, rail transportation is used only when large numbers of vehicles are outloaded or when one or more heavy tracked vehicles must be shipped to a destination where local highway ordinances prohibit use of commercial HETs. Moreover, it was determined that

TABLE 2-9.

COMPUTATION OF M60 TANK TRIPS FROM MATES

Unit Type	Units on Post	Tanks per Unit	Missions per Unit	Total M60 Trips
Armor Battalion	6	58	2	696
Cavalry Squadron	2	27	2	108

TOTAL M60 TRIPS				804

TABLE 2-10.

ANNUAL VEHICLE-MILES FOR ON-POST MOVEMENT OF TXNG UNITS

Alternative	Average M60 Mileage	Number of Train Movements	Average Railcar Mileage	Average Locomotive Mileage
Full Roadmarch	23,605			
Full Rail	3,296	50	137	1,361
West Line to Curry	3,891	48	181	1,728
West Line to Crittenberger	5,499	50	133	1,325
West Line Only	6,512	48	148	1,415

the existing rail facilities at South Ft. Hood are adequate for most rail shipments other than the vehicle outloading described in Section 2.2. On the basis of this information, it was concluded that the potential near-term benefits to South Ft. Hood for occasional shipments of vehicles and spare parts would be minimal.

For those shipments to and from MATES where rail offers significant cost savings over commercial truck, it is possible even today to transport or roadmarch the shipment to the existing South Ft. Hood Railhead. Thus, the maximum cost savings that an on-post railroad could provide for this activity is equal to the cost of roadmarching a tracked vehicle or transporting a shipment from MATES to the South Ft. Hood railhead. This distance was measured to be 22.0 miles. Based on information obtained from MATES, approximately 1000 tracked vehicles were shipped to or from North Ft. Hood during FY 1985. Thus, the potential savings in tracked vehicle mileage under any of the proposed rail alternatives for shipments to or from North Ft. Hood would be 22,000 miles per year.

Although some additional cost savings might also be achieved from the shipment of heavy vehicle parts, such as tracks or engine assemblies, by rail, the available information suggests that these savings will be small. Since the above estimate tends to overstate actual cost savings from the shipment of tracked vehicles, no additional cost savings were included for other MATES shipments.

In principle, a portion of the cost savings achieved by a railroad link to North Ft. Hood could also be realized under the Full HET alternative, assuming HETs were used to transport tracked vehicles to and from the South Ft. Hood railhead. However, this activity would increase total annual HET mileage by as much as 44,000 miles if the HETs had to deadhead from their motor pool to MATES. Moreover, use of HETs would require extra time and effort to transfer the tracked vehicles from the HETs to railcars. This transfer could be especially difficult if the tracked vehicle were inoperative. The combination of extra wear and tear on the HET vehicles, together with the extra time and effort involved in transfers would largely offset the cost savings from reduced tracked vehicle mileage. Thus, for this study, it was assumed that no benefits would accrue under the HET alternatives from the shipment of tracked vehicles and parts to MATES.

CHAPTER 3. DIRECT CAPITAL COSTS

Costs included in this section are initial or front-end expenditures for long-lived assets, consisting of vehicles and facilities. From the standpoint of estimating net benefits, it makes no difference whether items are accounted for on the cost or benefit side (so long as they have the right sign). From the standpoint of a fixed capital budget, however, alternatives may be selected in part on the basis of their benefit to capital cost ratios, and the ordering may depend upon which costs are included in the base of the ratio.

Direct capital costs are those which represent expenditures for acquisition of "new" equipment and facilities. Leased or rented vehicles and facilities could be covered on either the capital cost or the benefit (operating cost) side, but more likely the latter, since they would be taken from operating rather than capital budgets. Wear and tear of existing assets would be covered on the benefits (depreciation) side.

Replacement of existing transportation facilities, such as highways or tank trails, might be included in a base case alternative as capital costs if they were significant and imminent. If such a base case called for substantial direct capital expenditures, and the decision to replace existing facilities was not foregone, then another base case should be designed to represent a "disinvestment" scenario. Replacement of existing facilities would then become one investment alternative to be compared against other, perhaps higher capital, alternatives.

For this study, no direct capital costs are identified for the Full Roadmarch or Current HET Operations alternatives, because no transportation facilities are currently available whose costs could or would be avoided under an alternative scenario. Direct capital costs for the Expanded Exisiting HET and Full HET alternatives are summarized in Table 3-1; capital costs for the rail alternatives are summarized in Tables 3-2 and 3-3.

3.1 HET VEHICLES

A total of 44 HET tractor/trailer units would be required to outfit the equivalent of 2 HET companies as proposed in the Full HET alternative. The estimated cost of a new HET unit is $260,000 -- $160,000 for an M911 tractor and approximately $100,000 for a new XM1000 trailer with a net load capacity of 70 tons.

TABLE 3-1.

DIRECT CAPITAL COSTS - HET VEHICLES AND FIXED FACILITIES

	- Full HET Alternatives -			Expanded Existing HET
	2-Company	1-Company	Commercial	
HET Vehicles				
Unit Cost for HET Tractor/Trailer	$260,000	$260,000	$260,000	$260,000
x Number of New HETs Required	30	22	0	0
TOTAL COST FOR HET VEHICLES	$7,800,000	$5,720,000	0	0
HET Structures and Facilities				
Vehicle Parking	$150,000	$110,000	$220,000	0
Vehicle Maintenance Facilities	$800,000	$500,000	$500,000	0
Administrative Facilities	$1,000,000	$1,000,000	$300,000	0
Upgrade Range Road Bridges	$5,000,000	$5,000,000	$5,000,000	$5,000,000
TOTAL COST FOR FIXED FACILITIES	$6,950,000	$6,610,000	$6,020,000	$5,000,000
TOTAL HET CAPITAL COSTS	$14,750,000	$12,330,000	$6,020,000	$5,000,000

The estimated useful life of a HET tractor is 100,000 miles; existing HET trailers have a useful life of approximately 50,000 miles because they are underdesigned for the load of an M1 tank. It is assumed that new HET trailers will have a useful life more in line with that of the HET tractor -- 100,000 miles.

In addition to the 22 HETs currently assigned to the 13th SUPCOM, there are 8 HETs assigned to the 1st Cavalry Division and 6 HETs assigned to the 2nd Armor Division. Under the 2-Company Full HET Option, it is assumed that the 14 divisional HETs would be assigned to the new division HET companies; therefore, a total of 30 new HETs would have to be purchased. Under the 1-Company Full HET Option, it is assumed that the divisional HETs would remain with their units, and that 22 new HETs would be purchased for a second HET Company in the 13th SUPCOM. No new HETs would be purchased under either the commercial Full HET Option or the Expanded Existing HET Alternative.

The 14 existing divisional HET trailers and those currently assigned to the 13th SUPCOM will eventually have to be replaced in order to transport the new M1A1 tank, which has an estimated net weight of 70 tons. However, this vehicle replacement would have to take place under any of the proposed alternatives, if HETs are to continue their military function of transporting tanks to and from active combat areas. Consequently, the capital cost for immediate replacement of existing HET trailers is not explicitly included in any of the alternatives studied.

Capital costs for HET tractors and trailers under the commercial HET alternative are implicitly included in the price of the contract. Since there would be no up-front capital cost to the Army, the costs for commercial HETs are treated as depreciation to existing vehicles.

3.2 HET STRUCTURES AND FACILITIES

Under the Full HET alternative, it is assumed that HETs will travel over existing paved and improved surface roads on post; no new rights-of-way would have to be constructed. While increased HET usage will certainly result in a more rapid deterioration of the existing roads, these costs are accounted for under highway depreciation (see Section 6.1). It is also possible that additional paved or improved roads might be constructed to provide access to training areas that are currently accessible only via tank trails. However, such construction can be viewed as an extension to the Full HET alternative that would result in both additional costs and benefits. As such, it has not been included in this study.

Three capital investments which would be required in order to implement the Full HET alternative are: 1) the construction of parking and maintenance facilities for the new HET tractor/trailer units; 2) construction and equipping of administrative facilities for HET operations; and 3) upgrading or reconstruction of the existing range road bridges. The costs for these investments are discussed below.

HET Maintenance Facilities. The acquisition of 22 or 30 new HET tractor-trailer units will require additional parking and vehicle maintenance facilities. The unit cost to construct additional parking in the motor pool area is estimated to be $5000 per HET.

It is also assumed that additional maintenance bays would have to be constructed, at an estimated cost of $100,000 each. Eight new bays would be required under the 2-Company Option (four bays in each division's motor pool), while only 5 new bays would be required under the 1-Company Option. Under the commercial HET Option, it is assumed that maintenance facilities would be provided on-post, and that 5 new bays would have to be constructed to handle the commercial HET maintenance.

HET Administrative Facilities. Additional office space would be needed on post to house HET operations and general administrative functions for the new HET companies. In the absence of more detailed information regarding the cost of construction and availability of office space on post, an estimate of $1 million for HET infrastructure facilities is assumed for all military Full HET Options. Costs for construction of additional housing to accommodate military personnel assigned to the new HET companies has been implicitly included under HET operational costs as a component of military salaries and allowances. Capital costs for administrative facilities under the commercial HET alternative are assumed to be $300,000 for office space and equipment.

Upgrading or Replacement of Existing Range Road Bridges. Some of the existing bridges along the range roads would have to be upgraded to accomodate the expected loads under the Full HET alternatives. The most obvious and potentially most costly improvement would be to the bridge over the Cowhouse Creek on East Range Road. The existing bridge is both too narrow and unable to support the weight of two fully loaded HETs. In order to provide full HET access to firing ranges and training areas along East Range Road north of Cowhouse Creek, this bridge must be upgraded or replaced by a structure able to support the weight of two fully loaded HETs and of sufficient width to allow two oncoming HETs to pass one another on the structure itself.

No detailed engineering analysis has been performed, either as part of this study or by III Corps (DEH), to estimate the cost of upgrading the Cowhouse Creek bridge or any of the West Range Road bridges to accommodate anticipated HET loads. In the absence of more detailed information, an estimated total cost of $5 million is used for bridge improvements. Bridge improvement costs are also included for the Expanded Existing HET alternative.

3.3 RAIL VEHICLES

Two types of vehicles would be required under any of the proposed rail alternatives -- locomotive power units and flatcars capable of carrying the tracked vehicles resident at Ft. Hood. Capital cost estimates for each of these vehicle categories are presented below.

TABLE 3-2.

DIRECT CAPITAL COSTS - RAIL VEHICLES AND FACILITIES

Rail Locomotives	
Unit Cost for Locomotive	$250,000
x Number of Locomotives Required	2

TOTAL COST FOR LOCOMOTIVES	$500,000
Rail Flatcars	
Unit Cost for Flatcar	$90,000
x Number of Flatcars Required	25

TOTAL COST FOR FLATCARS	$2,250,000
Rail Maintenance and Administrative Facilities	
Railroad Administrative Facilities	$300,000
Track Maintenance Equipment	$34,000
Rail Vehicle Maintenance Equipment	$10,000

TOTAL COST FOR RAIL FACILITIES	$344,000

Rail Locomotives. Based on the railroad operating strategy described in Chapter 1 and the demand levels presented in Chapter 2, an on-post railroad at Ft. Hood would handle between 850 and 1150 train movements per year, with an average gross weight (including locomotive and railcars) of 1100 tons per train. The maximum expected gross weight per train, for transportation of an armor battalion to the field, is 2600 tons (assuming that a battalion would be transported in two train trips). In order to provide sufficent locomotive capacity to handle both the average daily volume of train movements and the maximum expected train load, a minimum of two 3600 hp locomotives would be required.

Reconditioned 200-ton GP-9 (general purpose) locomotives, upgraded to GP-15 status, would effectively meet Ft. Hood's rail locomotive requirements; these could be purchased for approximately $250,000 each. The estimated useful life of these reconditioned locomotives is 5 million miles.

Ft. Hood currently has two 100-ton switcher locomotives assigned to it for the purposes of moving small numbers of railcars on post and assembling consists in preparation for outloading. These locomotives would not be adequate over the long term to handle the estimated volume of on-post vehicle movements. They would, however, be suitable as temporary replacements for the "new" locomotives in the event of routine maintenance or breakdown.

It has been suggested that the capital cost of locomotives may be avoided altogether by utilizing Army-owned vehicles that are currently in cocoon storage. These locomotives may, indeed, have a zero opportunity cost as far as the Army is concerned. Actual depreciation would be relevant in any case, however, because increased use would require earlier replacement. Before a zero opportunity cost for existing locomotives is accepted, it should be determined that 1) they have the necessary performance characteristics, 2) they are the most efficient locomotives to use for this purpose, 3) their continued possession by the Army is a cost-effective choice even if they are not used at Fort Hood, and 4) their current benefits do not consist solely of option demand. Option demand means that retention of the locomotives keeps them available in the event of mobilization, for which purpose they are satisfactory for the indefinite future, whereas regular use would soon necessitate replacement. If one or more of these conditions is not met, the locomotives have an opportunity cost as well as a depreciation cost.

Rail Flatcars. A sufficient number of flatcars must be available under each rail alternative to enable transported military units to load and unload their tracked vehicles under normal operating conditions without excessive time pressure from other units waiting to use the empty flatcars. At an average of 4 to 6 train movements per day, this implies that a minimum of 60 flatcars would be needed for normal daily on-post operations.

The estimated unit cost for a 68 ft. 40-series DODX flatcar, with a gross weight of 150.5 tons is $90,000. The estimated useful life of these flatcars is 2.5 million miles.

There are currently 70 of the 40-series DODX flatcars assigned to Ft. Hood. Another 35 flatcars (38-series) are also assigned to Ft. Hood, but these would be unsuitable over the long term for on-post tracked vehicle movements due to their wood decks, their more primitive tie-down provisions, and their inability to carry more than one heavy tracked vehicle per car. Typical off-post training missions (e.g., to NTC at Ft. Irwin, CA) utilize approximately 30-35 of the 40-series DODX flatcars, leaving the remainder available for on-post activites. Thus, in order to assure sufficient on-post capacity at all times, an additional 25 flatcars would have to be purchased.

It has been reported that an additional 100 DODX flatcars will be assigned to Ft. Hood for mobilization purposes. Assuming that some or all of these assigned flatcars are 40-series cars, then no additional flatcars would have to be purchased under any of the rail alternatives.

3.4 OTHER RAIL FACILITIES AND EQUIPMENT

In addition to the acquisition of rolling stock and track construction (discussed in Section 3.5), other rail capital costs include the construction and equipping of locomotive and track maintenance facilities and administrative facilities for the railroad. These costs are described below.

Rail Maintenance and Administrative Facilities. Although it is not envisioned that a railroad at Ft. Hood would require extensive maintenance facilities, it should, at a minimum, have a maintenance siding where routine locomotive and railcar maintenance (e.g., oil changes, brakeshoe replacements) and inspections could be conducted. The cost of such a siding, including a locomotive maintenance pit has been estimated to cost approximately $350,000. This cost has been incorporated into the overall construction cost estimate for the South Ft. Hood railhead. The cost of additional office space and equipment for railroad administrative operations is estimated to be approximately $300,000.

Track and Rail Vehicle Maintenance Equipment. Basic, specialized tools for routine maintenance and repair of track, locomotives, and railcars would have to be purchased along with one or two high rail pick-up trucks for routine inspection and transportation of track maintenance crews. The estimated cost for two pick-up trucks and high rail sets is $24,000. Track maintenance tools, including rail drills, saws, vibrators/tampers, etc. would cost approximately $10,000. Basic locomotive and railcar maintenance tools, such as wheel pullers would cost an additional $10,000, resulting in a total cost for new tools and equipment of $44,000.

3.5 RAILROAD RIGHT-OF-WAY AND STRUCTURES

The predominant capital expense under any of the proposed rail alternatives is for construction of the railroad over which the trains would run. The railroad includes not only the mainline trackage, but all sidings, railheads, spurs, and connections to other existing trackage. Railroad construction costs consist of planning and engineering; clearing and grading of the right-of-way; ballast, ties, rails, switches, crossings and signals; bridges and drainage structures; and relocation and reconstruction of existing roads situated in the right-of-way.

In addition to construction costs for the railroad itself, each rail alternative will incur costs for the construction of ramps, staging areas, and lighting at each of the railheads and sidings where tracked vehicles would be loaded and off-loaded. It is assumed that all rail construction would be carried out by private firms procured under competitive contracts, so that expenditures would reflect the full costs of acquiring the capital facilities. Each of these costs is discussed below.

Railroad Construction. The length of the railroad varies by alternative from less than 30 miles of mainline track and 5 sidings/railheads under the West Line alternative to approximately 46 miles of mainline track and 7 sidings/railheads under the Full Rail alternative. These differences in track mileage, together with variations in the costs of right-of-way and site preparation due to terrain, result in significant differences in the estimated construction costs among the rail alternatives, as shown in Table 3-3. Preliminary construction cost estimates, including right-of-way preparation and trackwork for each rail segment, siding, and railhead were prepared by HDR Infrastructure, Inc., and R. M. Brown Associates. The estimates are included in Appendix Section F.6. A summary description of these cost components and reasons for their variations among alternatives is presented here.

Grading and Drainage. A substantial amount of earthmoving would be required in order to meet recommended design criteria for maximum track curvature (4 degrees) and grade (1.75 percent) within the mainline track alignment proposed by Ft. Hood. Additional earthwork would be required to prepare level sites for railheads and field sidings. Unit costs for earthmoving are assumed to average $2.75 per cubic yard. Total costs for each alternative were computed by multiplying the unit cost by the amount of cut-and-fill required for each track segment and siding. Costs for drainage structures (i.e. culverts and channels) to handle surface runoff and provide crossings for intermittent streams were estimated to add approximately 10 percent to the grading costs for each trackage segment.

Track and Switches. Estimates for the cost for installing track on a prepared right-of-way are based on recent bid prices obtained from the Union Pacific Railroad. An average cost of $82.75 per foot includes new 115# rail, 12" of ballast, wood ties, and labor. This unit cost applies to both mainline track and all sidings/railheads. Given the existing soil conditions at Ft. Hood, it is assumed that no additional sub-ballast would be required.

Two types of turnout switches would be used on the Ft. Hood railroad: #14 switches would be used for all turnouts from the mainline trackage, while #9 switches would be used within all sidings and railheads. The estimated costs per switch for materials and installation are $42,500 for the #14 switch and $27,850 for the #9 switch.

Crossings. The proposed railroad would cross existing range roads and tank trails at numerous locations along its alignment. Each crossing would require additional grading as well as construction of a durable road or trail surface to minimize damage to the rails.

The estimated cost for a typical range road crossing is $3000 plus the cost of reconstructing a portion of the road to provide a suitable angle of approach, both horizontally and vertically. Estimates were made of the length of road to be reconstructed at each crossing, and this length was multiplied by a unit cost of $500,000 per mile for reconstruction of a two-lane asphalt surface.

TABLE 3-3.

DIRECT CAPITAL COSTS - RAILROAD TRACK CONSTRUCTION

	Full Rail	West Line to Curry	West Line to Critten.	West Line Only
Mainline Track (total track miles)	(45.9)	(33.1)	(29.9)	(24.4)
Grading and Drainage	23,697,117	15,388,217	13,480,297	10,040,402
Trackwork and Switches	20,501,700	14,713,575	13,272,975	10,786,225
Crossings	1,050,000	783,000	818,000	689,000
Bridges and Drainage Structures	10,200,000	6,800,000	6,800,000	6,800,000
TOTAL COST OF MAINLINE TRACK	$55,448,817	$37,684,792	$34,371,272	$28,315,627
Railheads (North and South Ft. Hood)				
Grading and Drainage	899,436	899,436	899,436	899,436
Trackwork and Switches	4,580,466	4,580,466	4,580,466	4,580,466
Lighting, Ramps and Staging Areas	385,000	385,000	385,000	385,000
TOTAL COST OF RAILHEADS	$5,864,902	$5,864,902	$5,864,902	$5,864,902
Field Sidings (number per alternative)	(5)	(4)	(4)	(3)
Grading and Drainage	5,978,674	4,579,406	4,412,576	3,457,378
Trackwork and Switches	6,049,825	4,824,425	4,884,450	3,659,050
Lighting, Ramps, and Staging Areas	810,000	648,000	648,000	486,000
TOTAL COST OF FIELD SIDINGS	$12,838,499	$10,051,831	$9,945,026	$7,602,428
Highway Relocation/Reconstruction	$3,350,000	$2,400,000	$1,500,000	$900,000
TOTAL CAPITAL COSTS FOR RAILROAD CONSTRUCTION	$77,502,218	$56,001,525	$51,681,200	$42,682,957
Average Cost per Mile of Mainline Track	$1,281,005	$1,211,021	$1,199,708	$1,197,362
Average Cost per Field Siding	$2,567,700	$2,512,958	$2,486,256	$2,534,143

Tank crossings were provided at strategic locations along the length of the railroad at an average density of one crossing per mile to enable tracked vehicles to cross the right-of-way without damaging the tracks. The estimated cost for a heavy timber crossing, not including grading, is $2000. A more durable, reinforced concrete crossing would cost approximately $7,500. For the purposes of this study, it was assumed that the less expensive, timber crossings would be built.

Bridges. Under the Full Rail alternative, bridges would have to be constructed at four locations where the railroad crosses major rivers or streams. Costs for each bridge were based on their estimated length, using a unit cost of $2000 per foot for an open deck, steel girder trestle. Construction cost estimates for the four bridges are:

• House Creek (W. Range Road)	$2,400,000
• Cowhouse Creek (W. Range Road)	$3,200,000
• Henson Creek (W. Range Road)	$1,200,000
• Cowhouse Creek (E. Range Road)	$3,400,000

The costs for the three bridges along West Range Road would be incurred under all rail alternatives. The cost for the Cowhouse Creek bridge along East Range Road appears only in the Full Rail alternative.

Relocation of Existing Roads. The best alignment for the railroad crosses or coincides with the existing range roads at several points. In some cases, it would be less costly to use the existing road right-of-way for the railroad and relocate that section of range road to a more convenient alignment. In evaluating the rail alternatives, the cost of moving and reconstructing portions of the range roads is treated as a one-time capital cost, because these roads would be maintained in some location (existing or other) whether or not the rail line was constructed.

Average relocation costs for a two-lane asphalt road, including earthwork, subsurface material and flexible pavement are estimated to be $500,000 per mile. This unit cost was multiplied by the length of road to be relocated under each rail alternative.

<u>Tracked Vehicle Loading and Staging Areas</u>. Facilities must be provided at each railhead and field siding to load and unload tracked vehicles in an efficient manner. At a minimum, each siding should be equipped with an offloading platform and a sufficiently large staging area to maneuver tracked vehicles into columns for circus-style loading. The offloading platform should be constructed of reinforced concrete in order to handle heavy vehicle loads under all weather conditions. The construction cost for a 100' by 65' concrete platform, including a 10:1 ramp and a 2-foot concrete retaining wall with steel bumpers at the end of the siding tracks, is estimated to be $62,000 based on unit cost estimates obtained from the original Ft. Hood rail study.

(A copy of the cost appendices from the original Ft. Hood study are included as Appendix H.)

Although reinforced concrete pads were originally proposed for the staging area at each field siding, an adequate and less costly alternative would be to use packed gravel. The estimated cost for a 100' x 500' packed gravel staging area is $30,000.

For nighttime loading/unloading operations, fixed lighting facilities would be required along the length of the railhead to facilitate inspection of both railcars and the loaded tracked vehicles. Lighting costs at each field siding were based on a configuration of seven span-wire lights spaced 200' apart along the 1200' of siding tracks. Each span would consist of two poles with five lights per span. At a unit cost of $10,000 per span, the lighting cost for each field siding was estimated to be $70,000. Lighting cost estimates for the South Ft. Hood railhead were increased to $100,000 to allow for the more extensive layout of the railhead.

There is considerable disagreement among military and railroad personnel regarding the need for washing facilities at each siding/railhead to remove dirt and mud from the tracked vehicles before they are loaded onto railcars. Because of the uncertainty of this requirement and the potential high costs associated with providing washing facilities at each siding, cost estimates for these facilities were not included in this study.

Total costs at each field siding for offloading platform, staging area, and lighting were therefore estimated to be $162,000, plus the costs of site preparation and grading which are unique to each siding.

CHAPTER 4. TRACKED VEHICLE OPERATIONS AND COST SAVINGS

The "benefits" side of the accounting framework includes operating costs and depreciation, as well as time savings and other impacts of value, whether quantifiable or not. Operating costs involve the consumption of materials having lifetimes of less than a year, and operating labor. Depreciation is the loss in value of a long-lived asset, normally through wear and tear. The wearing out and replacement of a set of M1 tracks, for example, is an operating cost, in part because it occurs fairly frequently (about once a year) and in part because it is a direct support repair part. The wearing down of an engine or transmission, in contrast, is a depreciation cost, in part because the replacement occurs at long intervals, with no expenditure in between to reflect the actual deterioration that is taking place, and in part because the overhaul occurs at depot maintenance. As with other elements in a benefit-cost analysis, it is of primary importance to get everything accounted for exactly once, and of secondary importance as to where each element is classified.

In constructing these estimates, measurement is made of only those costs that are directly impacted by the alternative. For tracked vehicle operations, this means costs that would be avoided if the vehicles were driven fewer miles, excluding fixed costs that are simply averaged over lifetime miles. Care has been taken to delete any cost items that would not be avoided by reduced roadmarching.

4.1 OPERATING AND MAINTENANCE COSTS

Tracked vehicle operating and maintenance (O & M) costs under each alternative are the product of annual tracked vehicle mileage (from Chapter 3) and the O & M cost per mile for each tracked vehicle. Table 4-1 presents the unit O & M costs for each type of tracked combat vehicle on post at Ft. Hood. These costs are made up of three components: 1) petroleum, oil and lubricants (POL); 2) organizational and direct support repair parts; and 3) labor. The labor component covers pay and allowance for military maintenance labor. Crew pay has not been included, on the assumption that the value to the Army of the crew's labor is the same whether it is operating the vehicle or doing something else.

TABLE 4-1.

UNIT COSTS FOR TRACKED VEHICLE OPERATIONS AND MAINTENANCE
(in Dollars per Mile)

ID#	Description of Vehicle	O & M Cost Components POL	Parts	Labor	Total O & M Costs
M1	Combat Battle Tank	7.80	83.63	22.72	114.15
M2	Infantry Fighting Vehicle	1.61	41.47	17.30	60.38
M3	Cavalry Fighting Vehicle	1.61	41.47	17.30	60.38
AVLB	Bridge Launcher	2.00	28.02	10.01	40.03
M88	Heavy Recovery Vehicle	2.12	27.12	9.75	38.99
M106	Mortar Carrier	0.64	7.77	2.80	11.21
M109	155mm Howitzer	1.08	15.66	5.58	22.32
M110	8" Howitzer	0.99	27.47	9.49	37.60
M113	Personnel Carrier	0.64	7.77	2.80	11.21
M163	20mm Anti-Aircraft Gun	0.57	30.58	10.38	41.53
M270	Rocket Launcher System	1.61	41.47	17.30	60.38
M548	Ammunition Carrier	0.64	7.77	2.80	11.21
M577	Mobile Command Post	0.64	7.77	2.80	11.21
M578	Light Recovery Vehicle	1.07	16.14	5.74	22.95
M728	Combat Engineer Vehicle	1.89	47.62	16.50	66.01
M730	SAM Missle Launcher	0.97	19.50	6.82	26.96
M901	TOW Vehicle	0.64	7.77	2.80	11.21
M1015	Electronics Carrier	0.64	7.77	2.80	11.21
M60	Combat Battle Tank (TXNG)	2.57	28.67	10.41	41.65

Data Sources for M1 and M2/M3 Unit Costs. Unit cost data for the M1 and M2/M3 vehicles were obtained from the Army's Transportation and Automotive Command (TACOM), and apply to those vehicles operating in the continental United States. The TACOM estimates are derived from a combination of field data, accounting data, and engineering standards, depending upon the type of cost and the information available. Annual costs (such as military pay) were translated into unit costs assuming an average of 850 miles per year per vehicle. A 20-year lifetime was assumed by TACOM, with components being repaired, replaced, or overhauled at intervals suitable for each component. Where possible, only those costs associated with the automotive systems (as opposed to fire control, communications, etc.) of the tracked vehicles were counted in estimating the unit O & M costs.

The TACOM unit cost estimates for POL and repair parts are approximately 10 percent higher than those used by Ft. Hood. Aside from differences in the method and accuracy of cost accounting practices, other possible reasons for differences in unit costs include the terrain and climate over which the vehicles operate, stockpiling of replacement parts at Ft. Hood, and the annual mileage operated at Ft. Hood. The decision to use the TACOM cost estimates was based in part on the finer level of detail they provided, and in part on a suspicion, supported by discussions with Ft. Hood personnel, that the Ft. Hood estimates were less than comprehensive. Since no labor cost estimates were included in the Ft. Hood unit costs, TACOM estimates provided the only source for this cost component.

Data Sources for Other Tracked Vehicle Unit Costs. Unit cost estimates for other tracked vehicles at Ft. Hood were not available from TACOM in the same level of detail as those for the M1 and M2/M3. Unit cost estimates for other vehicles were available from Ft. Hood, but like those provided for the M1 and M2/M3, they did not include military labor costs, and probably underestimated average costs for POL and repair parts. In order to maintain a consistency between the unit costs for the M1, M2/M3 and all other tracked vehicles, the Ft. Hood unit cost estimates were adjusted as follows:

1. Unit costs for repair parts and for POL were increased by 10 percent over the estimates provided by Ft. Hood.

2. Labor costs were set equal to one-third of the combined costs for POL and repair parts.

The cost estimates in Table 4-1 reflect these adjustments for all tracked vehicles other than the M1 and M2/M3.

4.2 DEPRECIATION

Tracked vehicle depreciation, like O & M costs, is a product of the annual tracked vehicle mileage and a unit depreciation cost per mile for each vehicle type. Non-mileage depreciation is not relevant to the transportation investment decision, and therefore is assumed to be zero in this study. Table 4-2 presents the unit depreciation for each tracked combat vehicle at Ft. Hood. As shown in the table, depreciation is comprised of two major components: 1) depot maintenance, and 2) transportation. Depot maintenance includes all direct charges for repair parts and labor conducted at AMC depots. Transportation includes the cost of transporting a tracked vehicle and/or major component to and from a maintenance depot.

Data Sources for Unit Depreciation Costs. Depreciation costs for the M1 and M2/M3 vehicles were derived from the same TACOM cost estimates as used for the unit O & M costs described in Section 4.1. Annual cost components were converted to mileage-based costs using an average of 850 miles per year per vehicle. Where possible, only those costs associated with vehicle automotive systems were counted in estimating the costs of depot maintenance.

No comparable depreciation cost components were available for other tracked combat vehicles, either from TACOM or from Ft. Hood. Based on the TACOM cost estimates for the M1 and M2/M3, average vehicle depreciation was found to be equivalent to approximately 60 percent of the vehicle O & M costs. Lacking any other estimate for depreciation, this ratio was used to derive estimates of unit depreciation for the other tracked vehicles.

4.3 COMPUTATION OF ANNUAL TRACKED VEHICLE OPERATING COSTS SAVINGS

Total annual tracked vehicle operating costs are equal to the sum of annual O & M costs and annualized depreciation costs. Table 4-3 summarizes these computations for the three tracked vehicle categories (M1, M2/M3, and other) under each transportation alternative. O & M costs for the M1 and M2/M3 vehicle categories were obtained by multiplying the annual mileage estimated for each vehicle category under the various transportation alternatives (shown in Table 2-5) by the unit O & M costs from Table 4-1. Depreciation costs were obtained by multiplying the annual tracked vehicle mileage by the unit depreciation costs from Table 4-2.

Computation of annual O & M and depreciation costs for the "other" tracked vehicle category involved taking a weighted average of the unit costs, where the weighting factor was the share of overall annual mileage contributed by each vehicle type. These shares remain relatively constant across alternatives with the exception of the Full HET alternative. Under the Full HET altenative, over 95 percent of the mileage in the "other" tracked vehicle category was made by vehicles in the M113 family. By comparison, M113 and related vehicles make up only 62 percent of the mileage under the Full Roadmarch and other HET and rail alternatives. This difference can be

TABLE 4-2.

UNIT COSTS FOR TRACKED VEHICLE DEPRECIATION
(in Dollars per Mile)

ID#	Description of Vehicle	Depreciation Components: Depot	Depreciation Components: Transp.	Total Deprec. Costs
M1	Combat Battle Tank	67.75	0.95	68.70
M2	Infantry Fighting Vehicle	40.46	1.69	42.15
M3	Cavalry Fighting Vehicle	40.46	1.69	42.15
AVLB	Bridge Launcher			24.02
M88	Heavy Recovery Vehicle			23.39
M106	Mortar Carrier			6.73
M109	155mm Howitzer			13.39
M110	8" Howitzer			22.56
M113	Personnel Carrier			6.73
M163	20mm Anti-Aircraft Gun			24.92
M270	Rocket Launcher System			42.15
M548	Ammunition Carrier			6.73
M577	Mobile Command Post			6.73
M578	Light Recovery Vehicle			13.77
M728	Combat Engineer Vehicle			39.61
M730	SAM Missle Launcher			16.18
M901	TOW Vehicle			6.73
M1015	Electronics Carrier			6.73
M60	Combat Battle Tank (TXNG)			24.99

TABLE 4-3.

TRACKED VEHICLE ANNUAL OPERATING COST SUMMARY

	- Tracked Vehicle Category -			Combined Operating Costs	Operating Cost Savings
	M1	M2/M3	Other		
Full Roadmarch					
O & M Costs	12,948,605	5,106,518	2,565,472	20,620,595	
Depreciation	7,792,985	3,564,752	1,539,033	12,896,770	
TOTAL COSTS	20,741,590	8,671,270	4,104,505	33,517,365	
Current HET					
O & M Costs	9,656,633	4,820,679	2,457,742	16,935,054	
Depreciation	5,811,745	3,365,214	1,474,406	10,651,365	
TOTAL COSTS	15,468,378	8,185,893	3,932,148	27,586,419	$5,930,946
Expanded Existing HET					
O & M Costs	4,131,431	2,781,767	2,565,472	9,478,670	
Depreciation	2,486,459	1,941,893	1,539,033	5,967,385	
TOTAL COSTS	6,617,890	4,723,660	4,104,505	15,446,055	$18,071,310
Full HET					
O & M Costs	1,192,210	396,153	997,111	2,585,561	
Depreciation	717,572	276,546	598,429	1,592,547	
TOTAL COSTS	1,909,782	672,699	1,595,540	4,178,021	$29,339,344
Full Rail					
O & M Costs	5,701,108	2,090,597	1,083,805	8,875,510	
Depreciation	3,431,153	1,459,402	650,177	5,540,732	
TOTAL COSTS	9,132,261	3,549,999	1,733,982	14,416,242	$19,101,123
West Line to Curry					
O & M Costs	6,445,023	2,240,098	1,161,042	9,846,163	
Depreciation	3,878,871	1,563,765	696,512	6,139,148	
TOTAL COSTS	10,323,894	3,803,863	1,857,554	15,985,311	$17,532,054
West Line to Critten.					
O & M Costs	6,272,428	2,363,334	1,303,964	9,939,726	
Depreciation	3,774,996	1,649,793	782,251	6,207,040	
TOTAL COSTS	10,047,424	4,013,127	2,086,215	16,146,766	$17,370,599
West Line Only					
O & M Costs	8,042,210	2,804,651	1,625,225	12,472,086	
Depreciation	4,840,121	1,957,868	974,997	7,772,547	
TOTAL COSTS	12,882,331	4,762,519	2,600,222	20,245,072	$13,272,293

attributed to the assumption, under the Full HET alternative, that all vehicles in the M113 family would be roadmarched rather than transported via HET. Since the M113 family has the lowest overall O & M costs of all tracked vehicles, the resulting unit O & M cost under the Full HET alternative is only about 60 percent ($12.28 versus $20.52 per vehicle-mile) of that used for the other alternatives. Similarly, the weighted average unit depreciation costs used for the "other" vehicle category were $7.37 for the Full HET alternative and $12.31 for all other alternatives.

Annual savings in tracked vehicle operating costs were computed by subtracting the total annual operating costs estimated for each alternative from the total operating costs estimated for the Full Roadmarch alternative.

4.4 SCHEDULING AND MOVEMENT CONTROL

Scheduling and movement control represent those costs associated with the scheduling of training and allocation of training areas and firing ranges so as to avoid peaks in demand which would exceed the available capacity of the on-post transportation system. These costs are largely opportunity costs involving the reassignment of personnel in each division's training office to: 1) assure that division training movements do not exceed available transportation supply on a day-to-day basis; 2) coordinate with III Corps and the other division's training personnel on the use of training areas and firing ranges; and 3) schedule transportation requests based on training movements. The cost of movement control under the Full Roadmarch alternative has been set arbitrarily to zero, so that the cost estimates for each alternative represent the incremental costs over the base alternative.

Incremental costs for scheduling and movement control under the 2-Company Full HET option are estimated to be approximately one-half labor-year per division, or about $50,000 in total per year. Relatively little additional coordination of training between divisions, beyond what is currently done, would be necessary because each division would have control over its own HET company. More rigid, advanced scheduling of training would be required within each division's training office which would require some administrative effort on the part of G3 and loss of some flexibility among unit commanders. Finally, some additional coordination between each division and the 13th SUPCOM would be required to obtain additional HET transportation on an occasional basis.

The Expanded Existing HET alternative and the other, centralized Full HET options would require some additional coordination between divisions and more formal scheduling procedures since the HETs would not be organic to the division. On the other hand, consolidation of dispatching responsibilities might be expected to reduce scheduling costs relative to the 2-Company option. For the purposes of this analysis, therefore, scheduling and movement control costs for the other HET alternatives are estimated to be $50,000 per year.

Incremental costs for scheduling and movement control under any of the rail alternatives would likely be greater than under the HET alternatives. In addition to the advanced scheduling of training within each division, there would have to be more extensive coordination of training schedules between divisions to assure that the day-to-day capacity of specific railroad sidings are not exceeded by units traveling to nearby training areas or firing ranges. Also, division training offices would have to schedule each training movement with the railroad operator, and each military unit would have to more carefully plan and execute its training movements so as to not delay rail operations. The level of effort required to carry out these duties is estimated to be approximately one labor-year per division, or about $100,000 in total per year.

4.5 TRANSPORTATION FOR TRACKED VEHICLE CREWS

When tracked vehicles are moved by some means other than roadmarching, alternative transportation must be provided for the crews. The cost of providing this transportation is directly proportional to the savings in tracked vehicle mileage and offsets the tracked vehicle operating cost savings by a small but not insignificant amount.

Crews may be transported out to their tracked vehicles by various means including armored personnel carriers, trucks, or aboard other roadmarched tracked vehicles. In many instances, the vehicle would be traveling out to the field even if it weren't transporting personnel, making the marginal costs of transportation negligible. Such transportation would not be assured for all training missions, however. Therefore, it is assumed that all tracked vehicle crews would be transported to the field via 2 1/2-ton cargo trucks, and the full mileage-based O & M costs associated with this vehicle type are included for each alternative.

Unit O & M costs for a 2 1/2-ton cargo truck, based on information received from TACOM, is $1.56 per mile, exclusive of driver wages. Assuming that the trucks and drivers would be used 50 percent of the time to transport tracked vehicle crews to and from the field under the Full HET alternative, the average cost per mile for the driver is estimated to be $0.74. The total unit transportation costs are therefore $2.30 per mile.

Each truck can transport 15 to 18 troops, or the equivalent of 3 to 4 tracked vehicle crews. Using an average of 3.5 crews per truck, the incremental cost for crew transportation is estimated to be $0.66 per tracked vehicle mile saved. However, since the truck would generally have to deadhead one way, this cost should be doubled, for an average of $1.31 per tracked vehicle mile saved.

The unit crew transportation cost was multiplied by the annual tracked vehicle mileage saved under each alternative (as shown in Table 2.5) to obtain an estimate of the additional cost to provide alternative transportation for tracked vehicle crews under each alternative. Tracked vehicle crew transportation and division scheduling and movement control costs are summarized in Table 4-4.

TABLE 4-4

ADDITIONAL TRACKED VEHICLE COSTS
(in Dollars per Year)

Alternative	Scheduling & Movement Control	Alternative Crew Transport.
Current HET	0	50,858
Expanded Existing HET	50,000	151,625
Full HET	50,000	294,523
Full Rail	100,000	243,196
West Line to Curry	100,000	226,485
West Line to Crittenberger	100,000	216,667
West Line Only	100,000	166,273

CHAPTER 5. TRANSPORTATION SYSTEMS OPERATION

Operation of any of the proposed HET or rail systems incurs costs in the form of labor for operations, maintenance, and administration of the system, fuel and repair parts for the transportation equipment, and depreciation of existing equipment and facilities. Cost estimates for each of these categories are presented below. Background data, including sources and calculations of derived costs are documented in Appendix F.

5.1 HET OPERATIONS AND MAINTENANCE

There are three major components of operation and maintenance costs associated with HETs -- personnel costs (drivers, maintenance and support), mileage-based costs (POL and spare parts), and fixed facility operating costs (utilities and routine maintenance). These cost components are summarized in Table 5-1 and are discussed below.

Personnel Costs. In Chapter 1, it was assumed that the Full HET alternative would be implemented by establishing the equivalent of a full HET company in each of the two resident armor divisions. According to the most recent available Army MTOE, a full HET company has an authorized personnel strength of 151 men. This authorization is based on the assumption that, in a combat scenario, a HET company would need sufficient personnel to operate and maintain the vehicles around-the-clock. Consequently, the authorized staffing provides for two full crews of drivers and vehicle mechanics, plus enough supervisory and support personnel to enable the company to operate as a self-sufficient unit under fire. This level of staffing would not be needed in order to satisfy division transportation requirements on post at Ft. Hood. Therefore, in order to present a more realistic estimate of the annual personnel costs associated with the Full HET alternative, the staffing level for each division HET company was scaled down to a level more consistent with its proposed peacetime mission. The resulting personnel strength was computed to be 69 men per division HET company. A comparison of the proposed staffing to the staffing authorized in the MTOE is presented in Appendix Section F.3.

Using Army averages for base pay and housing allowances by grade for the revised personnel roster, estimates of annual labor costs for HET drivers, maintenance crews, and supervisory and support personnel were computed. Direct labor costs were increased by a factor of 40 percent to reflect

TABLE 5-1.

HET ANNUAL OPERATING COST SUMMARY

	Current HET Operation	Expanded Existing HET	- Full HET Alternatives -		
			2-Company	1-Company	Commercial
Mileage-Based Costs					
Annual HET Mileage per Alternative	82,482	244,657	475,893	475,893	475,893
x Unit HET O & M Cost	$6.23	$6.23	$6.23	$6.23	$3.94
TOTAL MILEAGE-BASED COSTS	$513,863	$1,524,213	$2,964,813	$2,964,813	$1,875,018
HET Personnel Costs					
HET Drivers	294,800	850,400	1,700,700	1,700,700	1,470,000
HET Maintenance	63,300	182,700	365,400	365,400	377,000
Supervisory and Support	144,900	418,000	836,000	836,000	120,000
TOTAL PERSONNEL COSTS	$503,000	$1,451,100	$2,902,100	$2,902,100	$1,967,000
Fixed Facility Operating Costs					
HET Maintenance Facilities	8,700	25,000	50,000	50,000	25,000
HET Administrative Facilities	8,700	25,000	50,000	50,000	10,000
TOTAL FIXED FACILITY OPERATING COSTS	$17,400	$50,000	$100,000	$100,000	$35,000
Profit on Commercial HET Contract					$377,230
TOTAL ANNUAL HET OPERATING COSTS	$1,034,263	$3,025,313	$5,966,913	$5,966,913	$4,254,248

military fringe benefits (leave, health care, military pensions, etc.). These costs were then multiplied by the number of HET companies required for each HET option.

HET personnel costs may represent actual new expenses or opportunity costs, depending on the alternative. In the 2-company Full HET option, the costs represent the additional military personnel who would have to be assigned to Ft. Hood. In the Expanded Existing HET alternative, the costs represent opportunity costs associated with using 96th Transportation Company personnel to provide on-post tracked vehicle transportation on a full time basis. The 1-company Full HET option includes both opportunity costs (for 96th Transportation Company personnel) and new personnel costs. In this analysis, opportunity costs and new incremental costs are assumed to be equally valued.

Personnel costs for the commercial HET alternative are based on estimates obtained from conversations with commercial heavy equipment haulers. It was assumed that the capacity of two HET companies could be provided using a fleet of 42 commercial HETs, with drivers working an average 40-hour week plus 8 hours of overtime. Assuming that maintenance and administrative facilities would be provided by the Army on post, an additional support staff of 14 would be needed to handle vehicle maintenance, dispatching, management, and administrative support. A more detailed discussion of the assumptions used to calculate the commercial HET alternative are presented in Appendix F.3.

Personnel costs for Current HET operations were computed by adjusting the costs of the Full HET alternative based on the reduced share of annual HET mileage for this alternative.

<u>Mileage-Based Costs</u>. Mileage-based costs for the military HET alternatives include POL and organizational repair parts. Based on information obtained from TACOM, 1986 POL costs averaged \$1.56 per mile, while organizational repair parts, parts transportation, and off-post civilian labor averaged \$4.67 per mile, for a unit operating cost of \$6.23 per mile. This cost estimate is applied to all military HET alternatives. Mileage-based costs for the commercial HET option include POL (\$1.56 per mile) and repair parts (\$2.38 per mile), for a unit operating cost of \$3.94 per mile. The primary reason for the difference in unit costs between the military and commercial HET alternatives is the greater sophistication and therfore higher cost of military versus civilian equipment.

The unit cost is multiplied by the average annual mileage for each HET alternative to obtain the average annual mileage-based costs shown in Table 5-1.

<u>Fixed Facility Operating Costs</u>. Fixed facility operating costs include utilities and normal maintenance on buildings used to support HET operations on post. In the absence of more detailed information on facility space requirements and operating costs at Ft. Hood, an arbitrary estimate of \$25,000 per year per company is used for both maintenance and administrative facil-

ities. The cost estimates for commercial HET operations are adjusted downward because it is assumed that less space would be allocated to, or needed by, a non-military HET unit. Cost estimates for current HET operations are also adjusted downward based on the reduced share of annual HET mileage for this alternative.

Profit on Commercial HET Contract. An additional cost included in the commercial HET alternative is a profit or fee for the commercial hauler who is awarded the transportation contract. The fee on a federal contract is typically set during the procurement process. Based on current federal procurement policy, the fee on a multi-year contract award involving some risk to the contractor ranges between 5 and 10 percent of the contract amount. For the purposes of this analysis, an estimate of 8 percent was selected.

5.2 DEPRECIATION OF EXISTING HET VEHICLES AND FACILITIES

Wear and tear on existing HET tractors and semitrailers as a consequence of carrying tracked vehicles constitutes a cost of the HET alternative. In principle, it does not matter whether this depreciation is a function of mileage or not, but the non-mileage portion may possibly be shared with other benefits of having HET capacity organic to military units. Mileage-related costs could be offset by the value of training that occurs while carrying tracked vehicles, but this was not done in this study.

Unit depreciation costs for HET vehicles are based on their estimated purchase price divided by their expected useful life. For the military HET alternatives, the assumed purchase price is that of a new HET tractor/trailer combination ($260,000). The purphase price for civilian HETs is assumed to be $165,000, based on information provided by commercial HET operators and HET manufacturers. A conservative estimate of the expected useful life of a HET (100,000 miles) is used for both the military and commercial HETs.

The appropriate unit costs are multiplied by the share of annual HET mileage incurred by the 14 existing division-based HETs for the 2-Company Full HET alternative, or the 22 HETs belonging to the 96th Transportation Company for the 1-Company Full HET alternative, the Expanded Existing HET alternative, and Current HET operations. For the commercial HET alternaitve, all 44 HET units are treated as existing equipment. For the purposes of this study, it is assumed that every existing HET incurs an equal share of total annual HET mileage. HET depreciation cost estimates are presented in Table 5-2.

Depreciation of administrative buildings, maintenance facilities, and other existing fixed facilities are included as annualized fixed costs, consistent with their expected utilization under each of the alternatives.

The depreciation costs presented here apply only to existing HET equipment and facilities. Depreciation of new HET vehicles and fixed facilities is explicitly treated in Chapter 8 as part of the annualization of direct capital expenditures.

TABLE 5-2

DEPRECIATION OF EXISTING HET VEHICLES AND FACILITIES

	Current HET Operation	Expanded Existing HET	- Full HET Alternatives - 2-Company	1-Company	Commercial
<u>Depreciation of Existing HET Vehicles</u>					
Average Annual Mileage per HET	3,749	11,121	10,816	10,816	10,816
x Existing HETs per Alternative	22	22	14	22	44
x HET Unit Depreciation Cost	$2.60	$2.60	$2.60	$2.60	$1.65
TOTAL ANNUAL VEHICLE DEPRECIATION	$214,443	$636,121	$393,702	$618,675	$785,242
<u>Depreciation of Existing Facilities</u>					
HET Maintenance Facilities	5,000	15,000	9,000	15,000	0
HET Administrative Facilities	3,500	10,000	10,000	10,000	0
TOTAL ANNUAL FACILITY DEPRECIATION	$8,500	$25,000	$19,000	$25,000	0
TOTAL ANNUAL DEPRECIATION FOR EXISTING HET RESOURCES	$222,943	$661,121	$412,702	$643,675	$785,242

5.3 RAILROAD OPERATIONS AND MAINTENANCE

There are four principal components of cost associated with the operation and maintenance of rolling stock under each of the rail alternatives -- fuel, train crew labor, routine vehicle maintenance, and administrative labor. Each of these costs is described more fully below.

Fuel. Locomotives consume fuel at substantially different rates depending on whether they are idling or underway pulling a loaded train. Under normal rail operations, locomotives remain running at all times, and are only shut down if they are to be repaired or out of operation for an extended period of time (e.g., 24 hours or more).

For this analysis, it was assumed that each locomotive would be running an average of 8640 hours per year (i.e., the equivalent of 360 days per year), and would travel between 10,000 and 15,000 miles, depending on the alternative. Locomotives would be operating under load for an average of 4 hours per day, or 1440 hours per year. The rest of the time, they would be idling.

Fuel consumption rates for a GP-15 locomotive under load range from 0.7 to over 6 gallons per mile depending on the total tonnage carried and the grade. For the purposes of this study, on-post train movements were separated into several weight categories (i.e., 2800 tons, 1000 tons, 300 tons, and 200 tons) and fuel expenditures computed for each category (see Appendix F.5). An average combined fuel consumption rate of 2.55 gallons per mile was derived for the Full Rail alternative which included all on-post train movements from both South and North Ft. Hood. This combined average was applied to the annual mileage estimates for each of the other rail alternatives to obtain the fuel consumption for locomotives under load.

Idling consumes fuel at the rate of 4 gallons per hour. For each rail alternative, it was assumed that a locomotive would be at idle an average of 7200 hours per year. Total annual fuel consumption for two locomotives at idle would therefore average 57,600 gallons.

The combined fuel consumption for locomotives under load and at idle was multiplied by an assumed fuel cost of $1.00 per gallon, to obtain a total annual fuel cost per alternative. These estimates are presented in Table 5-3 for each rail alternative.

Train Crew Labor. Operating personnel requirements were estimated from comparable military and short line railroads. A minimum train crew for on-post movement of tracked vehicles would consist of an engineer and a brakeman/switcher. In addition, a blocking, bracing inspector should be available every time a train is loaded to assure that tracked vehicles are properly secured on the flatcars. Because trains may be loaded at any of the railheads or field sidings on post, it appears likely that each train would require its own inspector. Three such train crews would be required to provide service 12 to 16 hours per day on weekdays and 8 hours per day on

TABLE 5-3.

RAILROAD OPERATING COSTS AND DEPRECIATION

	Full Rail	West Line to Curry	West Line to Critten.	West Line Only
Locomotive and Railcar Operations				
Train Crew Labor	253,530	253,530	253,530	169,020
Maintenance Crew Labor	59,130	59,130	59,130	59,130
Fuel	120,500	119,167	130,170	112,328
Repair Parts and Consumables	25,000	25,000	25,000	25,000
Annual TROSCOM Rail Inspection	10,000	10,000	10,000	10,000
TOTAL VEHICLE OPERATING COSTS	$468,160	$466,827	$477,830	$375,478
Railroad Administrative Costs				
Administrative and Support Personnel	73,980	73,980	73,980	73,980
Fixed Facility Operating Costs	25,000	25,000	25,000	25,000
TOTAL ADMINISTRATIVE COSTS	$98,980	$98,980	$98,980	$98,980
TOTAL ANNUAL RAILROAD OPERATING COSTS	$567,140	$565,807	$576,810	$474,458
Depreciation of Existing Railcars				
Annual Railcar Mileage (existing)	72,975	71,332	86,450	63,574
x Unit Railcar Depreciation	$0.50	$0.50	$0.50	$0.50
TOTAL ANNUAL EXISTING RAILCAR DEPRECIATION	$36,488	$35,666	$43,225	$32,287

weekends. Due to the reduced number of annual train movements under the West Rail alternative, only two train crews would be needed, and labor costs were reduced accordingly.

Since one of the anticipated benefits of the rail alternative would be training for military personnel in rail loading, it was assumed that actual loading of tracked vehicles would be performed by the units being transported; therefore no additional loading personnel would be required. Moreover, the opportunity costs for military personnel engaged in loading and unloading of tracked vehicles were assumed to be zero.

Locomotive and Flatcar Maintenance. Routine maintenance costs for both locomotives and railcars are largely functions of how much each vehicle is utilized. Although the locomotives and railcars stationed at Ft. Hood would be in service substantially less than comparable rolling stock operating on commercial railroads, some minimal level of inspection and routine maintenance would be required. For the purposes of this study, it was assumed that a two-man vehicle maintenance crew, consisting of a heavy equipment (diesel) mechanic and an assistant mechanic, would perform routine and emergency maintenance on the locomotives and railcars. Major locomotive repairs would very likely be contracted out to a commercial railroad.

In addition to routine maintenance performed on post, the Army's Troop Support Command (TROSCOM) offers the services of a mobile rail team to military railroad installations. This team conducts inspections of Army-owned locomotives on an annual basis and makes repairs as needed. The estimated annual cost per locomotive for this inspection is approximately $5000.

Additional expenses for rail vehicle maintenance include consumables and routine repair parts for locomotives and railcars (e.g., hydraulic oil, brake shoes, tiedown chains and O-rings, etc). The estimated cost for parts and consumables is $250 per year per railcar and $5000 per year per locomotive.

Administration. In addition to the vehicle operating and maintenance crews, personnel would be needed to oversee on-post rail operations, including the scheduling and allocation of locomotives and flatcars to meet daily demand requirements, scheduling of routine vehicle and track maintenance, and handling of emergency situations such as locomotive breakdowns, derailments, or track failures. At a minimum, a qualified yardmaster would be needed to oversee rail operations and scheduling of train movements on a day-to-day basis. Clerical support staff would also be required to handle routine processing of transportation requests, procurement of equipment and supplies, and scheduling of vehicle and track maintenance. Other administrative costs include supplies, utilities, and maintenance on railroad administrative facilities.

Railroad labor costs were based on the assumption that civilian government personnel (both wage grade (WG) and general schedule (GS) employees) would be hired to operate the railroad. Unit personnel costs for each position described above, are presented in Appendix Section F.5. Aggregate labor costs, summarized by major category (train crews, maintenance crews, and administrative personnel) are presented in Table 5-3.

As an alternative to operating the railroad using civilian government employees, major elements of the rail operation could be contracted out to a short-line commercial railroad. A typical contract arrangement (as described in Appendix F) would provide two locomotives with sufficent personnel to operate and maintain the vehicles and track for about $50,000 per month, or $600,000 per year. Costs typically covered under such a contract include locomotive fuel and maintenance; train crew labor, except possibly for the blocking, bracing inspector; track maintenance labor; and a yardmaster. In addition, the direct capital costs associated with the purchase of two locomotives would also be avoided. Assuming a discount rate of 7 percent, a contractual arrangement with a commercial railroad would probably reduce the costs of operating a railroad at Ft. Hood by about $321,000 per year, compared to operation by civilian government employees.

5.4 DEPRECIATION OF EXISTING RAIL EQUIPMENT

Locomotives and railcars already purchased by the Army and used for this project were assumed to depreciate at the same rate as newly purchased equipment. Unit estimates of railcar depreciation ($0.50/mile) were multiplied by the average annual on-post mileage traveled per railcar and by the number of existing railcars presumed to be used in on-post rail operations. These estimates are summarized in Table 5-3.

Use of existing Ft. Hood switcher locomotives for on-post transportation of tracked vehicles was assumed to incur negligible mileage beyond that which is currently being expended. Therefore, no additional costs were attributed to depreciation of existing locomotives.

Similarly, implementation of any of the rail alternatives was assumed to have a negligible impact on the utilization and wear of existing buildings. Depreciation of new rail facilities and equipment is explained in Chapter 8.

CHAPTER 6. RIGHT-OF-WAY AND STRUCTURES MAINTENANCE AND DEPRECIATION

In addition to the operating costs and depreciation of transportation equipment and facilities, the maintenance and depreciation of rights-of-way (ROW) and structures also constitute costs of the proposed alternatives. Increased HET usage will result in more rapid deterioration of existing roads, while the maintenance costs of tank trails would be reduced by any alternative that reduces travel on them. Land already owned by Ft. Hood does not depreciate, but it does have an opportunity cost. Each of these costs are described below.

6.1 TANK TRAIL MAINTENANCE

The constant travel of tracked vehicles over tank trails causes damage which must be repaired periodically. Typical tank trail maintenance costs include blading, done 4 to 5 times per year at a cost of $45 per mile, and major rehabilitation every 2 to 3 years, at a cost of $2000 per mile. Annual tank trail maintenance costs therefore average about $850 per mile.

Of the 410 miles of unpaved roads and tank trails currently maintained at Ft. Hood, approximately 100 miles are used predominantly by tracked vehicles to travel to and from training. It has been estimated by Ft. Hood (DEH) that about one-third of the tank trail maintenance costs could be saved if tracked vehicles were transported to training by some other means. Based on these estimates, a maximum of $28,333 could be saved in tank trail maintenance if <u>all</u> tracked vehicle mileage to and from training were transported via HET or rail. Dividing the above cost savings by the annual tracked vehicle mileage estimated for the Full Roadmarch alternative (323,031 miles) yields an average cost per tracked vehicle-mile of $0.88. Actual savings in tank trail maintenance will vary by alternative depending on the amount of tracked vehicle roadmarch mileage eliminated. Estimated cost savings in tank trail maintenance are presented in Table 6-1 for the HET alternatives and (later in this chapter) in Table 6-2 for the rail alternatives.

TABLE 6-1.

HET RIGHT-OF-WAY MAINTENANCE COSTS AND DEPRECIATION

	Current HET Operation	Expanded Existing HET	Full HET Alternative
Tank Trail Maintenance (Savings)			
Tracked Vehicle-Miles Saved	38,823	115,744	224,827
x Maintenance Cost per Veh-Mi.	$0.088	$0.088	$0.088
TOTAL ANNUAL TANK TRAIL MAINTENANCE SAVINGS	$3,416	$10,185	$19,785
Highway Depreciation			
Annual loaded miles (50+ tons)	33,515	81,711	123,119
x ESAL-mi./Veh-mi.	35.0	35.0	35.0
Annual loaded miles (<50 tons)	7,726	40,617	114,828
x ESAL-mi./Veh-mi.	3.2	3.2	3.2
Annual unloaded vehicle miles	41,241	122,328	237,947
x ESAL-mi./Veh-mi.	0.4	0.4	0.4
TOTAL ANNUAL ESAL-MILES	1,214,245	3,038,791	4,771,793
x Pavement damage cost per ESAL-mi.	$0.60	$0.60	$0.60
TOTAL ANNUAL HIGHWAY DEPRECIATION	$728,547	$1,823,275	$2,863,076

6.2 HIGHWAY DEPRECIATION

A major variable cost associated with each of the HET alternatives is the damage done to highway pavements by heavily loaded vehicles. This damage is seldom evident immediately (unless the soils are particularly unstable or saturated with water), but the long run cost of the continuing stresses may be large. The amount of stress is approximately a fourth-power function of axle weight (Figure 6-1), so that a small percentage increase in weight causes a much larger percentage increase in damage. Additional axles reduce the stress by spreading the load.

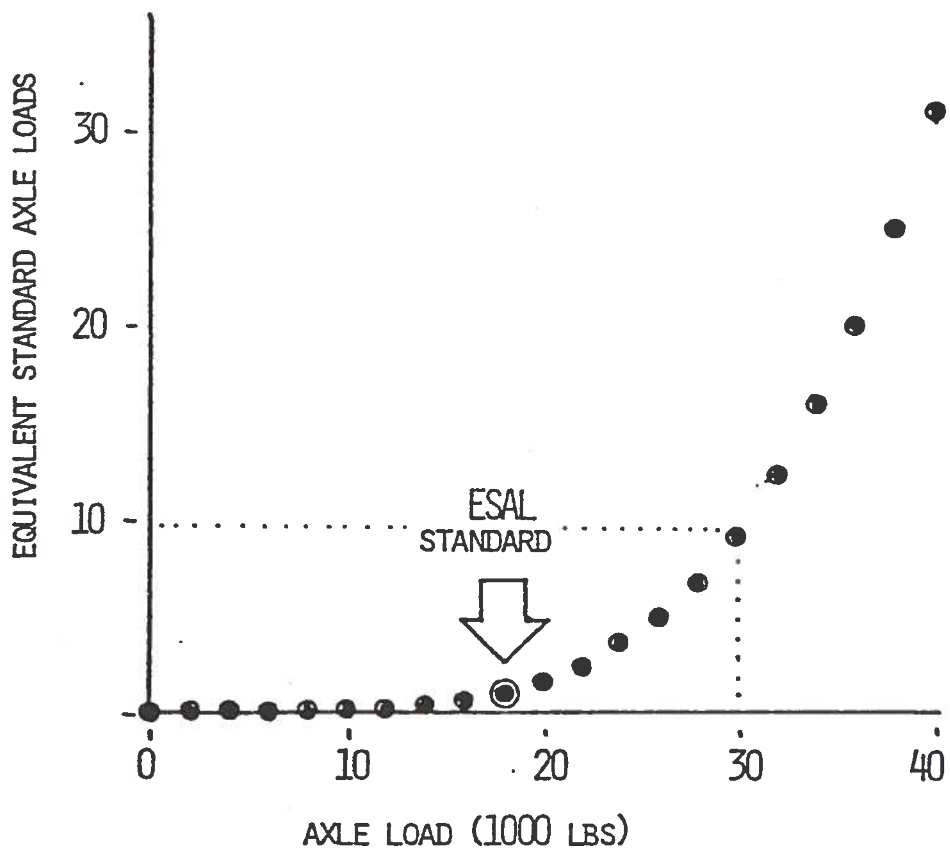
The standard of reference for quantifying stress is the Equivalent Single Axle Load (ESAL), taken to be the effect of a single heavy truck axle loaded to 18,000 pounds. A typical five-axle tractor-semitrailer rig found on U.S. highways with a gross weight of 72,000 pounds generates about 1.5 ESAL-miles per vehicle-mile. In comparison, a HET trailer loaded with an M1 tank (with a total gross weight of 90 tons carried on seven axles) generates about 35 ESALs. The cost of this damage is estimated as a share of the ESAL life of the pavement. A light duty pavement costs less to rebuild, but the share of life consumed by a heavy vehicle is much greater. Because of scale economies (strong pavements produce ESAL lifetimes proportionately greater than the increase in construction cost), a heavy axle on a light pavement is the most costly (as well as the most destructive) combination.

Roads that would be travelled by HETs carrying tanks to the field are owned and maintained by the military, hence the costs will eventually appear in the highway budget for Ft. Hood. Because local soil and weather conditions greatly affect the actual damage incurred by heavy loads, the unit cost is highly variable from place to place. A unit cost estimate of $0.60 per ESAL-mile used in this analysis represents an average cost for conditions similar to those at Ft. Hood. The unit cost also includes the time, wear, and extra operating costs of travelling on damaged (e.g., rough) pavement by other users of the highway. Annual cost estimates for pavement damage done by HETs are summarized in Table 6-1.

6.3 HET LAND USE

No cost was imputed to HET usage of the highways, on the assumptions that the road would continue to exist under any alternative, and adding HET vehicles would not increase congestion to the point that other road users would incur noticeable delay. Although this is not strictly true, the value of delay time would be insignificant in comparison to other costs and benefits of the alternatives.

Use of land for new HET facilities, however, does constitute an opportunity cost, in that the land could be alternatively used for some other worthwhile purpose. HET facilities include administrative buildings, barracks, maintenance shops, and parking. Only the land portion is valued in



AASHO EQUIVALENCE FACTORS FOR PAVEMENT DAMAGE

SINGLE AXLE ON FLEXIBLE PAVEMENT

FIGURE 6-1.

RELATIONSHIP OF PAVEMENT STRESS TO AXLE WEIGHT this section, while costs for the structures themselves are included under new capital costs (see Chapter 3). In the absence of a detailed site plan showing actual land area consumed by proposed HET facilities, an estimate of 25 acres was assumed for the Full HET alternatives. No additional land area is needed under the current or expanded existing HET alternatives because the facilities occupied by the 96th Transportation Company would continue to exist whether or not it were used to transport tracked vehicles on-post.

While the marginal value of a single acre of land on the Ft. Hood reservation may be insignificant, as more and more land is taken, the equivalent of one or more training areas could be lost. Then, in order to maintain an equivalent number of training facilities, the Army would have to purchase additional land along the borders of Ft. Hood at market prices. Unit costs for land at Ft. Hood were estimated at $1000 per acre, based on real estate valuations of the current selling price of rangeland in the area.

6.4 RAIL RIGHT-OF-WAY AND STRUCTURES MAINTENANCE

Annual maintenance costs for the railroad right-of-way include all labor and materials required for the inspection and repair of the roadbed, track, bridges and drainage structures associated with mainline track, railheads and field sidings. Rail maintenance costs also include costs associated with the tracked vehicle loading facilities including ramps, staging areas and lighting. Each of these costs are described below.

Track Maintenance Crew. Based on information obtained from other military and short line railroads, the recommended track maintenance personnel for 50 miles of mainline track and associated sidings would include two 3-man track gangs, each gang consisting of a track inspector and two laborers. This estimate was used for three of the four rail alternatives; under the West Rail Only alternative, a single track gang was assumed. Unit costs for these positions, based on current civil service wage scales, are included in Appendix Section F.5. Annual costs are summarized in Table 6.2.

Track Inspection. In addition to daily, visual track inspections, mainline tracks and sidings should be ultrasonically inspected on a periodic basis to detect flaws and perturbations in the rail which cannot be seen with the naked eye. On commercial railroads, track inspections of this nature are done annually; at Ft. Hood, inspections might be done every two years. The unit cost for a full track inspection, using a Sperry railcar, is approximately $400 per track mile plus $5000 for setup and removal of the railcar. This unit cost was multiplied by the total track mileage (mainline trackage plus sidings) under each rail alternative, and the product divided by two to compute an annual cost for track inspection.

TABLE 6-2.

RAILROAD RIGHT-OF-WAY AND STRUCTURES MAINTENANCE COSTS

	Full Rail	West Line to Curry	West Line to Critten.	West Line Only
<u>Tank Trail Maintenance (Savings)</u>				
Tracked Vehicle-Miles Saved	185,646	172,889	165,395	126,926
x Maintenance Cost per Veh-Mi.	$0.088	$0.088	$0.088	$0.088
TOTAL ANNUAL TANK TRAIL MAINTENANCE SAVINGS	$16,337	$15,214	$14,555	$11,169
<u>Track and Structures Maintenance Costs</u>				
Track Maintenance Labor	153,630	153,630	153,630	76,815
Track Inspection	15,300	12,300	11,700	10,100
Track Materials and Equipment	19,200	14,700	13,800	11,400
TOTAL ANNUAL TRACK MAINTENANCE COSTS	$188,130	$180,630	$179,130	$98,315
Tracked Vehicle Loading Facilities	$14,000	$12,000	$12,000	$10,000
Bridge Maintenance	$10,200	$6,800	$6,800	$6,800
TOTAL ANNUAL TRACK AND STRUCTURES MAINTENANCE COSTS	$212,330	$199,430	$197,930	$115,115
<u>Land Opportunity Cost</u>				
Acres of Land Taken for Railroad	353	267	247	205
x Opportunity Cost for Land ($/acre)	$1,000	$1,000	$1,000	$1,000
TOTAL OPPORTUNITY COST FOR RAILROAD LAND	$353,000	$267,000	$247,000	$205,000

Track Materials and Equipment. Annual cost for track materials, including rails, ties, tieplates, etc., and for the operation and maintenance of the daily track inspection vehicles were estimated using an average unit cost of $300 per track mile.

Tracked Vehicle Loading Facilities. Typical maintenace costs for these facilities would include blading of the staging areas, repair of ramps and lighting facilities, and utility costs for the lighting. In the absence of a detailed investigation of each component cost, an average unit cost of $2000 per facility per year was assumed.

Bridge Maintenance. Separate from the trackage, additional maintenance costs would be incurred to keep the railroad trestle bridges in repair. The estimate unit cost for railroad bridge maintenance was assumed to be $2 per linear foot per year.

6.5 RAIL LAND USE

The land which would have to be taken for the railroad right-of-way, as well as for all railheads, field sidings, and tracked vehicle staging areas, is now owned by Ft. Hood, and removing it from its existing use to build a railroad represents an opportunity cost. The amount of land taken by the various rail alternatives ranges from 205 acres for the West Line Only to 353 acres for the Full Rail Loop.

Placing a value on this opportunity cost depends upon the current use of the land as a maneuver area, and its potential impact as a physical barrier to movement of vehicles during training exercises. Furthermore, transfer of the land to rail use increases the pressure to expand the post at its boundaries. In the absence of more explicit information on the value to the Army of the land taken for the railroad, a unit value of $1000 per acre was assumed, the same value used for land taken under the Full HET alternaitve.

CHAPTER 7. OTHER COSTS AND BENEFITS

7.1 ON-POST TRANSPORTATION OF TEXAS NATIONAL GUARD VEHICLES

The annual tracked vehicle mileage saved by transporting Texas National Guard (TXNG) units from MATES to firing ranges by rail was estimated in Section 2.3 for each of the rail alternatives. Total annual cost savings resulting from this activity were computed by multiplying the savings in tracked vehicle mileage by the combined unit O & M costs and depreciation for the M60 tank (as shown in Tables 4-1 and 4-3). Table 7-1 summarizes these computations and presents the total estimated cost savings under each rail alternative.

TABLE 7-1.

COST SAVINGS FROM THE ON-POST TRANSPORTATION OF TXNG VEHICLES

Rail Alternative	Annual Mileage Savings	Combined Unit Cost per Mile	Annual Cost Savings
Full Rail	20,309	$66.64	$1,353,392
West Rail to Curry	19,714	66.64	1,313,741
West Rail to Crittenberger	18,106	66.64	1,206,584
West Rail Only	17,093	66.64	1,139,077

7.2 SHIPMENT OF MATES TRACKED VEHICLES AND SPARE PARTS BY RAIL

The maximum potential cost savings that could be realized from shipping tracked vehicles and parts to and from MATES by rail was estimated in Section 2.4 to be equivalent to the cost savings associated with a reduction of 22,000 tracked vehicle miles. Using the inventory of tracked vehicles shipped into and out of MATES during FY 1985, an average combined unit cost (O & M plus depreciation) of $36.53 per vehicle-mile was computed based on the relative shares of each vehicle type shipped. The total estimated annual cost savings for this activity is therefore equal to the estimated annual mileage saved multiplied by the average combined unit cost:

22,000 miles/yr x $36.53/mi = $803,660 per year

7.3 OUTLOADING OF TRACKED VEHICLES FROM SOUTH FT. HOOD

The estimated annual savings in tracked vehicle mileage from using the proposed South Ft. Hood railhead instead of the existing railhead to outload vehicles and equipment was computed in Section 2.2 for the three major vehicle categories: M1 tank, M2/M3 fighting vehicle, and all other tracked vehicles. Total annual cost savings were computed by multiplying the savings in road-march mileage by the combined unit O & M costs and depreciation for each vehicle category. Unit costs for the "other tracked vehicles" category were computed by taking a weighted average of the unit costs for each vehicle type based on the relative share of each vehicle type on post. Table 7-2 summarizes the computations and presents the total estimated cost savings from outloading. Since the South Ft. Hood railhead would be constructed under any of the proposed rail alternatives, there is no difference in net benefits among rail alternatives.

7.4 SHIPMENT OF AMMUNITION BY RAIL

Currently, all ammunition used for training at Ft. Hood is transported via truck to the ammunition storage bunker (ASB) located at West Ft. Hood. From there it is transported by individual military units to specific training locations as needed. It has been proposed that some savings in transportation costs could be achieved by shipping larger volumes of ammunition to Ft. Hood via rail or by using an on-post railroad to transport ammunition between the ASB and training sites.

Based on discussions with personnel at 13th SUPCOM (Material Management Center), the volume of ammunition required by individual armor or artillery units for gunnery practice is generally too small to achieve measurable cost

TABLE 7-2.

COST SAVINGS FROM OUTLOADING AT THE SOUTH FT. HOOD RAILHEAD

Tracked Vehicle Category	Annual Mileage Savings	Combined Unit Cost per Mile	Annual Cost Savings
M1 Combat Battle Tank	1624	$182.85	$296,948
M2/M3 Fighting Vehicles	1288	102.53	132,059
Other Tracked Vehicles	4354	29.56	128,704

TOTAL ANNUAL COST SAVINGS			$557,711

savings by using rail for this activity. One possible exception to this is the quarterly ammunition draw made by 8-inch/MLRS battalions, where an on-post railroad would allow shipment of rocket pods and artillery rounds from AMC depots directly to the training site. However, even here it is unlikely that the annual cost savings resulting from a total of eight such missions per year would be sufficient to offset the added cost of constructing a secured rail siding to temporarily store the ammunition on post. Consequently, the net benefits from using an on-post railroad to transport ammunition directly to training areas are estimated to be zero.

In order to realize any benefits from shipping larger volumes of ammunition by rail to the present ASB, a separate rail spur would have to be constructed. The minimum length of this rail spur, including sidings and a connection to the existing Santa Fe trackage is estimated to be 5 miles. In addition to normal grading and trackwork, the rail spur would require construction of a bridge or tunnel across U. S. Route 190 and a secured, blast-protected siding at the ASB. Although a detailed cost estimate for such a rail spur was not part the original scope of this study, a rough cost estimate of $6 million was made, based on an average cost of $1.2 million per mile from the Full Rail alternative. Given this cost estimate, it is unlikely that the total annual transportation cost savings from shipping ammunition by rail instead of truck would offset the annualized cost of constructing the rail spur. Consequently, the net benefits from shipping ammunition to Ft. Hood via rail were estimated to be zero.

7.5 INCREASES IN TRAVEL TIME FOR TRACKED VEHICLE MOVEMENTS

The savings in tracked vehicle O & M costs and depreciation achieved under any of the on-post transportation alternatives are partially offset by increases in the time required to move the vehicles between their motor pool areas and training sites. The increases in vehicle movement times relative to roadmarching range from a minimum of one-half hour for a company-level movement under the HET alternatives to a maximum of 8 to 9 hours for a battalion-level movement under one of the rail alternatives. Table 7-3 presents estimates of the average increases in travel time for each military unit and training mission combination under the Full HET and each of the four rail alternatives. These travel time increments represent unit values which would have to be multiplied by 1) the number of personnel per unit, 2) the number of units on post, and 3) the number of training missions per unit per year to obtain the total annual labor hours lost to extra travel time.

The relative value (i.e., monetary cost) of these increases in travel time depends to a large extent on how the additional travel time would otherwise be used. Some examples of how this time might be used and valued are presented below.

1. If the movement of vehicles to and from the field is considered to be part of total annual field training time, and this time were to remain constant, then the increases in travel time would result in equivalent decreases in overall field training time. This would imply a decrease in net benefits equivalent to the Army's implicit or explicit unit value for field training multiplied by the total number of training hours lost annually.

2. If field training time were increased so as to compensate for the additional travel time, then there would have to be a corresponding decrease in time spent either in non-training related duties or off-duty activities. This would imply a decrease in net benefits equivalent to the total increase in travel time multiplied by either the Army's unit value for duty time other than field training or the Army's implicit unit value for a soldier's off-duty time. Presumably, the unit values for these activities would be less than that for field training.

3. Some of activities involved in transporting units to the field under the HET or rail alternatives, such as the loading and offloading of tracked vehicles, could be viewed as additional training. That portion of total travel time spent on these activities could then be treated as a benefit having its own implicit value. This value might be equal to that of field training, but it is unlikely that it would have a higher value. Consequently, there would still be a decrease in net benefits equivalent to the total number of hours not assignable to training multiplied by the Army's implicit value for that time.

TABLE 7-3.

ADDITIONAL TRAVEL TIME REQUIRED PER TRAINING MISSION

	Extra Travel Time over Roadmarching (in Hours)				
Military Unit and Mission Type	HET	Full Rail	West Line to Curry	West Line to Critten.	West Line Only
Armor Company to Firing Range	1.0	4.0	4.0	4.5	4.5
Armor Company to Training Area	1.0	4.0	4.2	4.5	4.2
Armor Battalion to Training Area	11.5	17.0	17.2	17.5	17.2
Composite Battalion to Training Area	11.5	17.0	17.2	17.5	17.2
Infantry Company to Firing Range	1.0	4.0	4.2	4.2	4.2
TOW Company to Firing Range	0.0	4.0	4.2	4.2	4.2
Infantry Company to Training Area	1.0	4.0	4.2	4.5	4.2
TOW Company to Training Area	0.0	4.0	4.2	4.5	4.2
Infantry Battalion to Training Area	11.5	17.0	17.2	17.5	17.2
Cavalry Troop to Firing Range	3.5	4.0	4.2	4.2	4.2
Cavalry Troop to Training Area	4.0	7.0	7.2	7.5	7.2
Engineer Company to Training Area	1.0	3.0	3.2	3.2	3.0
DIVARTY Battery to Firing Range	1.0	0.0	0.0	0.0	0.0
DIVARTY Battery to Artillery Range	1.0	4.0	4.2	4.5	4.2
DIVARTY Battalion to Artillery Range	4.0	10.0	10.2	10.5	10.2
DIVAD Battery to Artillery Range	1.0	4.0	4.2	4.5	4.2
DIVAD Battalion to Field Training	1.0	4.0	4.2	4.5	4.2

In actual practice, it is likely that the increased time required to move tracked vehicles to the field will involve all of the above scenarios. Under the HET alternatives, for example, one-day training exercises may require a unit to spend an extra hour in the field. Under the rail alternatives, on the other hand, one-day training exercises would become infeasible except to those areas where a unit would ordinarily have to roadmarch. Battalion-level training exercises might have to be increased by an additional day to accommodate the extra travel time to and from the training area. Alternatively, training exercises could be shortened, or reduced by an average of one exercise per year to make up for the lost travel time.

While additional training benefits would certainly be realized in having troops load and offload tracked vehicles from HETs or railcars, at some point the marginal value of additional increments of this training would become insignificant. Moreover, the training benefits associated with this activity would be offset in part by the loss of training benefits associated with roadmarching a column of tracked vehicle along tank trails. Some roadmarch training would still be retained under the rail alternatives for those missions located nearby the cantonment area or at West Ft. Hood where no rail access is available.

Without more explicit guidance on how the additional travel time would be accommodated at Ft. Hood, and on what value the Army implicitly or explicitly places on the loss of time for field training and other activities, differences in travel time among the alternatives cannot readily be monetized.

7.6 TIME SAVINGS FOR MOBILIZATION

Based on a 1982 MTMC Study (MTMC Report TE 81-3a-44) the existing rail facilities at Ft. Hood provide a mobilization outloading capability of 212 flatcars and 40 Container-on-Flatcar (COFC) railcars per day. At this rate, the minimum time required to outload a full armor division (consisting of approximately 2000 tracked and wheeled vehicles) from Ft. Hood by rail would be approximately 5 days.

Under any of the rail alternatives, railheads at South Ft. Hood and MATES would provide additional outloading capability of up to 160 railcars per day. Use of field sidings could further increase outloading capabilities by 240 to 400 railcars per day, depending on the alternative. Thus, the minimum time required to outload a full armor division under the rail alternative could be reduced from 5 to 2 days or less, assuming that sufficient numbers of railcars would be available on post to sustain that rate of outloading.

The strategic value of a 3-day reduction in the time required to outload a full armor division from Ft. Hood depends on a number of factors including the specific combat scenario under which the mobilization occurs, and downstream constraints on the mobilization network. Without more explicit guidance from the Army, differences in time savings for mobilization cannot readily be monetized.

7.7 QUALITATIVE BENEFITS AND INTANGIBLES

Those benefits or disbenefits which cannot be easily monetized or quantified using a common measure such as time, fall into a residual category of intangibles and incommensurables. An objective of careful benefit-cost analysis is to place as many "intangibles" as possible in the other categories, so that the list of residual items is minimized. This does not mean that those attributes that are least quantifiable are given less value, but that measurable attributes are separated from the intangibles, allowing judgment to be concentrated on those impacts where judgment is most needed.

The following list includes those benefits or considerations which cannot be quantified at this time but which may be relevant in the selection of a heavy vehicle transportation system for Ft. Hood.

Impacts on Division Troop Morale. The institution of any heavy vehicle transportation system at Ft. Hood will significantly limit the flexibility that individual unit commanders currently enjoy in scheduling training for their troops. Under either the HET or rail alternatives, unit commanders would be required to reserve not only a training site, but also a sufficient number of HETs or railcars to transport their tracked vehicles. Since the transportation system represents a shared resource, individual units might not be able to travel when they would prefer. For example, a 5-day training mission which currently begins on Monday and ends on Friday might instead have to be conducted between Wednesday and Sunday in order to spread out the demand on the transportation system. These limitations would, in all likelihood, be more severe under the rail alternatives because of the additional travel time requirements and the constraints imposed by limited capacity at loading and offloading points.

Clearly, the more rigid training schedules and the negative impacts on troop morale by being required to remain longer in the field will tend to undermine support for the proposed transportation systems by many unit commanders. This inevitably will lead to situations where unit commanders will attempt to circumvent using the transportation system by citing increased need for roadmarch training. The severity of this potential problem and its impact on reducing the benefits realized from any of the HET or rail alternatives cannot be determined at this time. However, in order to achieve anything near the level of benefits identified in this study, the Ft. Hood Command Staff must demonstrate a forceful and continuing commitment to using whatever transportation system is implemented, and must also impose this same level of commitment on the unit commanders of the 1st Cavalry and 2nd Armor Divisions.

Training Benefits. Each of the proposed transportation alternatives provides military training benefits that should be considered in the final evaluation. The rail alternatives would provide both Army and National Guard units with extensive practice in railroad loading and off-loading, while the HET alternatives would provide division units with similar practice in loading and off-loading tracked vehicles from HETs. In addition, the 2-company Full HET alternative would provide trained core staffing for two division-based HET companies. Under each alternative, however, these benefits would be partially offset by a reduction in training associated with roadmarching tracked vehicles out to the field.

Discussions were held with FORSCOM and Ft. Hood staff concerning the relative training value associated with various methods of transporting tracked vehicles to the field. While it was generally agreed that training on all three transportation modes was of value to armor division units, there was considerable disagreement on which training is more important and on how much training is necessary to maintain proficiency in each area. Current procedures at Ft. Hood provide substantial opportunities for roadmarching and HET loading, and at least minimal training in railcar loading when units travel off post to the National Training Center at Ft. Irwin. Under any of the proposed HET or rail alternatives, minimal training would continue to be provided on all three transportation modes, but training opportunities on the primary mode would increase significantly at the expense of roadmarching. Although each type of training is undoubtedly valuable to the Army, the relative value of one type of training over another depends on the likelihood of specific combat scenarios and the mode by which tracked vehicles would be transported to the front lines. In the absence of more specific guidance from the Army on the relaive values and acceptable minimum levels of training for each transportation mode, further quantification of this issue appears inappropriate.

Depending on how they were implemented, the HET and rail alternatives could also provide long-term training opportunities for HET drivers or railroad crews. The benefits associated with this training depend on a number of factors including: 1) differences in the cost of using military instead of civilian labor; 2) the strategic value of this type of training to the Army; and 3) existing opportunities for such training at other Army installations.

<u>Maintaining the Combat Readiness of Military HETs</u>. A major concern expressed by the staff of the 96th Transportation Company was that greater utilization of HETs for on-post transportation would result in more rapid depreciation of the existing vehicles and a corresponding decreased state of combat readiness. Since the primary mission of the 96th Transportation Company is to provide transportation to armor units moving to and from combat, the potential peacetime cost savings associated with using military HETs for on-post transportation must be carefully weighed against the risk that not enough vehicles would be operationally ready for their wartime mission. This risk is clearly present in the Expanded Existing HET and 1-Company Full HET alternatives, and may also be applicable in the 2-Company Full HET alternative, depending on the mission statements of the division-based HET companies. It is not applicable in the commercial HET alternative or in any of the rail alternatives, since those vehicles would not routinely be mobilized.

Reorganization of Military Units. Implementation of either the 1-Company or 2-Company Full HET alternatives implies certain changes to existing organizational units at Ft. Hood. In the 1-Company Full HET alternative, the organizational structure of the 13th SUPCOM must be expanded to include a second HET company. This HET company must then be filled either through the reassignment of an existing HET company from another Army installation, or the establishment of sufficient military billets and procurement of all necessary equipment, including HET vehicles. In the 2-Company Full HET alternative, the organizational structure of each armor division must be expanded to include a divisional HET company. These companies must also be filled either through the establishment of new units or reassignment of existing HET companies from other posts. The administrative and political barriers inherent in a major reorganization of this type should be carefully considered in the final evaluation of these two alternatives.

Although no major organizational changes would be needed to implement any of the other alternatives, expanded utilization of the 96th Transportation Company would require that the Army, and especially the Ft. Hood command staff, explicitly recognize and accept the potential reduction in combat readiness of existing equipment, as well as the increased operating and maintenance costs associated with the HET company's new role.

Vulnerability to Fuel Shortages. Some concern has been expressed by the Ft. Hood planning staff that the possibility of future fuel shortages would severely limit the ability of HETs to provide adequate on-post transportation. A comparison of the fuel requirements for the Full HET and Full Rail alternatives indicates that HETs would use approximately 45,100 gallons more fuel annually than rail locomotives in transporting tracked vehicles to and from the field (112,000 versus 66,900 gallons). However, under the Full Rail alternative, M1 tanks would have to roadmarch 39,500 miles further than under the Full HET alternative. Differences in mileage for other tracked vehicles between the Full HET and and Full Rail alternatives are negligible. At an average fuel consumption rate of 5 gallons per mile for the M1, the combined fuel consumption of rail locomotives plus the M1s (Full Rail) would be 152,400 gallons more than that for the HETs plus M1s (Full HET).

Of course, under a severe energy crisis, it is very likely that the amount and nature of training conducted at Ft. Hood would have to be modified. Total training mileage would almost certainly be curtailed, so that the potential difference in fuel savings among alternatives would tend to diminish rather than increase. Without more explicit guidance on what types of training would be given priority, however, no definitive statement can be made on which transportation alternative would be more effective in times of severe fuel shortages.

Compatibility with Future Plans for Ft. Hood. Another consideration raised by the Ft. Hood planning staff concerns the relative compatibility of the transportation alternatives with future plans for facility relocations and overall expansion of the Ft. Hood reservation itself. If, for example, the ASB were relocated to a site north of U. S. Route 190, then the potential cost savings of shipping ammunition via rail might become significant. Similarly, if the size of Ft. Hood's training area were substantially increased through the acquisition of additional rangeland, and rail access were provided to this new territory, then the net benefits attributable to a rail alternative would very likely increase. On the other hand, implementation of any rail alternative requires construction of a fixed right-of-way which substantially limits the ability of the transportation system to adapt to change without incurring additional capital expenses.

In the absence of more definitive plans regarding facility expansion, the Full HET alternative appears to represent a lower investment risk because of: 1) its lower initial capital cost, and 2) its ability to adapt to future changes without requiring additional capital expenditures for new rights-of-way.

CHAPTER 8. EVALUATION OF ALTERNATIVES

Each of the previous chapters provides input information necessary for the evaluation of the alternatives. Additional parameters are incorporated during the evaluation phase, and some transformations of the data take place to permit summation and comparison of costs and benefits, and to generate summary indicators.

8.1 PROJECT EVALUATION

Comparison of two alternatives is accomplished by adding the incremental costs of one relative to the other, and separately adding the incremental benefits. The initial test for each alternative is against a reference base case; subsequent comparisons can be made of higher cost alternatives against lower ones to determine which of the worthwhile project alternatives is the best.

Time streams of costs and benefits are aggregated only after discounting the elements; summing without discounting has no meaning other than giving the result for a zero discount rate. Also, all analysis is done in real (constant base year dollar) terms, i.e., net of inflation, before discounting.

<u>Classification of Costs and Benefits</u>. At the simplest level, the labelling of an item as a cost or a benefit is of no consequence. All that matters is the arithmetic sum of all items, comprehensively enumerated without double counting. Any project that generates positive net benefits is worth doing; among substitute projects, the one generating the most net benefits, other things being equal, is the best.

This is true in principle because the opportunity cost of withdrawing resources from the rest of the economy is represented by the discount rate. No matter how large the list of projects -- so long as it is small in comparison to the rest of the world -- the discount rate will not be affected by which projects are chosen for implementation, or how many of them are chosen. Any project meeting the test adds to society's net worth.

Pragmatic considerations impose compromises on this simple rule. One reality is that the magnitudes and values of the various items are not known with equal certainty, and it helps in their interpretation to have well-documented items (usually initial expenditures) placed in one category and fuzzy items (usually intangible benefits and disbenefits) collected elsewhere. Another consideration is the convenience of having similar items grouped together so that subtotals can be readily interpreted. Finally, various summary indicators and ratios (e.g., benefit-to-cost) depend upon items being grouped according to the concepts underlying the indicator.

<u>Net Benefits vs Benefit-Cost Ratios</u>. The basic rule is that any project which generates net benefits is worthwhile. In seeking to identify the best projects, there are two steps: selection of projects that are substitutes for each other (choosing HETs or rail, but not both), and selecting projects that are complementary or independent (e.g., the best tank training program plus the best transportation investment). If the selections are made in the right order, net benefits from each project are cumulative.

The benefit-cost ratio is a summary indicator which becomes useful when the constraint is imposed on the choice of projects that some subcategory of costs cannot exceed an externally fixed sum, referred to as the "budget". Such costs are usually expenditures earmarked for a restricted type of capital facility. The objective then becomes to obtain the maximum net benefits subject to the constraint that expenditures from the restricted-purpose budget cannot exceed the total in the budget.

To solve this constrained optimization problem, it is helpful to array (complementary) alternatives in rank order on the ratio of benefits to costs, where costs consist only of expenditures from the budget, and benefits include everything else. If the set of worthwhile projects is exhausted before bumping against the constraint, the choice of projects is unaffected by the constraint. If the constraint is binding, then one or more projects are rejected in favor of ones which yield higher benefits relative to their drawdown of the constrained budget. For project alternatives which are substitutes (as in the present case), B/C ratios have little significance.

In practice, the "cost" category can be designed to coincide with the eligible categories of expenditures from the controlling budget. Because Department of the Army budgets do not place rail facilities (mobilization) and HETs (organic transportation) in the same category, the process for choosing between truck and rail is made more awkward. Net benefits are not affected by the classification of costs and benefits, but ratios do depend upon accounting conventions. Thus it is important to understand how each indicator derives from its associated budgetary (or other) constraint. Several of the HET alternatives have very high B/C ratios based on initial outlay (from the constrained budget), even though their annual capital consumption rates are higher than those for the rail alternatives.

<u>The Discount Factor</u>. A revenue or a cost occurring at a future point in time can be transformed into an equivalent value at the present time by discounting, which involves multiplying the original value by the discount factor,

$$\text{Discount factor} = \frac{1}{(1+DR)^N}$$

where DR = discount rate and N = number of time periods between the present and the future date. Thus if the discount rate = 10% and the time period is 2 years, the discount factor equals 1/1.21 or .826; the present value of an expenditure of ten dollars in year two would thus be .826($10)=$8.26. Discount factors can also be used to move or restate values at any point prior to the future date, not necessarily the present.

Present Worth and Equivalent Annual Cost. Evaluation can be carried out in either present value terms or in annualized terms. The present value format discounts each cost and benefit from the time it occurs and sums the results as a single lump sum figure. Annualization transforms all costs and benefits into constant annual streams, yielding an equivalent annual stream of net benefits. Either format can use either a fixed project lifespan, or an infinite time horizon that operates each alternative project in perpetuity.

Annualized (Equivalent Annual Cost) and lump sum (Present Value) figures differ by nothing more than the ratio of the discount rate, i.e.,

$$PW = EAC/\text{Discount Rate}$$

where EAC = Equivalent Annual Cost and PW = Present Worth. Thus annual values can be "capitalized" as above, or lump sums can be annualized by multiplying by the discount rate. An infinite annual stream of $33, for example, has a present value of $330 at a 10% discount rate.

Unless the project being evaluated is to be closed down at a known future date (its purpose having been completed), the most neutral assumption is that the facility will continue operating in perpetuity. Capital facilities get replaced as they wear out, and there is no salvage value or cost at the end of a facility's life. With any reasonable discount rate, what happens 40 or 50 years out is of little quantitative importance anyway, but there is no point in setting an arbitrary time horizon (however long) unless there is reason to doubt the project's continued viability.

Alternatively, if there is uncertainty about future demand and the right technology to serve it, then a fixed time horizon should be imposed and the project salvaged. Doing so will reduce the net present worth of the project by some amount, more for capital intensive projects than low-capital ones. This introduces a conservative bias to offset the future uncertainty.

Capital Recovery Factor. A convenient way to annualize capital costs is by using a capital recovery factor. The CRF is calculated according to

$$CRF(DR,N) = \frac{DR}{(1+DR)^N-1} + DR = \frac{DR(1+DR)^N}{(1+DR)^N-1}$$

where DR = discount rate and N = the lifetime in years (or whatever time unit DR is stated in). When applied to the initial cost of the capital asset,

$$EAC = CRF * \text{Capital Cost}$$

gives the annual amount each year that will pay off the "principal" or initial cost of the asset, over its lifetime, and also pay the "interest" on the remaining balance.

A CRF applied in this manner to a capital asset implies a pattern of depreciation and "interest" payments. For project evaluation, the interest portion is referred to as an opportunity cost, representing the benefits foregone by tying up capital resources in one form and thereby making them unavailable for another use. The time pattern of depreciation and opportunity cost can be shown graphically, as in Figure 8-1. The top portion shows an asset costing $260,000 and lasting for ten years, representative of a HET tractor plus semi-trailer. The bulk of the annualized cost is depreciation, which occurs at a slightly higher rate as the asset wears out. The bottom portion shows a $50-million asset with a lifetime of 40 years, such as the track and structures on a 45-mile railroad. A much larger share of annual cost consists of opportunity cost, which is not surprising given the long lifetime.

8.2 EVALUATION PARAMETERS

A group of parameters that are applied in the evaluation phase are shown in Table 8-1. Overall feasibility of the alternatives, or their ranking, may be very sensitive to some of these parameters, most especially the discount rate.

Discount Rate. The discount rate is the real (net of inflation) "interest" rate that should be charged to the project. Resources are more valuable the sooner they are available, and opportunities are foregone by allocating resources to one purpose and not another. The discount rate summarizes these opportunity costs and time preferences. It is analogous to the "hurdle" rate in business investment analysis, except that the hurdle rate includes an allowance for inflation. The discount rate represents the social

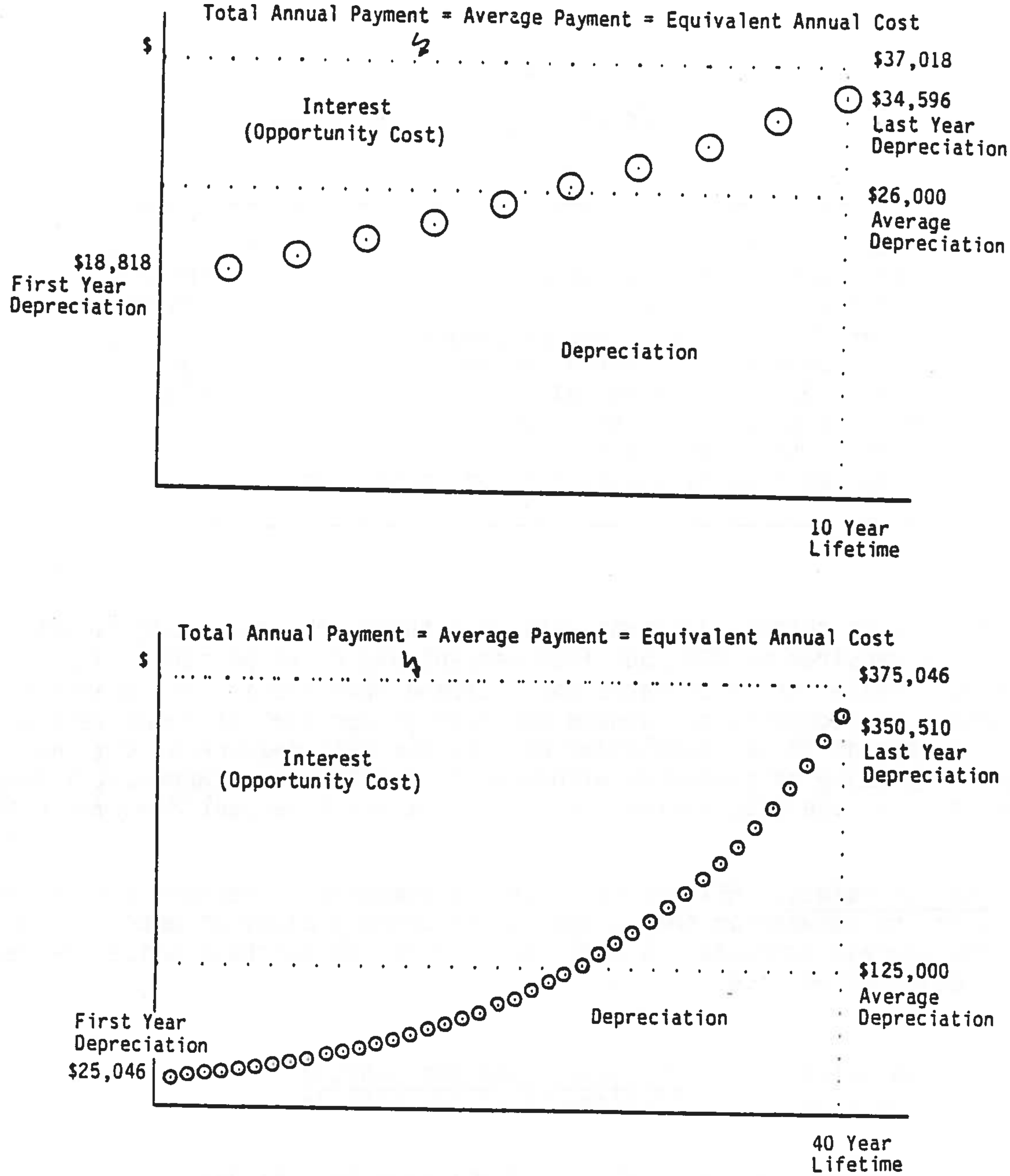


FIGURE 8-1. TIME PROFILE OF DEPRECIATION AND INTEREST WITH CRF.

rate of return that is foregone by withdrawing resources from the economy and investing them in the project.

TABLE 8-1.

PARAMETERS USED IN EVALUATION

Discount rate (DR)	.04,.07,.10
HET Tractor Lifetime (miles)	100,000
HET Trailer Lifetime "	100,000
Other HET Facility Lifetime (years)	20
Rail Locomotive Lifetime (miles)	400,000
Rail Flatcar Lifetime (miles)	400,000
Rail Structures Lifetime (years)	40
Highway Lifetime (years)	20
Time Lag from Rail Construction to Startup	2

There is no correct discount rate, but there are reasonable ranges. Ten percent is required by OMB, but four percent and seven percent can also be defended. Higher or lower rates would depend upon special circumstances concerning the competition (demand and supply) for current funds versus future ones. A rate of 7% is recommended here as the best measure of the real opportunity value of resources withdrawn from other uses (Appendix I presents comparisons of the alternatives at 10 percent and 4 percent discount rates.)

Asset Lifetimes. HET and rail vehicle component lifetimes are stated in miles, on the assumption that usage is the primary cause of depreciation. Thus the average depreciation cost per mile is the purchase price divided by the lifetime miles, i.e.,

$$\text{Depreciation Rate/Mile} = \frac{\text{Purchase Price per Vehicle}}{\text{Lifetime Miles per Vehicle}}$$

This is the method for calculating depreciation on vehicles acquired as part of an investment alternative. It assumes that all maintenance and repair costs during the life of the asset are included under operating costs. Also, depreciation for existing vehicles or for vehicles owned for purposes other than transporting heavy equipment is counted separately from new capital costs. Based on actual usage under the alternative, mileage lifetimes are converted to lives measured in years, and then annualized.

Costs of buildings, structures, and other facilities are annualized by means of the capital recovery factor (CRF). In this case, the lifetime is stated in terms of years.

Average Remaining Life Factor (ARLF). The opportunity cost of retaining a capital asset depends upon the value of the asset, commonly measured as the amount of productive life remaining to be used. Assuming a locomotive or HET tractor, say, could be sold at any time, its value would depend in part upon the amount of its service lifetime that still remained. The opportunity costs of holding such an asset is the foregone "interest" on the value of the asset.

Because the value of the asset declines over its life, the opportunity cost of keeping it also declines. In separating depreciation from opportunity costs in annualized form, the life cycle pattern of Figure 8-1 can be averaged into a constant stream. This implies an average asset value which would yield the same total interest or opportunity cost over the asset's life.

In the summary evaluation tables where opportunity costs are stated, they are calculated as the value of the asset new, times the share of its service life remaining, times the discount rate, or

$$\text{Opportunity Cost} = \text{Purchase Price} \times \text{Average Remaining Life Factor} \times \text{Discount Rate}$$

By using a capital recovery factor for calculating equivalent annual cost, the implied ARLF may be as low as .5 (high depreciation relative to interest) or as high as 1.0 (an infinite life), but tends to fall in the .6-.7 range for typical investments.

Time Lags. If there is a time differential between when costs are incurred and when benefits commence, the benefits become discounted by more than the costs, no matter what year is chosen for the base year. Complete precision requires an annual time stream of costs and benefits, with each item discounted separately to the base year and then summed. An adequate approximation can be obtained, however, by specifying the time lag between the midpoint of construction (when capital costs are incurred) to the startup of full benefits. A zero value means that benefits start at the same time the costs are incurred.

For the HET alternatives, no time lag is included. For the rail alternatives, a 2-year lag is assumed between initial capital expenditures and the beginning of operating costs and benefits.

TABLE 8-2.

SUMMARY COMPARISON OF HET ALTERNATIVES TO ROADMARCH BASE

Discount Rate = .07	Current HET Operation	Expanded Existing HET	- Full HET Alternatives - 2-Company	1-Company	Commercial
<u>Capital Costs (annualized)</u>					
New HET Equip./Facil. Depreciation	0	250,000	1,191,130	949,162	301,000
New HET Equip./Facil. Opportunity Cost	0	221,965	639,005	535,785	267,245
Existing HET Equip./Facil. Depreciation	222,943	661,121	412,702	643,675	785,242
Existing HET Equip./Facil. Opportunity Cost	208,700	461,800	146,400	225,200	200,200
Land Opportunity Cost	0	0	1,750	1,750	1,750
TOTAL ANNUALIZED CAPITAL COSTS	$431,643	$1,594,886	$2,390,987	$2,355,572	$1,555,437
<u>Annual Operating Costs</u>					
HET Operations and Administration	1,034,263	3,025,313	5,966,913	5,966,913	3,877,018
Division Scheduling and Movement Control	0	50,000	50,000	50,000	50,000
Tracked Vehicle Crew Transportation	50,858	151,625	294,523	294,523	294,523
Highway Maintenance and Repair	728,547	1,823,274	2,863,076	2,863,076	2,863,076
Commercial HET Profit					377,230
TOTAL ANNUAL OPERATING COSTS	$1,813,668	$5,050,212	$9,174,512	$9,174,512	$7,461,847
<u>Annual Benefits and Cost Savings</u>					
Tracked Vehicle Operating Cost Savings	5,930,946	18,071,310	29,339,344	29,339,344	29,339,344
Tank Trail Maintenance Cost Savings	3,416	10,185	19,785	19,785	19,785
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$5,934,362	$18,081,495	$29,359,129	$29,359,129	$29,359,129
Annualized Net Benefits of HETs Compared to Full Roadmarch Base	$3,689,051	$11,436,397	$17,793,630	$17,829,045	$20,341,845

8.3 COMPARISON OF HET AND FULL ROADMARCH ALTERNATIVES

Four HET alternatives plus current HET operations are evaluated against the Full Roadmarch base, spanning a range of output levels and alternative methods (private versus military) for providing the service.

Capital Costs. For capital assets acquired initially as part of the project, depreciation amounts to the initial dollar value of the asset divided by its lifetime output (in miles, here), as is described above under asset lifetimes. Depreciation for vehicles already owned is estimated using either this method or using empirical information on actual capital replacement costs and rates. Capital costs include depreciation and opportunity costs, for both new and existing vehicles, facilities, and land. As shown in Table 8.2, they are given in terms of annual base year dollars in perpetuity.

Operating Costs. Except for highway damage, the costs are calculated as annual expenditures for operation and administration of the HET services. Highway pavement is a capital cost item, with replacement every twenty years or so, but pavement consumption can be calculated in annual increments. The cost applied to pavement damage is discounted for the average time between damage and replacement.

Benefits. The bulk of the benefits consist of tracked vehicle operating and depreciation cost savings. The difference in the total annual mileage between the HET alternative and the base, for each tracked vehicle type, is multiplied by the avoided costs per mile and summed for all tracked vehicles. Tank trail maintenance cost savings are included as a separate item.

The difference in the level of output (measured either as HET vehicle miles or loaded miles) between current operations and the Full HET alternative is a factor of almost six; associated net benefits increase by a factor of almost five. Thus HETs can be operated at widely varying scales with only minor declines in marginal benefits.

8.4 COMPARISON OF RAIL AND FULL ROADMARCH ALTERNATIVES

The summary evaluation of the rail investment, in Table 8-3, also shows large net benefits in comparison to the Full Roadmarch alternative, for all four rail alternatives. The distribution of costs across categories, however, is much different than for the HET alternative.

TABLE 8-3.

SUMMARY COMPARISON OF RAIL ALTERNATIVES TO ROADMARCH BASE

Discount Rate = 0.07 * Lag Period = 2 yr	Full Rail	West Rail to Curry	West Rail to Critten.	West Rail Only
Capital Costs (annualized)				
New Rail Equip./Facil. Depreciation	22,250	21,312	26,225	19,236
New Rail Equip./Facil. Opportunity Cost	148,740	149,238	146,194	150,672
New Track & Structures Depreciation	1,098,025	826,962	793,322	693,244
New Track & Structures Opportunity Cost	4,571,217	3,282,920	3,007,396	2,457,546
* Existing Rail Equipment Depreciation	31,870	31,152	37,754	28,201
Existing Rail Equipment Opportunity Cost	147,000	147,000	147,000	147,000
Land Opportunity Cost	24,710	18,690	17,290	14,350
TOTAL ANNUALIZED CAPITAL COSTS	$6,043,812	$4,477,274	$4,175,181	$3,510,249
Annual Operating Costs				
* Rail Operations and Administration	495,362	494,198	503,808	414,410
* Division Scheduling and Movement Control	87,344	87,344	87,344	87,344
* Tracked Vehicle Crew Transportation	212,417	197,820	189,245	145,229
* Track and Structures Maintenance	185,457	174,190	172,880	100,546
TOTAL ANNUAL OPERATING COSTS	$980,580	$953,552	$953,277	$747,529
Annual Benefits and Cost Savings				
* Tracked Vehicle Operating Cost Savings	16,683,664	15,313,178	15,172,156	11,592,556
* Tank Trail Maintenance Cost Savings	14,269	13,288	12,713	9,756
* MATES On-Post Vehicle Cost Savings	1,182,105	1,147,472	1,053,877	994,915
* MATES Shipment Cost Savings	701,948	701,948	701,948	701,948
* Vehicle Outloading Cost Savings	487,126	487,126	487,126	487,126
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$19,069,112	$17,663,012	$17,427,820	$13,786,301
Annualized Net Benefits of Rail Compared to Full Roadmarch Base	$12,044,720	$12,232,186	$12,299,362	$9,528,523

Capital Costs. Depreciation and opportunity costs of rail locomotives, flatcars, and way and structures are estimated separately and annualized. Depreciation uses purchase price and lifetime miles for vehicles, and the CRF (implicit ARLF) for opportunity costs. Track and structures depreciation uses a lifetime in years rather than miles, i.e.,

$$\text{Track \& Structures Depreciation} = \frac{\text{Capital Cost of T\&S}}{\text{Lifetime in years}}$$

but opportunity cost for track and structures is again calculated using the CRF. Right-of-way is assumed to have an infinite life, so no depreciation is involved. Highway relocation costs include only opportunity costs (as if the lifetime were infinite) because normal maintenance and replacement of the highway are not affected by the presence of the railroad.

Operating Costs. Calculations here are parallel to those for the the HET/Base comparison. Because all rail alternatives require most of the functional capabilities of a fully equipped and staffed railroad, even though the annual output is much less, operating costs include many components that do not vary by much within the range of outputs encompassed by these alternatives. In short, the bulk of rail costs are fixed.

Benefits. In addition to savings in tracked vehicle movements from South Fort Hood to field areas, the rail alternatives permit additional types of cost savings for training and other movements from North Fort Hood, and for outloading purposes. Because of the 2-year startup lag, annual rail benefits (as well as some operating costs) are discounted to account for the delay between construction and operation.

Track and structures opportunity costs dominate the capital cost items, which simply reflects the high initial costs and long lifetimes of these assets. Rail operating costs and capital replacement costs are much lower than for HETs, but the difference is insufficient to overcome the greater productivity of the HETs in reducing tracked vehicle mileage. Net benefits are lowest for the smallest (West Rail) alternative, but essentially equal for the other three. Thus the additional costs of the Full Rail alternative do not add anything to the quantified net benefits. The rail system appears to be feasible in the sense that it generates more than enough benefits to justify the costs, but it does not appear to do so at as high a rate as the HET alternatives.

8.5 SUMMARY INDICATORS FOR COMPARING ALTERNATIVES

A primary purpose of the benefit-cost framework is to transform all impacts into commensurable and cumulative terms. Even if this effort is only partially successful, leaving some impacts unquantified, the ability to summarize the results in easily comprehended form still provides a starting point for judgmentally evaluating the choices.

The results are only useful to the extent that they are tied, in the minds of managers, to the assumptions underlying the results. In other words, the summary measures give a quick view of the consequences of a (large) set of what-if conditions, leaving managers to assess which assumptions are most appropriate. The summary measures do not give "the answer," even if they are "believed," but they reduce the assumptions to a distilled form.

Annual Net Benefits. Each of the previous two tables shows the arithmetic sum of costs and benefits. Annual net benefit is the single best measure of investment worthiness, in a world without funding constraints or other arbitrary distortions. This does not imply that investment funds are "free," but it does assume that funds can be obtained for any project that offers a greater return than that represented by the discount rate.

Both HET and rail alternatives are fully feasible, in that they produce a substantial surplus of benefits over costs. This result does not derive from any consumer surplus valuations or other elusive benefits, but, rather, is based entirely on cost savings. The HET alternative, however, generates substantially larger net benefits, as the rail advantage in operating costs is more than offset by disadvantages in benefits and capital costs.

Net Present Value. As mentioned above, the numbers for net present worth can be obtained from the annualized figures by simply dividing them by the discount rate. Thus net present worth (or net present value) and annualized net benefit (or equivalent annual cost) contain exactly the same information. Preference for one or the other is a matter of taste.

In either present value form or annualized form, capital and operating costs can be broken into components, as shown in Figure 8-2 and also in Table 8-4. Capital costs, in particular, can be disaggregated for several different analytic purposes, including the construction of summary indicators based on initial investment only rather than on all capital costs. Capital consumption or depreciation is the decline (or appreciation) in value of a capital asset, usually through physical wear and tear. Opportunity cost is the imputed real interest on the remaining value of the asset. Together, these two components make up the full cost of capital assets, or any subgroup of assets.

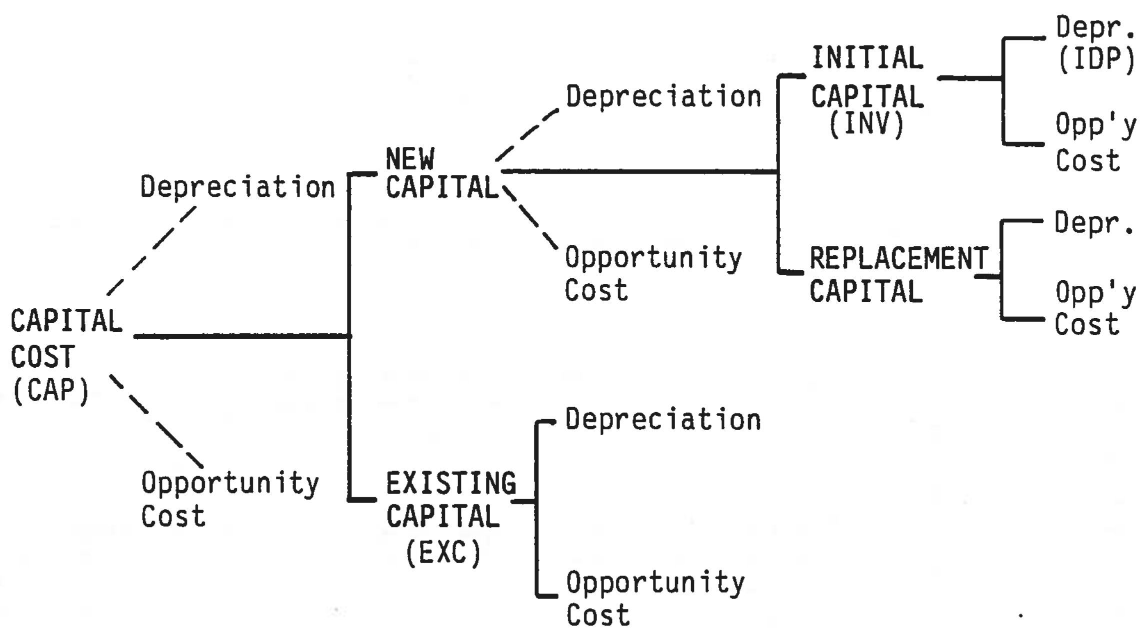


FIGURE 8-2. CAPITAL COST COMPONENTS USED FOR SUMMARY INDICATORS

TABLE 8-4.

SUMMARY EVALUATION MEASURES

Discount Rate = .07 Startup Lag = 2 yrs	Current HET	Expanded HET	- Full HET - Commercial	- Full HET - Military	Full Rail	West Rail to Critt.	West Rail to Curry	West Rail Only
<u>Summary Costs</u> (in $ millions)								
Net Present Value (infinite)	52.7	163.4	290.6	254.2	172.1	175.7	174.7	136.1
PV of Benefits	84.8	258.3	419.4	419.4	272.4	249.0	252.3	196.9
PV of Operating Costs	25.9	72.1	106.6	131.1	14.0	13.6	13.6	10.7
PV of Capital Costs	6.2	22.8	22.2	34.2	86.3	59.6	64.0	50.1
Net Present Value (40 years)	49.3	152.8	271.2	237.5	155.9	160.4	159.3	124.2
Net Present Value (20 years)	39.2	121.4	215.5	188.7	100.4	110.0	108.1	84.6
Total Capital Consumption Costs	3.3	13.4	15.5	23.2	16.5	12.2	12.6	10.6
Total Capital Opportunity Costs	2.9	9.4	6.7	11.0	69.9	47.4	51.4	39.6
Present Value of New Capital	0	6.7	8.1	26.1	83.4	56.7	61.1	47.4
Depreciation of New Capital	0	3.6	4.3	17.0	17.2	12.2	13.0	10.5
Opportunity Cost of New Capital	0	3.2	3.8	9.1	66.2	44.5	48.2	36.9
Initial Capital Expenditures	0	5.0	6.0	14.8	80.2	54.4	58.7	45.4
Value of Replacement Capital	0	1.7	2.1	11.4	3.2	2.3	2.4	2.0
Present Value of Existing Capital	6.2	16.0	14.1	8.0	2.9	2.9	2.8	2.7
Depr. of Existing Capital	3.3	9.8	11.2	6.2	.5	.5	.4	.4
Op. Cost of Existing Capital	2.9	6.2	2.9	1.8	2.5	2.3	2.4	2.3
Annual Operating Benefits	4.1	13.0	21.9	20.2	18.1	16.5	16.7	13.0
Benefit/Cost Ratio (Total Costs)	2.7	2.7	3.3	2.5	2.7	3.4	3.3	3.2
40 Year Horizon	2.7	2.7	3.3	2.5	2.6	3.3	3.2	3.2
20 Year Horizon	2.7	2.7	3.3	2.5	2.1	2.7	2.6	2.6
Benefit/Cost Ratio (Capital Costs)	9.5	8.2	14.1	8.4	3.0	3.9	3.7	3.7
Return on Equity ($/$)	n.a.	31.6	46.0	17.1	2.9	3.9	3.7	3.7
Annual Yield "	n.a.	2.3	3.4	1.3	.2	.3	.3	.3
Payback Period (years)	0	.4	.3	.8	5.6	3.9	4.2	4.2

Two capital cost subgroups are of interest: existing capital can be distinguished from new capital; and initial capital investment can be separated from replacement of capital. Each of these can be divided into depreciation and opportunity cost. For capital items with infinite lifetimes (land, grading), the depreciation component is zero. At the other extreme, a short-lived asset has a positive, although relatively small, opportunity cost component. These breakdowns of capital costs are useful in constructing the summary indicators which follow.

<u>Total Benefit-Cost Ratio</u>. Several ratios of benefits to costs can be constructed, the differences amounting to which costs are included in the denominator rather than the numerator. Placing all costs in the denominator,

$$\text{Total B/C} = \frac{\text{BEN}}{\text{OPC + CAP}}$$

where BEN = total benefits, OPC = operating costs, and CAP = capital costs. This ratio gives the value of the resources gained (or saved) for each dollar of resource consumed, throughout the (infinite) lifetime of the project. Opportunity costs, operating costs, and existing capital depreciation are all included in the cost base. The resulting figure will be the lowest for any of the ratios of this type, because the cost definition is the most inclusive. For a feasible project (net benefits > 0), all of the B/C ratios will be greater than 1.0, but by different amounts.

For incremental comparison of projects -- whether within or between major (HET or rail) alternatives -- the total B/C ratio is most suitable because it treats all resources consumed equally. Greater emphasis is not placed, for example, on new capital, or on capital relative to operating costs, as is true of the ratios described below. All of the projects show relatively high B/C ratios, indicating not only that they are feasible but that they would compete well against other worthwhile projects, if priorities had to be set.

Ratios for all of the rail projects are higher than for all the military HET alternatives, reflecting -- perhaps surprisingly -- that full-scale HET operation is the most expensive (in total cost, whether annualized or present value) of the projects. The military Full HET alternatives achieve higher net benefits by producing a greater output, but the benefits per dollar of total cost are less than for the rail. The next inference -- that a HET alternative scaled back to the same total cost as the rail would produce fewer net benefits -- is not valid, however. At lower levels of output, HETs would concentrate their efforts on the high-cost tracked vehicles, thereby increasing the ratio of benefits to costs. The reverse would be true for the rail system, which depends upon scale economies to maximize the ratio of benefits to (mostly fixed) costs.

Within the rail alternative, the B/C ratios indicate that either of the two intermediate variations generate incremental net benefits relative to the

West Rail alternative, and at a higher rate than the basic system. This can be observed from the fact that the ratios increase (if only slightly). In going to the Full Rail, however, net benefits do not increase and hence the ratio falls. On this basis, the best rail system is one which includes the basic West line plus one or both of the spurs. Not included in this assessment are differences in performance, such as total elapsed travel time for movements, and the ability to close a segment of mainline track and still have access to the entire system.

Capital Benefit-Cost Ratio. If operating costs are netted out of the benefits stream and only capital costs are included in the base,

$$\text{Capital B/C} = \frac{\text{BEN} - \text{OPC}}{\text{CAP}}$$

the resulting measure treats all capital costs as the inv tm base. This ratio, then, gives an indication of return on investment, treating new and existing capital resources identically. As with the previous ratio, this one can be calculated using either present worth or annualized figures. The capital B/C ratio will be higher, for the same project, than the total B/C ratio.

Return on Equity. If the net present worth of the project excluding the initial expenditures is divided by the initial capital costs, i.e.,

$$\text{ROE} = \frac{\text{BEN} - \text{OPC} - (\text{CAP} - \text{INV})}{\text{INV}}$$

the ratio gives the dollars returned for each dollar used to buy into the project. All capital depreciation is covered, and all "borrowing" takes place at the "market" discount rate. Thus, after paying all costs including opportunity costs, the ROE indicates how much is returned relative to the up-front investment. The "equity" is the amount put up by the investors, as distinct from the capital that is rented or borrowed.

The ROE measure is directly analogous to a benefit-cost ratio in which costs are restricted to a limited set of up-front expenditures from a categorical budget, and everything else is netted out of the benefits side.

Annual Yield. In calculating a yield, all costs -- including depreciation of the initial capital -- are subtracted from benefits, except for opportunity costs on the new capital:

$$\text{Yield} = \frac{\text{BEN} - (\text{OPC} + \text{EXC} + \text{IDP})}{\text{INV}}$$

All items in the numerator are in annual form while the denominator is in present value form. Depreciation of replacement capital for the initial or new capital is implicitly included, but not the opportunity costs of this replacement capital. Thus the measure gives the annual rate of return on the new investment, including for the period after it is replaced. If the yield is less than the discount rate, the investment is not earning a sufficient return and the project is not feasible. Other things being equal, the more highly a (worthwhile) project is "leveraged" (i.e., the smaller the share of its cost that must be invested initially), the higher will be its yield and its return on equity. Because the HET alternatives require little "equity" relative to benefits, yields are over 100 percent per year.

Payback Period. The length of time needed for the annual surplus generated by the project to return the initial investment is called the payback period. In calculating the payback, both depreciation and interest on the initial investment must be netted out of the surplus. A direct method for calculating the payback period is to solve for the lifetime, PYB, which is the shortest that could be sustained by the annual operating benefits. Hence, the problem is to solve for the particular lifetime in the capital recovery factor that will make

$$INV * CRF(DR,PYB) = BEN - (OPC + EXC)$$

where DR = the specified discount rate for the evaluation. If PYB turns out to be greater than the actual life of the asset, then the project never pays for itself and is not worthwhile. Projects with large initial expenditures will take longer to pay back, other things being equal.

Conceptually, it might appear that the payback period is simply the inverse of the yield. For example, a yield of 20 percent suggests that the initial cost will be recovered in 5 years. The actual payback period is longer, however, because it includes interest on the initial expenditure while the yield does not; the yield itself is the interest earned or opportunity value of the initial investment.

Each of these last three three measures provides a slightly different perspective on the performance of the project. All accept an essentially arbitrary distinction between new investment and existing capital, focusing all of the project's net gains on the restricted portion of capital costs classified as "new." For any of these measures, the smaller the share of capital costs included in the restricted category, the better (for a feasible project) the performance of that capital will be. To a manager who is allocating funds from a constrained budget, these indicators suggest ways for maximizing the returns to the constrained budget while ignoring the performance of assets belonging to other managers. The measures are analogs of private-sector investment analysis, and less suitable for public sector project evaluation than are annual net benefits or benefit-cost ratios.

Internal Rate of Return. The yield, as defined above, gives the internal rate of return for that portion of capital costs labelled new investment. If the discount rate is assumed to be the same for all capital costs, new or existing, monetary or imputed, then it is possible to find a discount rate that will make annual benefits just equal to annual costs, or reduce the net present worth of the project to zero. This discount rate is called the internal rate of return. It is computed by trial and error, until the condition is satisfied that

$$PW(BEN - OPC - CAP, IRR) = 0$$

where PW(,) represents the present value computation as a function of the input data and the discount rate. It is well known that the IRR may provide a different ranking of feasible projects than will the net present value criterion, under some conditions. There is no reason to prefer the IRR as an investment measure, and hence it is of only minor interest.

Sensitivity to Assumptions. The numerical results and summary measures derive from numerical estimates that may innacurately quantify the pertinent cost or benefit concept, and from a long list of assumptions. If the numerical results are helpful for decisionmaking, it is because the conclusions do not shift over ranges of estimates and assumptions that are within intuitively plausible ranges of uncertainty. Thus the sensitivity of the results to inputs is an important part of the analysis. Many of the numbers presented above are routinely stated in whole dollars, but this does not at all imply a quantitative accuracy of anything like that level of precision.

Several critical assumptions or parameters are shown in Table 8-5, along with summary measures illustrating the sensitivity of the results. The discount rate is always an important parameter, in that reasonable ranges show large impacts. The higher the discount rate, the less valuable are long-lived assets. At a rate of 10%, the rail investment looks much weaker than it does at 7% or 4%. Another critical assumption for the Ft. Hood analysis is the lag between the time rail track and structures costs are incurred and the time operations (therefore benefits) start. Any delay in accruing benefits after large costs have been incurred has a severe impact on project feasibility, as can be seen in the rail net benefits.

Sensitivity testing of a truncated time horizon was shown previously in Table 8-4. Here again, numerous assumptions are involved. For the HETs, it was assumed that all capital assets could be redeployed (liquidated or used for another purpose) any time the project was terminated. No "sunk" costs would remain. The result is that shortening the time horizon to forty or twenty years reduces costs and benefits correspondingly, but has no effect on the B/C ratio. For the rail alternatives, grading costs are not recoverable and track and structures cannot be amortized short of their forty year life.

TABLE 8-5.

SENSITIVITY TESTS AND SUMMARY STATISTICS

	HET				Rail			
	Current	Expanded	Commercial	Full	Full	West+ Crit	West+ Curry	West only
Annual Net Benefits ($ millions) with Discount Rate of:								
r=.04	3.8	11.7	20.5	18.1	15.3	14.8	14.8	11.6
* r=.07	3.7	11.4	20.3	17.8	12.0	12.3	12.2	9.5
r=.10	3.6	11.1	20.1	17.4	8.7	9.8	9.6	7.5
Annual Net Benefits with discount rate = .07 and startup lag of:								
0 yrs	3.7	11.4	17.8	20.3	15.0	14.7	14.6	11.4
* 2 yrs	"	"	"	"	12.0	12.3	12.2	9.5

* = value of parameter used for evaluation of alternatives

Vehicle Cost rates ($/mile):	New	Existing
M1 Tank (avoidable mileage costs)		182.85
M2/M3 Vehicle "		102.53
Other Tracked Vehicles		60.95
HET Operation (Full HET)	12.54	12.54
HET Depreciation (except Commercial)	2.60	2.60
Rail Locomotive Operation (Full Rail)	25.79	n.a.
Rail Locomotive Depreciation	.63	n.a.
Rail Flatcar Depreciation	.23	.50

Utilization and other statistics:	Full HET		Full Rail	
	Tractor	Trailer	Locomotive	Flatcar
Annual Miles per Vehicle	10,816	10,816	10,997	2,085
Average Life (years)	9.25	9.25	36.37	191.8

Thus a shortened time horizon has a larger effect on reducing benefits than costs. At forty years the effect is small (at a 7% discount rate), while at 20 years the effect is significant. Even so, the rail system would be worthwhile relative to the Full Roadmarch base.

Effectiveness Measures. Several measures of performance or effectiveness can be calculated, and used to gain insight into why one alternative comes out better than another. This information may serve to improve confidence in the preferred alternative, or help in redesigning an alternative to enhance its net benefits. Effectiveness measures also provide reasonableness or "sanity" checks on assumptions and calculations.

It must be borne in mind, however, that all of these measures are subordinate to the benefit-cost evaluation described above. Although effectiveness indicators often have a great deal of appeal as summary performance measures, interpreting them will be misleading unless they are clearly treated as supporting information and not as substitutes for benefit-cost evaluation.

Four such measures are shown in Table 8-6. It is highly desirable that productivity and performance indicators be tied to the same output and cost categories used in the benefit-cost evaluation, and that the indicators provide disaggregations of broader summary measures rather than being overlapping and collectively non-exhaustive. Cost per track mile saved and benefit per track mile saved, for example, yield the total B/C ratio.

Savings in tracked vehicle miles of travel is the sole output of the HET alternatives and the primary output of the rail alternatives. Hence, it is the key measure of "effectiveness." This measure of output varies considerably across the alternatives, especially those for the HETs. A "place" mile is taken to be a unit of service capable of carrying one tracked vehicle one mile, either a HET tractor and trailer, or half of a rail flatcar in a train. Total cost divided by place miles varies somewhat across alternatives, but the lowest HET and the lowest Rail options are about the same.

Cost per track mile saved removes deadheading from the previous calculation, and also circuity (a train must travel farther to eliminate a roadmarch mile than a HET). Mostly because of deadheading, HET costs per track mile saved are much higher than rail costs. Finally, total benefits averaged over track miles saved shows that HETs concentrate on reducing the most costly tracked vehicle travel, while the rail alternatives carry similar amounts of less valuable mileage. The combined result is the net benefits and benefit-cost ratios previously shown in Tables 8-2 through 8-5.

TABLE 8-6.

EFFECTIVENESS MEASURES

	HET Current	HET Expanded	HET Commercial	HET Full	Rail Full	Rail West+ Crit	Rail West+ Curry	Rail West only
Annual Track Miles Saved (000s/yr)	38.8	115.7	224.8	224.8	235.3	221.9	212.8	173.3
Cost per Place Mile Supplied ($/mile)	27.22	27.16	18.95	24.3	32.14	25.42	19.81	22.02
Cost per Track Mile Saved ($/mile)	57.83	57.41	40.11	51.44	34.18	28.02	27.59	28.12
Benefit per Track Mile Saved ($/mile)	152.86	156.22	130.59	130.59	92.80	91.13	93.76	91.07

Parameters: discount rate = 7%, startup lag = 2 years.

CHAPTER 9. PRE-POSITIONING: AN ALTERNATIVE APPROACH

The basic problem addressed in this study is summarized by the following question: How can the Army best reduce the costs of moving heavy tracked vehicles between the cantonment areas at South and North Ft. Hood and the numerous training areas and firing ranges on the Ft. Hood reservation? Each of the alternatives analyzed thus far provides a lower cost means of transporting the tracked vehicles for some portion of a fixed set of annual vehicle movements, but none of the alternatives alters either the frequency or distribution of those movements, which are assumed to be determined by training needs rather than by transportation considerations.

A different approach to reducing heavy tracked vehicle movement costs entails pre-positioning tracked vehicles at the training areas. This approach would provide for the same training needs, but would reduce the number of tracked vehicle movements between the cantonment areas and the training areas.

Pre-positioning can be viewed as complementary to the transportation alternatives in that if both approaches were implemented together, the resulting economic benefits (i.e., cost savings) would be greater than if either approach were implemented by itself. Pre-positioning also entails different costs and implementation problems than those associated with the various transportation alternatives. Although some of these problems cannot be easily quantified, they have serious implications for troop morale and combat readiness, and should therefore be carefully weighed in evaluating this approach. These issues are addressed later in this chapter.

9.1 PRE-POSITIONING OPTIONS

Permanent Pre-positioning for All Training. The pre-positioning approach could be implemented to include all movements to and from training, or only a subset of those movements. In its most comprehensive form, sufficient numbers of tracked vehicles would be permanently located at or near each firing range, artillery emplacement, and field training area to enable all current training exercises to be conducted without having to routinely move any tracked vehicles to or from the cantonment area. Although this option could reduce avoidable tracked vehicle costs by as much as $27.5 million annually over current on-post operations, it appears to be economically and operationally impractical for a number of reasons:

1. A tremendous number of additional tracked vehicles (the equivalent of at least another full armor division) would have to be procured or reassigned to Ft. Hood to provide adequate coverage at all training areas and firing ranges. Additional maintenance facilities would also have to be constructed to handle this increase in equipment. The cost to the Army to acquire, locate, and maintain these additional vehicles at Ft. Hood would be prohibitively expensive, when compared to the costs of the various transportation options analyzed earlier in this study.

2. Permanent, secure enclosures would have to be constructed at numerous locations across the Ft. Hood reservation. Aside from the costs of constructing and maintaining those enclosures, a substantial amount of land, currently used for training, would be lost. Moreover, the enclosures would create new, permanent obstacles to training movements.

3. Each field enclosure would require 24-hour security whenever the tracked vehicles were not being used for training. Additional security personnel would therefore be needed, and would have to be acquired either through changes in the current duties of on-post military personnel, or through the hiring of new security personnel.

4. All tracked vehicles, including those currently belonging to the two resident armor divisions, would become a shared resource. New procedures would have to be established to address such issues as vehicle ownership, maintenance and replacement responsibilities, and equipment mobilization procedures for both off-post training and actual combat. Furthermore, there would be tremendous resistance by resident armor units to use of "their" vehicles by other units. This issue is discussed in more detail later in this chapter.

<u>Permanent Pre-Positioning of M1/M2/M3 Vehicles at Firing Ranges</u>. A somewhat less comprehensive pre-positioning alternative would involve locating additional companies of M1 tanks and M2/M3 "Bradley" fighting vehicles adjacent to each primary tank or Bradley range on post. These vehicles would be used by every armor, mechanized infantry, or cavalry unit for all gunnery practices and qualification exercises. Company- and battalion-level field training exercises would be conducted as they are currently, using tracked vehicles organic to each division which would be roadmarched or transported from the cantonment area to the training area. Division artillery equipment would also be roadmarched or transported to training from the cantonment area.

Under this alternative, the potential savings in avoidable tracked vehicle costs could range from $8.2 million annually compared to the full roadmarch alternative to as little as $630,000, if implemented in conjunction with the Full HET alternative. However, by pre-positioning the requisite tracked vehicles at each firing range, the costs associated with moving tracked vehicles <u>between</u> firing ranges during gunnery qualification exercises could also be avoided. As discussed more fully in the following section, the additional cost savings resulting from the elimination of inter-range travel could approach $4.4 million annually.

In order to implement this pre-positioning alternative, the Army would have to acquire, either through procurement or reassignment, the equivalent of up 6 companies of M1s (84 vehicles) and 8 companies of M2/M3s (104 vehicles). In addition, permanent, secure enclosures would have to be constructed, maintained, and staffed at each of the 11 primary tank or Bradley ranges. The capital costs associated with these vehicle and facility acquisitions make this alternative prohibitively expensive, either in conjunction with, or as a replacement for any of the various transportation options.

Pre-Positioning in Conjunction with Brigade Range Assignments. An even more modest pre-positioning alternative requires no acquisition of additional tracked vehicles, and mitigates some of the problems associated with joint vehicle use. Under this alternative, a brigade would be responsible for pre-positioning adequate numbers of M1s and M2/M3s at each firing range used by its units during its assigned 3-week "brigade block." A typical deployment scenario based on this alternative might be as follows:

1. Each armor and infantry company scheduled for gunnery practice or qualification during a brigade block would have its tracked vehicles assigned to a specific M1 or Bradley range.

2. Tracked vehicles would be roadmarched or transported out to the ranges at the time the unit begins its qualification sequence. Typically, the first unit to begin training would have use of its own vehicles at the first firing range. When the first unit completes training at the first range, its personnel would be transported to the second range, where they would train in vehicles belonging to the next unit out. The second unit's personnel would be transported to the first range where they would begin training in the first unit's vehicles.

3. This process would continue until all units scheduled for training during the brigade block had completed the first range. As soon as the last unit completes training on the first range, those vehicles located on the first range would be roadmarched or transported back to the cantonment area.

4. Units would be responsible for the security of tracked vehicles located at the range on which they are currently training. Security responsibilities would shift as units moved from one range to the next.

With the above approach, only those vehicles belonging to units which would be scheduled for gunnery practice would be subject to pre-positioning. Each unit would have use of its own vehicles on at least one of the ranges, and each unit would have use of its own vehicles again for other training within one or two days after completing its practice or qualification sequence. There would be no need for permanent secure enclosures, because the vehicles would not be left unattended. As one unit moves off a firing range, it would be replaced by the next unit.

9.2 COMPUTATION OF TRACKED VEHICLE COST SAVINGS FROM PRE-POSITIONING

The principal benefit that would accrue from implementation of the last pre-positioning alternative would be the elimination of tracked vehicle mileage resulting from units moving <u>between</u> firing ranges during their gunnery qualification sequence. These movements are currently conducted through a combination of roadmarching and HET lifts, but they have not been explicitly accounted for as separate tracked vehicle movements. Only travel from the cantonment area to the first firing range and travel back to the cantonment area from the last range were included in the tracked vehicle mileage estimates used to evaluate the transportation alternatives. Consequently, inter-range travel represents additional tracked vehicle mileage which could be saved either by pre-positioning or one of the transportation alternatives.

The magnitude of the potential savings in avoidable tracked vehicle costs was computed in the following way:

1. Typical training sequences used for armor and mechanized infantry company gunnery qualification were obtained from III Corps. The training sequences listed the primary and alternate ranges and the order in which they were used.

2. Using a topographic map of the Ft. Hood area, paths were constructed between firing ranges along identified tank trails. Total path lengths from the first to the last firing range were measured for both armor and infantry training sequences.

3. The total path length was multiplied by the average number of gunnery qualification rounds per year (2) and the number of tracked vehicles on post (464 M1s and 368 M2/M3s) to compute estimates of the total annual tracked vehicle mileage, by vehicle type, expended in inter-range travel.

4. Annual inter-range tracked vehicle mileage was multiplied by the corresponding avoidable tracked vehicle operating cost and depreciation ($182.85 per mile for M1s and $102.53 per mile for M2/M3s) to compute the total potential cost savings attributable to elimination of inter-range travel.

5. Total cost savings were reduced by an average of $1.31 per tracked vehicle mile to account for additional costs of alternate transportation for tracked vehicle crews.

The above computations and resulting estimates are summarized in Table 9-1. The results should be treated as conservative estimates of the potential cost savings achievable through the pre-positioning alternative, because they are based on the assumption that an entire company of tracked vehicles would be moved out to each firing range. In preliminary discussions with 2nd Armor

TABLE 9-1.

TRACKED VEHICLE COST SAVINGS FROM PRE-POSITIONING

	M1	M2/M3
Inter-Range Mileage (5 ranges)	20.1 mi	14.2 mi
x Number of Qualifying Rounds per Year	x 2	x 2
x Number of Vehicles on Post	x 464	x 368
TOTAL ANNUAL INTER-RANGE MILEAGE	18,653 mi	10,451 mi
Tracked Vehicle Avoidable Unit Cost	$182.85/mi	$102.53/mi
- Crew Transportation Unit Cost	- 1.31/mi	- 1.31/mi
TRACKED VEHICLE UNIT COST SAVINGS	$181.54/mi	$101.22/mi
TOTAL ANNUAL TRACKED VEHICLE COST SAVINGS FROM INTER-RANGE TRAVEL	$3,386,266	$1,057,850

Division training staff, however, it was noted that at many tank ranges, only a few vehicles are firing or are on the course at one time. Thus, it is possible that certain ranges would require significantly fewer vehicles than assumed in this analysis. Additional cost savings would accrue because all tracked vehicles other than those needed for specific tank range could remain in the cantonment area, thereby reducing the annual roadmarch or transported mileage currently assumed in the transportation demand analysis. Based on the average round-trip mileages to firing ranges for armor and infantry units, the additional cost savings for each M1 tank left in the cantonment area range from $880 under the HET alternatives to $2850 under the Full Roadmarch alternative. Additional cost savings for the M2/M3 range from $660 to $2040 per vehicle.

9.3 IMPLEMENTATION CONSIDERATIONS AND OTHER IMPACTS

As estimated in the preceding section, the economic benefits of even a modest level of pre-positioning can be significant. However, these benefits can only be achieved through a fundamental change in the Army's philosophy regarding the assignment and use of tracked combat vehicles at Ft. Hood.

The current policy at Ft. Hood (and at other CONUS armor garrisons) is that tracked vehicles are assigned to combat units (e.g., armor, infantry, cavalry, artillery, etc.) like any other piece of equipment -- i.e., the unit has exclusive use of, and responsibility for maintaining, the tracked vehicle. An M1 tank crew, for example, will use the same vehicle for all of its field training and gunnery practice. In this way, the crew becomes intimately familiar with the vehicle and learns to adjust to any minor eccentricities that the vehicle may have.

In order for pre-positioning to succeed, tracked vehicles would have to be shared, at least on a temporary basis, among all tank crews taking gunnery practice. Because tank crews would no longer be using their own equipment for most of the qualification rounds, gunnery proficiency scores could be expected to decline somewhat. Moreover, tank crews would no longer have complete control over how their vehicles were used. Considerable resistance to sharing vehicles can therefore be expected, based on concerns of potential equipment abuse by other units. These concerns must be allayed by the Ft. Hood command staff, or any economic savings resulting from the pre-positioning approach may be more than offset by a serious decline in troop morale.

Although the shared use of tracked vehicles may cause a decline in gunnery proficiency scores in the near term, it could ultimately prove beneficial to the combat readiness of armor units over the long term. Because armor troops will be mobilized ahead of their equipment in most combat scenarios, they would be assigned unfamiliar equipment upon arrival at their destination. In order to avoid a situation of crews being weaned from their own vehicles under actual combat conditions, it may be advantageous for crews to routinely train in different vehicles. Based on this argument, vehicle sharing may be viewed as a potential benefit of the pre-positioning alternative, rather than a liability.

Pre-positioning also eliminates another opportunity for incidental roadmarch training. Particularly if pre-positioning were used in conjunction with one of the Full HET alternatives, there would be relatively few occasions when an armor or infantry company could roadmarch vehicles incidental to another training exercise. While the need for roadmarch training may be cited by unit commanders as a reason not to implement pre-positioning or one of the transportation alternatives, this argument appears to have little validity. Roadmarch training, to the extent that it is deemed valuable, could be instituted as part of normal field training, or could substitute for a HET or rail move on occasion without significantly changing the conclusions of this analysis.

APPENDIX A.

DETAILED SPECIFICATIONS AND SCHEMATICS FOR RAIL ALIGNMENT AND SIDINGS/RAILHEADS

The siting and layout of an alignment and profile for the Fort Hood Rail Feasibility Study was achieved by utilizing design criteria consistent with similar terrain and operating conditions in commercial railroading. Criteria used for design consisted of a 40 mph operating speed and a four degree maximum horizontal curvature. For profiling, a maximum gradient of 1.75 percent was maintained with the following allowable changes in gradient through vertical curves:

- 0.06 maximum change in gradient per 100 ft. for sag curves.
- 0.10 maximum change in gradient per 100 ft. for crest curves.

The alignment was also controlled by several physical constraints which were imposed. Most important, it was necessary to avoid live fire zones on the reservation by remaining outside a live fire perimeter formed by the following range roads:

- South Range Road
- West Range Road
- East Range Road
- Hubbard Road
- Black Gap Road

The alignment was to follow the range road perimeter as closely as possible to minimize the length of trackage and its impact on training areas outside the live fire perimeter as well as to provide good access to the rail alignment. It was indicated that limited relocation of range road segments to achieve more favorable grades on the rail alignment would be feasible, but should be avoided.

Service was to be provided to railhead sites near the South Fort Hood and North Fort Hood cantonment areas, to principal practice areas near House Creek, Jack Mountain and Henson Mountain, and to the Crittenberger and Curry Firing Ranges.

Working within those constraints, the alignment was set in an effort to minimize construction earthwork. The resulting alignment is described in the following paragraphs.

The South Fort Hood Railhead is sited along the South Range Road immediately south of the Pilot Knob practice ranges. It consists of a single main line track with two parallel passing tracks each approximately 5400 feet long and four 1200 foot long sidings for loading tracked vehicles. The railhead also includes a 1500 foot car repair track and a 1000 foot locomotive service track with a 125 foot long repair pit.

The railhead location is not ideal in terms of earthwork because of an existing hill it cuts into, but it results in the least travel distance from the motor pools and it was indicated as the site favored by base personnel. Approximately 2800 feet of range road relocation would be required to eliminate a grade crossing in the railhead.

The aligment runs northwest from the South Fort Hood Railhead along the West Range Road. About a mile and a half from the railhead a "Y" is provided where the alignment intersects a rail connection linking the proposed Fort Hood trackage to an existing Santa Fe Railroad spur. This connection extends south along the western perimeter of the South Fort Hood cantonment and ties into a Santa Fe spur just south of Copperas Cove Road.

Continuing northwest from the Santa Fe connection, the Fort Hood alignment crosses House Creek just west of the existing range road bridge. Located about a mile north of the crossings the House Creek siding which consists, as do all of the sidings, of a 5400 foot passing track that parallels the mainline and an extension to four 1200 foot long siding tracks for unloading.

The alignment extends north across the Cowhouse Creek to the Jack Mountain siding located about two miles northeast of Cowhouse Creek. From Jack Mountain the trackage parallels the West Range Road to its intersection with Royalty Ridge Road where the Henson Mountain siding is sited. The alignment continues to parallel the West Range Road from Henson Mountain northeast to North Fort Hood.

Along the West Range Road section of trackage there are five segments where some relocation of the range road is required to maintain acceptable grades on the rail line while avoiding substantial grading. These segments total about 1.8 miles and are located in the Cowhouse Creek Valley, where the alignment skirts the Manning Mountain Ridge and on the approaches to the Henson Mountain Ridge.

At North Fort Hood the railhead consists of a 5400 foot passing track parallel to the main line, a "Y" and an extension to the cantonment area, where two 1000 foot set-out tracks and four 1200 foot siding tracks are located.

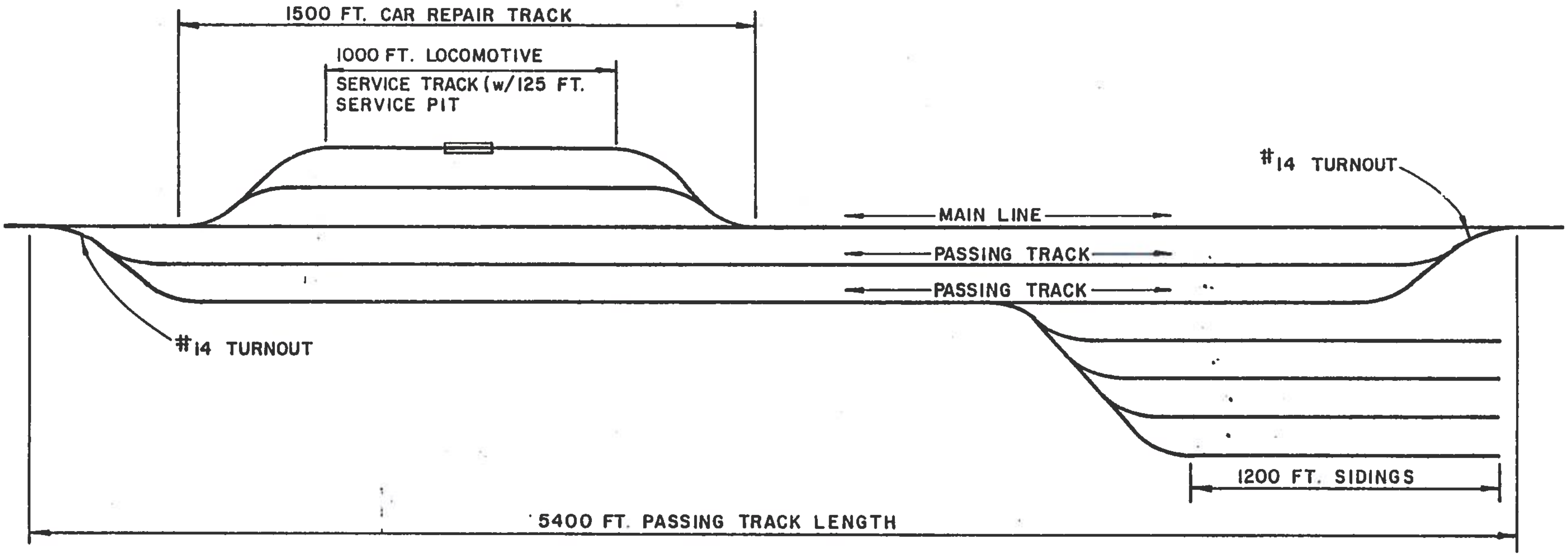
The alignment follows East Range Road from North Fort Hood to Training Area 73, which it crosses diagonally, to the Crittenberger siding, located in the southeast corner of Training Area 73. Along this segment, approximately 1.2 miles of the East Range Rad would have to be shifted to reduce earthwork costs where the alignment climbs into the Henson Mountains.

From Crittenberger siding, the Fort Hood trackage roughly parallels Hubbard Road to its intersection with East Range Road. Near the intersection, the alignment bends to the southwest, crosses back through part of the Henson Mountain ridge and descends into the Cowhouse Creek Valley. Through the ridge crossing and downgrade to Cowhouse Creek, two segments of East Range Road totaling 0.7 miles must be relocated. The rail alignment crosses Cowhouse Creek next to East Range Road and continues south for about a mile to Curry siding in Training Area 12.

Extending southwest from Curry siding, the alignment follows East Range Road to Trapnell Point where it crosses inside the Range Road for a distance of approximately one mile to avoid extremely deep cut sections. Relocation of about two miles of East Range Road would be required to keep the road within the rail alignment from Trapnell Point to Post Oak Mountain.

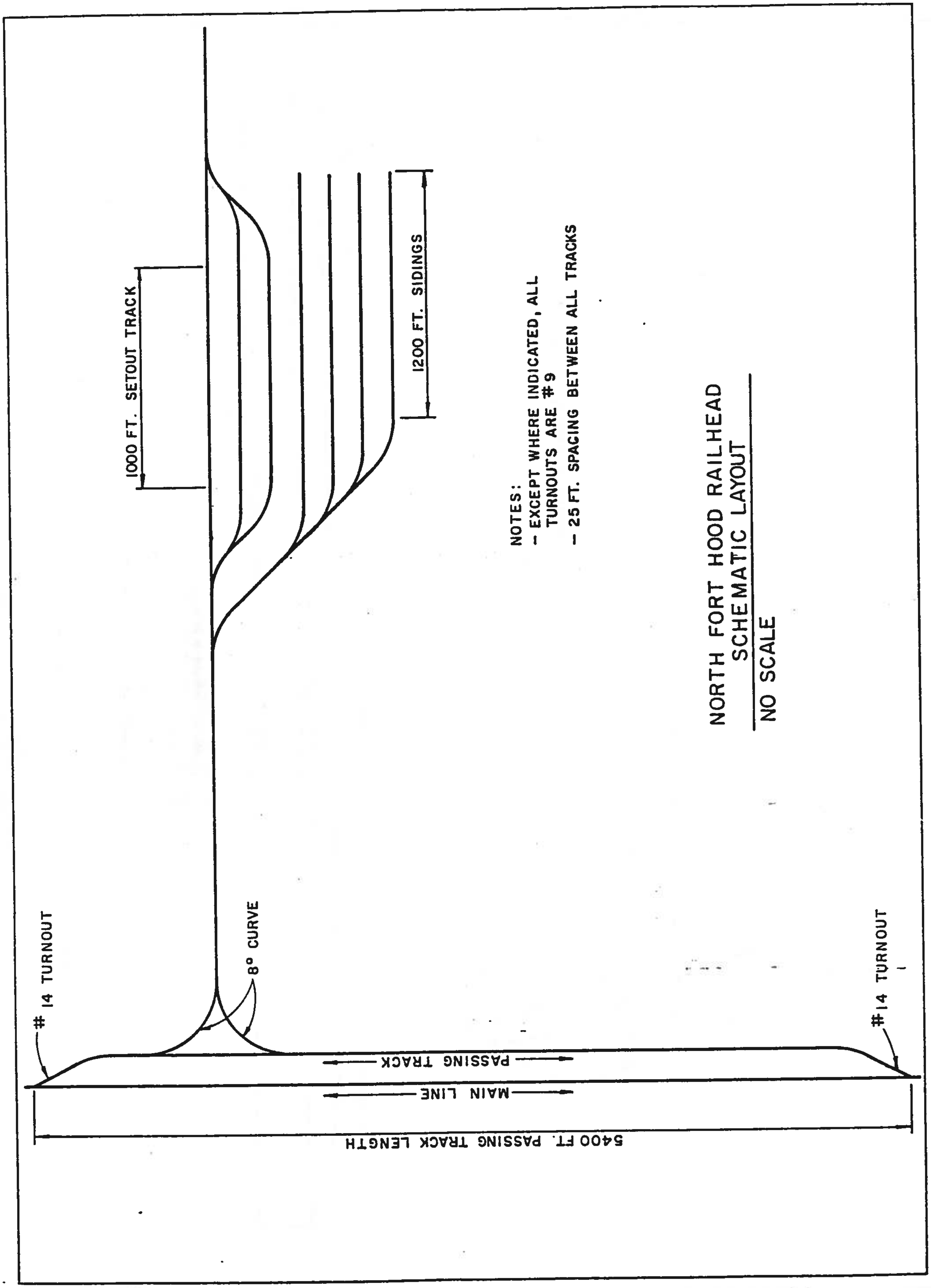
The alignment runs along the base of Post Oak Mountain and passes through Sugar Loaf Gap. South of the gap it crosses East Range Road and parallels an existing tank trail southwest to South Range Road. From that point it follows South Range Road west to the South Fort Hood Railhead to complete the rail loop. The total length of range road relocation from Curry siding to South Fort Hood is approximately three miles.

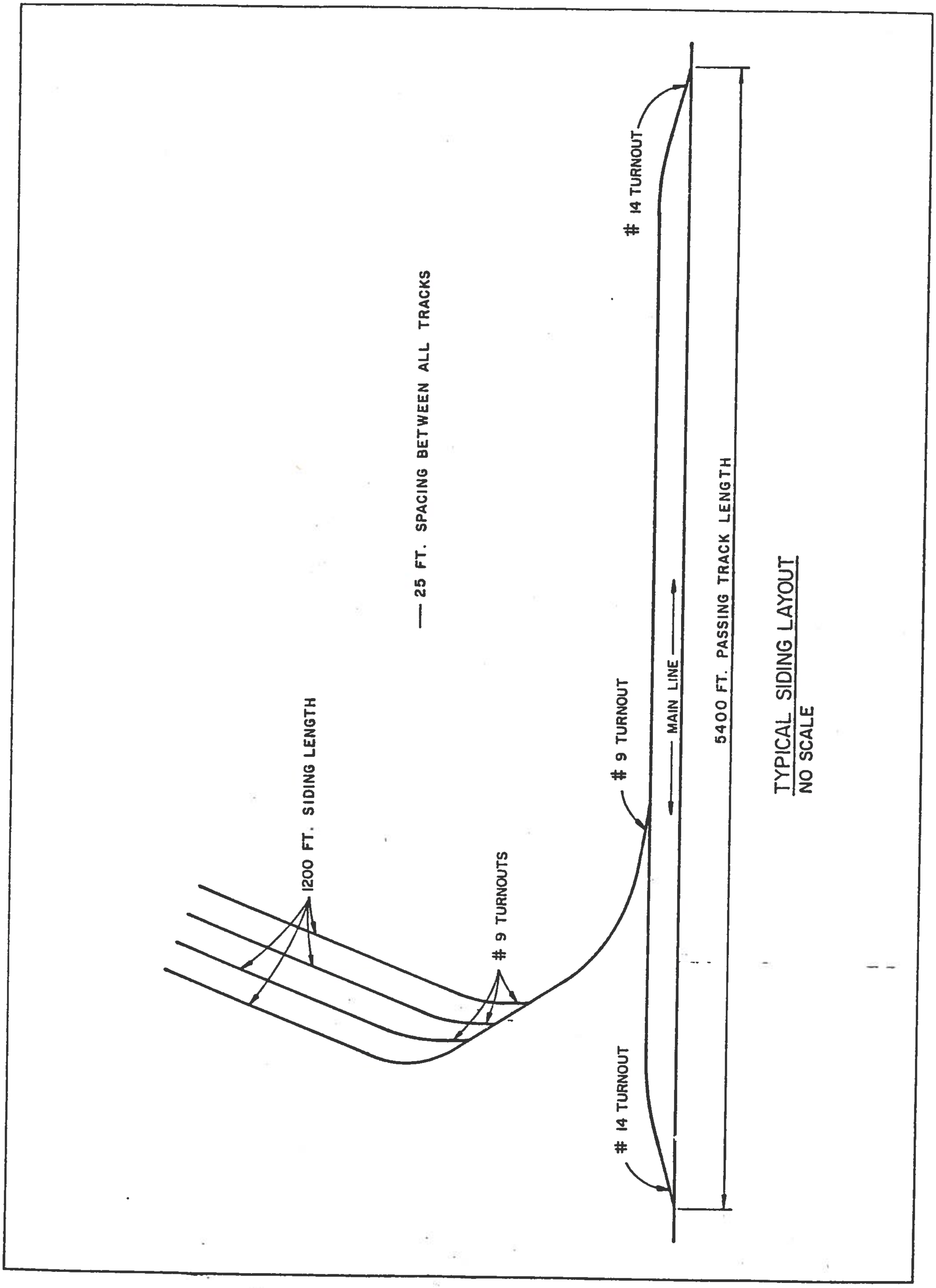
NOTES:
- EXCEPT WHERE INDICATED, ALL TURNOUTS ARE # 9
- 25 FT. SPACING BETWEEN ALL TRACKS



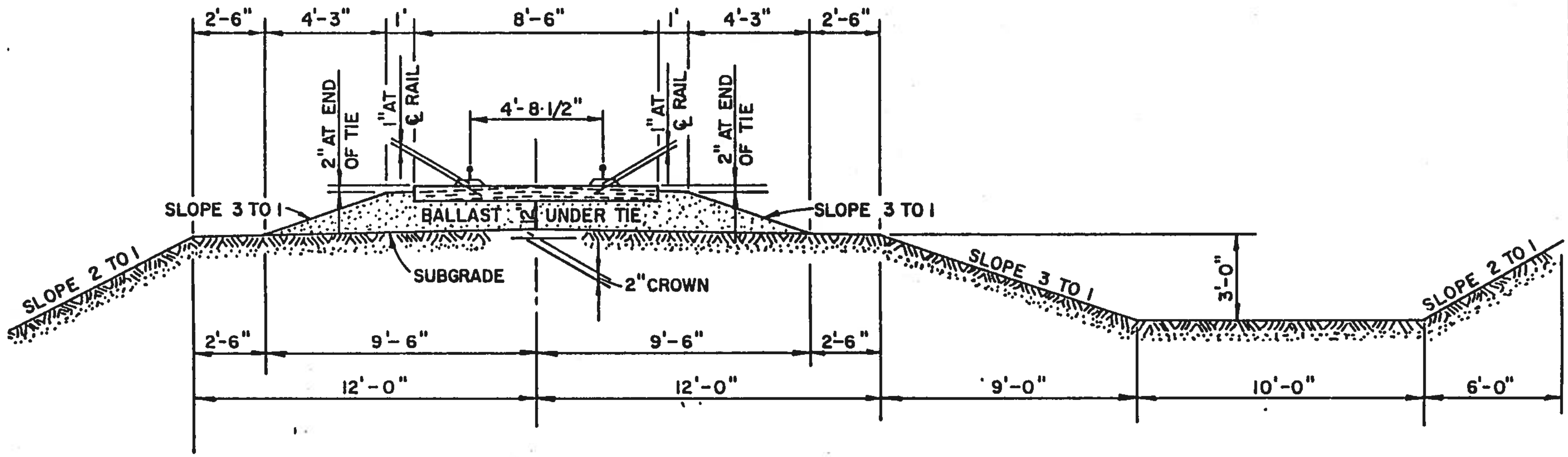
SOUTH FORT HOOD RAILHEAD
SCHEMATIC LAYOUT

NO SCALE


1000 FT. SETOUT TRACK
1200 FT. SIDINGS
NOTES:
- EXCEPT WHERE INDICATED, ALL TURNOUTS ARE #9
- 25 FT. SPACING BETWEEN ALL TRACKS
NORTH FORT HOOD RAILHEAD
SCHEMATIC LAYOUT
NO SCALE
14 TURNOUT
8° CURVE
14 TURNOUT
PASSING TRACK
MAIN LINE
5400 FT. PASSING TRACK LENGTH



TYPICAL SIDING LAYOUT
NO SCALE



ROADBED SECTION

DITCH SECTION THROUGH EXCAVATION

SINGLE TRACK-TYPICAL ROADBED

APPENDIX B. TRACKED VEHICLE INVENTORY

ARMOR BRIGADE UNITS

1. Armor Battalion (2 per Brigade)

Vehicle Type	Headquarter Company (1)	Armor Company (4)	Battalion Total
M1	2	14	58
M3	6		6
M88	7		7
M106	6		6
M113	11		11
M577	8		8
	-----	-----	-----
TOTAL	40	14	96

2. Mechanized Infantry Battalion (1 per Brigade)

Vehicle Type	Headquarter Company (1)	Infantry Company (4)	TOW Company (1)	Battalion Total
M2	2	13		54
M3	6			6
M88	7			7
M106	6			6
M113	15	1	4	23
M577	8			8
M901			12	12
	-----	-----	-----	-----
TOTAL	44	14	16	116

3. Brigade Headquarters (1 per Brigade)

Vehicle Type	Headquarter Company (1)	Brigade Total
M113	6	6
M577	1	1
	-----	-----
TOTAL	7	7

DIVISION FIELD ARTILLERY (DIVARTY)

1. 155 mm Howitzer Battalion (2 per Brigade)

Vehicle Type	Headquarter Battery (1)	Howitzer Battery (3)	Service Battery (1)	Battalion Total
M109		6		18
M548		6		18
M577	7	1		10
M578			1	1
	-----	-----	-----	-----
TOTAL	7	13	1	47

2. 8" Howitzer and Rocket Battery (1 per Brigade)

Vehicle Type	Headquarter Battery (1)	Howitzer Battery (2)	Rocket Battery (1)	Service Battery (1)	Battalion Total
M88				2	2
M110		6			12
M270			9		9
M548		6			12
M577	3	2	4		11
M578				2	2
	-----	-----	-----	-----	-----
TOTAL	3	14	13	4	48

3. Brigade Headquarters (1 per Brigade)

Vehicle Type	Headquarter Battery (1)	Brigade Total
M577	1	1

DIVISION TROOP UNITS

1. Cavalry Squadron (1 per Division)

Vehicle Type	Headquarter Company (1)	Cavalry Troop (2)	Squadron Total
M3	2	19	40
M88	2	1	4
M106		3	6
M113	9	1	11
M577	6	1	8
	-----	-----	-----
TOTAL	19	25	69

2. Air Defense Battalion (DIVAD) (1 per Division)

Vehicle Type	Headquarter Battery (1)	Vulcan Battery (2)	Chaparral Battery (2)	Battalion Total
M113		4	4	16
M163		12		24
M577	2			2
M578		1	1	4
M730			12	24
	-----	-----	-----	-----
TOTAL	2	17	17	70

3. Combat Engineer Battalion (1 per Division)

Vehicle Type	Headquarter Company (1)	Engineer Company (3)	Battalion Total
AVLB		4	12
M88		1	3
M548		1	3
M577	3	1	6
M728		2	6
	-----	-----	-----
TOTAL	3	9	30

OTHER DIVISION TROOP UNITS - SUMMARIZED

Vehicle Type	Headquarter Command	Military Intelligence	Support Command	Other Units	Total All Units
M113	2	8	50	20	80
M577	2	1			3
M578			9		9
M1015		4			4
	-----	-----	-----	-----	-----
TOTAL	4	13	59	20	96

DIVISION SUMMARY (1st Cavalry and 2nd Armor Divisions)

Vehicle Type	Armor Brigade (2)	Field Artillery (1)	Cavalry Squadron (1)	Air Defense (1)	Combat Engineers (1)	Other Units	Division Total
M1	116.						232
M2	54						108
M3	18		40				76
AVLB					12		12
M88	21	2	4		3		51
M106	18		6				42
M109		36					36
M110		12					12
M113	51		11	16		80	209
M163				24			24
M270 *		9					9
M548		48			3		51
M577	25	32	8	2	6	3	101
M578		4		4		9	17
M728					6		6
M730				24			24
M901	12						24
M1015						4	4
	-----	-----	-----	-----	-----	-----	-----
TOTAL	315	143	69	70	30	96	1038

* The M270 Multiple Launch Rocket System (MLRS) is currently assigned only to the 2nd Armor Division. However, it is expected that this weapon system will also be assigned to the 1st Cavalry Division during FY 1986.

APPENDIX C. COMPUTATION OF AVERAGE ON-POST DISTANCES TO TRAINING

This appendix documents the assumptions and procedures used to estimate average distances between the motor pool areas at South and North Ft. Hood and various firing ranges and training areas on post. Separate assumptions and computations were used to estimate average distances for each major category of training (direct-fire gunnery practice, field training, and artillery practice) and for different military unit types within each training category. Applying the criteria described in Chapter 2, these distances were used to compute average annual mileage estimates for tracked vehicles and their transportation modes under each of the heavy vehicle transportation alternatives. Mileage estimates for the current HET operations alternative were computed by factoring the average mileage estimates for the Full Roadmarch and Full HET alternatives.

Note also that roadmarch distances computed for the HET alternative apply only to those vehicles which would be transported in via HET. For tracked vehicles belonging to the M113 class, the Full Roadmarch distances would apply even under the Full HET alternative.

C.1 DIRECT-FIRE GUNNERY PRACTICE

Gunnery practice for each of the resident armor, infantry, and cavalry units takes place at various tank ranges and tank tables located along the perimeter of the live fire area at Ft. Hood. Distances were measured from the South Ft. Hood motor pool area to the apex of the boundary of each major tank range or tank table identified by III Corps (Range Control Divsion). Average distances were then computed for various military units based on assumptions and procedures described below. Table C-1 presents the measured and computed average distances for each military unit type and transportation alternative.

Armor Company. Each armor company travels to a tank range for gunnery practice an average of four times per year. Armor company gunnery practice is restricted to Ft. Hood's six M1 or combination ranges. For this analysis, it was assumed that the Crittenberger tank course is used an average of once a year by each armor company, and that the other ranges are used with equal frequency for the other three gunnery practices.

TABLE C-1.

DISTANCES TO FIRING RANGES FROM SOUTH FT. HOOD

	Base	HET Alternative		Full Rail Alternative			West Line Only			West Line to Curry			West Line to Crittenberger		
Range or Training Area	Roadmarch Distance	HET Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance
- M1 Firing Ranges -															
Pilot Knob (M1)	1.6	0.0	1.6		0.0	1.6		0.0	1.6		0.0	1.6		0.0	1.6
Blackwell (M1)	2.2	0.0	2.2		0.0	2.2		0.0	2.2		0.0	2.2		0.0	2.2
Sugar Loaf (M1)	5.5	5.3	0.4		0.0	5.5		0.0	5.5		0.0	5.5		0.0	5.5
Jack Mountain (Comb)	8.3	8.5	0.2	J	7.6	1.6	J	7.6	1.6	J	7.6	1.6	J	7.6	1.6
Clabber Creek (M1)	9.3	9.5	0.0	J	7.6	1.6	J	7.6	1.6	J	7.6	1.6	J	7.6	1.6
Crittenberger (M1)	15.0	15.6	0.2	CB	14.3	2.0	NF	20.2	9.9	C	9.2	7.1	CB	27.3	2.0
WGT AVG DISTANCE TO M1 RANGES	7.79	7.40	0.71		5.86	2.38		7.33	4.35		4.58	3.65		9.11	2.38
- M2/M3 Firing Ranges -															
Trapnell (M2/M3)	6.5	7.3	0.4	C	9.2	2.4		0.0	6.5	C	9.2	2.4		0.0	6.5
House Creek (M2/M3)	5.3	4.9	0.4	E	4.8	1.6	E	4.8	1.6	E	4.8	1.6	E	4.8	1.6
Browns Creek (M2/M3)	12.6	12.8	0.2	H	14.3	3.8	H	14.3	3.8	H	14.3	3.8	H	14.3	3.8
Henson Mountain (M2/M3)	15.7	16.0	0.0	H	14.3	1.6	H	14.3	1.6	H	14.3	1.6	H	14.3	1.6
Dalton Mountain (M2/M3)	18.5	18.7	0.4	NF	20.2	4.2	NF	20.2	4.2	NF	20.2	4.2	NF	20.2	4.2
WGT AVG DISTANCE TO ALL RANGES	9.94	9.89	0.46		9.69	2.61		8.91	3.61		9.38	2.93		9.36	3.12
- Special Training Ranges -															
Post Oak Artillery Direct Fire	4.5	4.7	0.0		0.0	4.5		0.0	4.5		0.0	4.5		0.0	4.5
Curry Engineer Demo Training Area	10.7	10.7	0.2	C	9.2	3.0		0.0	10.7	C	9.2	3.0		0.0	10.7

Two of the M1 ranges (Pilot Knob and Blackwell) are so close to the South Ft. Hood motor pool area that it would not be cost-effective to transport tracked vehicles to them by HET or rail. Consequently, all travel to these two ranges was assumed to be by roadmarching.

The average distance for armor company gunnery practice was computed by taking a weighted average of the distances to each of the six ranges, using a factor of .25 for the Crittenberger range and .15 for each of the other five ranges.

Infantry Company and Cavalry Troop. Each infantry (including TOW) company and cavalry troop also travels to a tank range for gunnery practice an average of four times per year. Gunnery practice for these units can take place at any of the 11 M1, Bradley, or combination ranges on post. For this analysis, it was assumed that the five designated Bradley ranges are used by infantry and cavalry units at twice the frequency of the M1 or combination ranges.

The average distance for infantry and cavalry gunnery practice was computed by taking a weighted average of the distances to each of the 11 ranges, using a factor of .125 for the five Bradley ranges and .0625 for the six M1 and combination ranges.

Artillery Battery Direct-Fire Training. Artillery batteries travel to the Post Oak artillery range an average of twice a year for direct-fire (target in site of gunner) gunnery practice. The average roadmarch distance from the motor pool area to this range is 4.5 miles. The distance to Post Oak by HET is 4.7 miles, with no additional roadmarching required.

No field siding is sufficiently close to Post Oak to make rail a cost-effective transportation option for this trip. Consequently, all travel to this site under any of the rail alternatives was assumed to be by roadmarching.

Engineer Company Training and Gunnery Practice. Combat engineer companies conduct most of their training and gunnery practice at the Curry engineer demo training area, located 10.7 roadmarch miles from the South Ft. Hood motor pool area. The average distance to Curry by HET is also 10.7 miles with an additional 0.2 miles of roadmarching.

For this analysis, is was assumed that engineer companies travel to Curry an average of four times per year, and participate in field training as part of an armor battalion or brigade an additional 2 times per year. Consequently, the average distance traveled by an engineer company was computed by taking a weighted average of the distance to Curry and the average distance for an armor battalion field training exercise (described in Section C.3), using a factor of .67 for the Curry distance and .33 for the armor battalion distance.

Texas National Guard. Armor and cavalry units from the 49th Armor Division of the Texas National Guard (TXNG) also use the Ft. Hood tank ranges and tank tables, but access them from MATES instead of the South Ft. Hood motor pool area. Consequently, separate distance measurements had to be taken for travel from MATES to each tank range or tank table. These measurements are presented in Table C-2, along with the computed average distances under the Full Roadmarch and four rail alternatives.

Each TXNG unit takes gunnery practice an average of twice a year. Although any of 14 tank ranges or tables may be used, the preferred tank ranges are Blackwell, Sugar Loaf, and Trapnell, all located along the southern edge of the live fire area.

The average distance traveled by TXNG units for gunnery practice was computed by taking a weighted average of the distances to each tank range from North Ft. Hood, using a factor of .167 for the three primary tank ranges and .045 for the other 11 ranges.

C.2 COMPANY-LEVEL FIELD TRAINING EXERCISES

Company-level field training exercises (FTXs) can take place in any one of the 43 designated training areas on post that are accessible to tracked vehicles. (TA 23 is off-limits to all tracked vehicles, and was therefore not included in the distance calculations). Distances were measured from the South Ft. Hood motor pool area to the center of each training area; the center was arbitrarily defined on the map by the location of the training area identification number.

An average distance to all training areas was computed based on the assumption that the training areas are used with equal frequency. Table C-3 presents the measured distances to each training area and a computed average distance to all training areas for each transportation alternative. Average distances to training for specific military units were computed based on assumptions about training frequency, described below.

Armor and Infantry Company. Each armor and infantry (including TOW) company travels to the field an average of four times a year for company-level FTXs. The average distance to all training areas, as computed above, was used for each of these units.

Cavalry Troop. Cavalry troops also participate in field training exercises an average of four times per year. However, the troop trains only about one-half the time as an independent unit; the rest of the time it trains as part of an armor battalion or brigade. Thus, the average distance to training for for a cavalry troop was computed as the average of the distances for company-level field training, and armor battalion-level field training (described below).

TABLE C-2.

DISTANCES TO FIRING RANGES FROM NORTH FT. HOOD (MATES)

	Base	Full Rail Alternative			West Line Only			West Line to Curry			West Line to Crittenberger		
Range or Training Area	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance
- Primary Tank Ranges -													
Blackwell	22.3	SF	20.2	1.7	SF	20.2	1.7	SF	20.2	1.7	SF	20.2	1.7
Sugar Loaf	17.2	C	15.5	3.6	SF	20.2	5.7	C	29.5	3.6	SF	20.2	5.7
Trapnell	15.4	C	15.5	1.8	SF	20.2	7.7	C	29.5	1.8	CB	10.2	7.1
- Secondary Tank Ranges -													
Pilot Knob	20.5	SF	20.2	1.6	SF	20.2	1.6	SF	20.2	1.6	SF	20.2	1.6
Black Mountain	21.1	SF	20.2	2.4	SF	20.2	2.4	SF	20.2	2.4	SF	20.2	2.4
House Creek	16.4	E	15.4	0.8	E	15.4	0.8	E	15.4	0.8	E	15.4	0.8
Jack Mountain	13.4	J	12.6	0.8	J	12.6	0.8	J	12.6	0.8	J	12.6	0.8
Clabber Creek	12.2	J	12.6	0.8	J	12.6	0.8	J	12.6	0.8	J	12.6	0.8
Browns Creek	9.3	H	5.9	3.0	H	5.9	3.0	H	5.9	3.0	H	5.9	3.0
Henson Mountain	5.7	H	5.9	0.8	H	5.9	0.8	H	5.9	0.8	H	5.9	0.8
Dalton Mountain	3.2		0.0	3.2		0.0	3.2		0.0	3.2		0.0	3.2
Brookhaven	13.8	C	15.5	0.4	SF	20.2	9.1	C	29.5	0.4	CB	10.2	5.5
Ruth	4.7		0.0	4.7		0.0	4.7		0.0	4.7		0.0	4.7
Crittenberger	8.5	CB	10.2	1.2		0.0	8.5		0.0	8.5	CB	10.2	1.2
WGT AVG DISTANCE TO ALL RANGES	14.68		13.61	2.05		14.74	4.05		18.00	2.42		13.25	3.42

TABLE C-3.

DISTANCES TO FIELD TRAINING AREAS FROM SOUTH FT. HOOD

- Field Training Areas -	Base	HET Alternative		Full Rail Alternative			West Line Only			West Line to Curry			West Line to Crittenberger		
	Roadmarch Distance	HET Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance
TA 1	14.4	15.4	0.2	CB	14.3	1.2	NF	20.2	10.5	C	9.2	6.7	CB	27.3	1.2
TA 2	12.2	12.0	1.0	C	9.2	4.7	NF	20.2	12.2	C	9.2	4.7	CB	27.3	4.8
TA 3	14.6	16.6	1.0	CB	14.3	5.5	NF	20.2	14.6	C	9.2	7.5	CB	27.3	5.5
TA 4	11.8	11.2	1.2	C	9.2	4.4		0.0	11.8	C	9.2	4.4	CB	27.3	6.1
TA 5	14.8	12.0	3.9	CB	14.3	6.1		0.0	14.8	C	9.2	7.3	CB	27.3	6.1
TA 6	17.6	12.0	6.9	CB	14.3	9.1		0.0	17.6	C	9.2	10.3	CB	27.3	9.1
TA 7	17.2	11.2	7.1	C	9.2	9.9		0.0	17.2	C	9.2	9.9	CB	27.3	10.9
TA 8	13.2	14.2	0.6	C	9.2	4.9		0.0	13.2	C	9.2	4.9		0.0	13.2
TA 11	5.9	6.1	0.8		0.0	5.9		0.0	5.9		0.0	5.9		0.0	5.9
TA 12	8.3	7.9	1.2	C	9.2	2.0		0.0	8.3	C	9.2	2.0		0.0	8.3
TA 13	10.7	10.3	0.4	C	9.2	4.0		0.0	10.7	C	9.2	4.0		0.0	10.7
TA 14	6.9	6.5	0.6		0.0	6.9		0.0	6.9		0.0	6.9		0.0	6.9
TA 15	8.9	6.5	2.4	C	9.2	6.1		0.0	8.9	C	9.2	6.1		0.0	8.9
TA 16	11.6	12.4	1.4	C	9.2	7.3		0.0	11.6	C	9.2	7.3		0.0	11.6
TA 17	13.2	12.4	1.8	C	9.2	7.9		0.0	13.2	C	9.2	7.9		0.0	13.2
TA 18	4.7	4.5	0.6		0.0	4.7		0.0	4.7		0.0	4.7		0.0	4.7
TA 19	3.6	3.4	0.2		0.0	3.6		0.0	3.6		0.0	3.6		0.0	3.6
TA 21	6.7	6.3	0.4		0.0	6.7		0.0	6.7		0.0	6.7		0.0	6.7
TA 22	8.7	9.5	0.0		0.0	8.7		0.0	8.7		0.0	8.7		0.0	8.7
TA 23 (off limits to tracks)															
TA 24	11.8	11.8	0.2		0.0	11.8		0.0	11.8		0.0	11.8		0.0	11.8
TA 25	11.6	12.6	0.0		0.0	11.6		0.0	11.6		0.0	11.6		0.0	11.6
TA 26	13.0	12.8	0.4		0.0	13.0		0.0	13.0		0.0	13.0		0.0	13.0
TA 27	14.0	12.8	1.2		0.0	14.0		0.0	14.0		0.0	14.0		0.0	14.0
TA 30	6.3	5.3	0.6		0.0	6.3		0.0	6.3		0.0	6.3		0.0	6.3
TA 31	6.9	5.7	1.2		0.0	6.9		0.0	6.9		0.0	6.9		0.0	6.9
TA 32	5.5	4.7	0.8		0.0	5.5		0.0	5.5		0.0	5.5		0.0	5.5
TA 33	7.9	6.7	1.2		0.0	7.9		0.0	7.9		0.0	7.9		0.0	7.9
TA 34	6.3	4.7	1.2	E	4.8	4.2	E	4.8	4.2	E	4.8	4.2	E	4.8	4.2
TA 35	9.1	8.9	0.2	E	4.8	5.5	E	4.8	5.5	E	4.8	5.5	E	4.8	5.5
TA 36	6.1	5.1	1.4	E	4.8	2.4	E	4.8	2.4	E	4.8	2.4	E	4.8	2.4
TA 41	12.4	12.0	0.8	E	4.8	9.3	E	4.8	9.3	E	4.8	9.3	E	4.8	9.3
TA 42	9.1	10.3	1.2	J	7.6	3.6	J	7.6	3.6	J	7.6	3.6	J	7.6	3.6
TA 43	13.4	12.0	1.4	J	7.6	5.7	J	7.6	5.7	J	7.6	5.7	J	7.6	5.7
TA 44	11.0	10.1	1.2	J	7.6	3.6	J	7.6	3.6	J	7.6	3.6	J	7.6	3.6
TA 45	14.6	14.8	1.2	J	7.6	7.5	J	7.6	7.5	J	7.6	7.5	J	7.6	7.5
TA 48	14.2	13.4	1.0	H	14.3	4.2	H	14.3	4.2	H	14.3	4.2	H	14.3	4.2
TA 51	18.7	18.9	0.8	H	14.3	4.9	H	14.3	4.9	H	14.3	4.9	H	14.3	4.9
TA 52	19.3	18.5	0.8	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6
TA 53	16.0	16.1	0.6	H	14.3	2.2	H	14.3	2.2	H	14.3	2.2	H	14.3	2.2
TA 54	19.3	18.9	0.4	NF	20.2	4.0	NF	20.2	4.0	NF	20.2	4.0	NF	20.2	4.0
TA 71	20.3	21.5	0.6	NF	20.2	3.0	NF	20.2	3.0	NF	20.2	3.0	NF	20.2	3.0
TA 72	18.9	19.5	0.8	NF	20.2	5.1	NF	20.2	5.1	NF	20.2	5.1	NF	20.2	5.1
TA 73	18.0	18.9	0.6	CB	14.3	4.9	NF	20.2	6.5	NF	20.2	6.5	CB	27.3	4.9
AVERAGE DISTANCE TO TRAINING AREAS	11.83	11.31	1.20		7.48	6.08		5.77	8.24		7.14	6.34		8.97	6.93

Air Defense Battery. Air defense batteries participate in field training exercises as part of an armor battalion or brigade an average of twice a year. Consequently, the average distance to field training for this unit was assumed to be the same as that for an armor battalion (described below).

C.3 BATTALION-LEVEL FIELD TRAINING EXERCISES

Battalion- and brigade-level field training exercises typically take place over a larger area than company-level training. For this analysis, it was assumed that battalion-level field training exercises take place in one of seven training area groups, where a group is defined as a set of training areas having a common first digit in their identification number (e.g., TA 21 to 27). Average distances to each training area group were computed by averaging the distances to all training areas contained in the group. The average distance to all training area groups was computed by assuming that each group is used with equal frequency. Computed distances to individual training area groups and the combined average distances for battalion-level training are presented in Table C-4 for each transportation alternative.

Armor battalions travel to the field an average of four times a year -- twice as a pure armor battalion and twice as a composite battalion in which a mechanized infantry company replaces one of the armor companies. Infantry battalions travel to the field as a pure inantry battalion an average of three times a year. Each of these units used the average training distances presented in Table C-4.

C.4 AIR DEFENSE AND ARTILLERY GUNNERY PRACTICE

Gunnery practice for both battery- and battalion-sized units of division field artillery (DIVARTY) and division air defense (DIVAD) takes place at one or more of the 196 artillery firing positions clustered within various training areas on post. For this analysis, 19 separate clusters were identified, and travel distances were measured from the South Ft. Hood motor pool area to the approximate center of each cluster. The average distance to all firing clusters was computed as the weighted average distance to all clusters, where each cluster was weighted by its share of total firing positions. This implicitly assumes that the frequency of use of any particular cluster is directly proportional to the number of firing positions in that cluster. Table C-5 presents the measured distances to each artillery cluster and the weighted average distance to all clusters for each transportation alternative.

DIVARTY units travel to the field for artillery practice an average of 6 times per year -- twice as a battery and four times as a battalion. DIVAD units take artillery training an average of four times per year as a battery. Each of these units and mission types used the average training distances presented in Table C-5.

TABLE C-4.

DISTANCES TO TRAINING AREA GROUPS FROM SOUTH FT. HOOD

	Base	HET Alternative		Full Rail Alternative			West Line Only			West Line to Curry			West Line to Crittenberger		
Range or Training Area	Roadmarch Distance	HET Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance
- Training Area Groups -															
GROUP 1 (TA 1..8)	14.48	13.08	2.74	CB/C	11.75	5.73	NF	7.58	13.99	C	9.20	6.96	CB	23.89	7.11
GROUP 2 (TA 11..19)	8.20	7.78	1.04	C	5.11	5.38		0.00	8.20	C	5.11	5.38		0.00	8.20
GROUP 3 (TA 21..27)	10.97	10.97	0.37		0.00	10.97		0.00	10.97		0.00	10.97		0.00	10.97
GROUP 4 (TA 30..36)	6.87	5.87	0.94	E	2.06	5.53	E	2.06	5.53	E	2.06	5.53	E	2.06	5.53
GROUP 5 (TA 41..48)	12.45	12.10	1.13	E/J/H	8.25	5.65	E/J/H	8.25	5.65	E/J/H	8.25	5.65	E/J/H	8.25	5.65
GROUP 6 (TA 51..54)	18.33	18.10	0.65	H/NF	15.78	3.93	H/NF	15.78	3.93	H/NF	15.78	3.93	H/NF	15.78	3.93
GROUP 7 (TA 71..73)	19.07	19.97	0.67	NF/CB	18.23	4.33	NF	20.20	4.87	NF	20.20	4.87	NF/CB	22.57	4.33
AVERAGE DISTANCE TO TA GROUPS	12.91	12.55	1.08		8.74	5.93		7.69	7.59		8.66	6.18		10.36	6.53

TABLE C-5.

DISTANCES TO ARTILLERY FIRING POSITIONS FROM SOUTH FT. HOOD

	Base	HET Alternative		Full Rail Alternative			West Line Only			West Line to Curry			West Line to Crittenberger		
Range or Training Area	Roadmarch Distance	HET Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance	Rail Siding	Rail Distance	Roadmarch Distance
- Artillery Positions -															
TA 1 (21 positions)	14.2	16.2	0.4	CB	14.3	3.4	NF	20.2	12.6	C	9.2	6.7	CB	27.3	3.4
TA 3 (8 Positions)	14.6	16.6	0.8	CB	14.3	5.3		0.0	14.6	C	9.2	6.9	CB	27.3	5.3
TA 4 (16 positions)	13.0	12.0	2.6	C	9.2	5.7		0.0	13.0	C	9.2	5.7	CB	27.3	5.8
TA 11 (5 positions)	7.1	6.3	1.0	C	9.2	3.4		0.0	7.1	C	9.2	3.4			7.1
TA 12 (10 positions)	9.5	9.7	0.2	C	9.2	1.8		0.0	9.5	C	9.2	1.8			9.5
TA 13 (5 positions)	11.0	10.4	0.6	C	9.2	4.4		0.0	11.0	C	9.2	4.4			11.0
TA 15 (12 positions)	8.1	6.3	1.8	C	9.2	6.5		0.0	8.1	C	9.2	6.5			8.1
TA 36 (7 positions)	5.5	6.1	0.6	E	4.8	2.0	E	4.8	2.0	E	4.8	2.0	E	4.8	2.0
TA 42a (15 positions)	8.7	9.5	0.6	J	7.6	2.2	J	7.6	2.2	J	7.6	2.2	J	7.6	2.2
TA 42b (29 positions)	12.0	11.6	0.6	J	7.6	4.6	J	7.6	4.6	J	7.6	4.6	J	7.6	4.6
TA 44 (5 positions)	10.7	10.3	0.4	J	7.6	2.8	J	7.6	2.8	J	7.6	2.8	J	7.6	2.8
TA 48 (11 positions)	13.8	13.4	0.4	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6
TA 62 (15 positions)	17.4	14.6	2.8	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6	H	14.3	4.6
TA 73 (7 positions)	16.6	17.2	0.4	CB	14.3	4.4	NF	20.2	8.1	NF	20.2	8.1	CB	27.3	4.4
TA 76 (8 positions)	10.5	11.0	0.2	C	9.2	3.0		0.0	10.5	C	9.2	3.0	CB	27.3	5.0
TA 83 (6 positions)	7.9	7.7	0.2	J	7.6	2.8	J	7.6	2.8	J	7.6	2.8	J	7.6	2.8
TA 89 (5 positions)	7.1	6.1	1.0	E	4.8	2.2	E	4.8	2.2	E	4.8	2.2	E	4.8	2.2
TA 91 (7 positions)	1.0	0.0	1.0		0.0	1.0		0.0	1.0		0.0	1.0		0.0	1.0
TA 93 (4 positions)	6.9	6.9	0.2	C	9.2	2.8		0.0	6.9	C	9.2	2.8		0.0	6.9
WGT AVG DISTANCE TO ARTY RANGES	11.26	11.09	0.95		9.77	3.85		7.21	7.09		9.22	4.40		12.68	4.78

APPENDIX D. TRACKED VEHICLE MILEAGE COMPUTATIONS

TABLE D-1.

ANNUAL TRACKED VEHICLE MILES - FULL ROADMARCH ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	28897.9	2989.4	0.0	31887.4
Armor Company to Training Area	4	32	42398.7	0.0	0.0	42398.7
Armor Battalion to Training Area	2	8	23961.0	2478.7	13219.8	39659.5
Composite Battalion to Training Area	2	8	18177.3	7849.3	13633.0	39659.5
Infantry Company to Firing Range	4	16	0.0	19094.4	0.0	19094.4
TOW Company to Firing Range	4	4	0.0	0.0	3818.9	3818.9
Infantry Company to Training Area	4	16	0.0	19685.1	1514.2	21199.4
TOW Company to Training Area	4	4	0.0	0.0	6057.0	6057.0
Infantry Battalion to Training Area	3	4	0.0	18590.4	17351.0	35941.4
Cavalry Troop to Firing Range	4	4	0.0	6364.8	0.0	6364.8
Cavalry Troop to Training Area	4	4	0.0	7521.0	2375.0	9896.0
Engineer Company to Training Area	6	6	0.0	0.0	7409.9	7409.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	7026.2	7026.2
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	16935.0	16935.0
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	2522.2	2522.2
MLRS Battery to Artillery Range	2	2	0.0	0.0	1171.0	1171.0
8" FA Battalion to Artillery Range	4	2	0.0	0.0	8647.7	8647.7
Vulcan Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Chaparral Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Vulcan Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
Chaparral Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
TOTAL ALL UNITS AND MISSIONS			113434.9	84573.1	125023.0	323031.0

TABLE D-2.

ANNUAL TRACKED VEHICLE MILES - CURRENT HET OPERATIONS

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	28897.9	2989.4	0.0	31887.4
Armor Company to Training Area	4	32	32874.2	0.0	0.0	32874.2
Armor Battalion to Training Area	2	8	12978.1	1342.6	11894.3	26215.0
Composite Battalion to Training Area	2	8	9845.4	4251.4	12307.4	26404.3
Infantry Company to Firing Range	4	16	0.0	19094.4	0.0	19094.4
TOW Company to Firing Range	4	4	0.0	0.0	3818.9	3618.9
Infantry Company to Training Area	4	16	0.0	19685.1	1514.2	21199.4
TOW Company to Training Area	4	4	0.0	0.0	6057.0	6057.0
Infantry Battalion to Training Area	3	4	0.0	18590.4	17351.0	35941.4
Cavalry Troop to Firing Range	4	4	0.0	6364.8	0.0	6364.8
Cavalry Troop to Training Area	4.	4	0.0	7521.0	2375.0	9896.0
Engineer Company to Training Area	6	6	0.0	0.0	7409.9	7409.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	7026.2	7026.2
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	15367.2	15367.2
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	2522.2	2522.2
MLRS Battery to Artillery Range	2	2	0.0	0.0	1171.0	1171.0
8" FA Battalion to Artillery Range	4	2	0.0	0.0	7616.2	7616.2
Vulcan Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Chaparral Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Vulcan Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
Chaparral Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
TOTAL ALL UNITS AND MISSIONS			84595.7	79839.1	119772.6	284207.4

TABLE D-3.

ANNUAL TRACKED VEHICLE MILES - FULL HET ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	2635.5	272.6	0.0	2908.2
Armor Company to Training Area	4	32	4300.8	0.0	0.0	4300.8
Armor Battalion to Training Area	2	8	1995.2	206.4	10568.8	12770.4
Composite Battalion to Training Area	2	8	1513.6	653.6	10981.9	13149.1
Infantry Company to Firing Range	4	16	0.0	892.8	0.0	892.8
TOW Company to Firing Range	4	4	0.0	0.0	3818.9	3818.9
Infantry Company to Training Area	4	16	0.0	1996.8	1514.2	3511.0
TOW Company to Training Area	4	4	0.0	0.0	6057.0	6057.0
Infantry Battalion to Training Area	3	4	0.0	1548.0	15362.8	16910.8
Cavalry Troop to Firing Range	4	4	0.0	297.6	0.0	297.6
Cavalry Troop to Training Area	4.	4	0.0	693.1	2015.7	2708.8
Engineer Company to Training Area	6	6	0.0	0.0	1893.6	1893.6
155mm FA Battery to Firing Range	2	12	0.0	0.0	1296.0	1296.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	4055.5	4055.5
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	10663.5	10663.5
8" FA Battery to Firing Range	2	4	0.0	0.0	576.0	576.0
MLRS Battery to Firing Range	2	2	0.0	0.0	144.0	144.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	1532.0	1532.0
MLRS Battery to Artillery Range	2	2	0.0	0.0	428.4	428.4
8" FA Battalion to Artillery Range	4	2	0.0	0.0	4521.7	4521.7
Vulcan Battery to Artillery Range	4	4	0.0	0.0	1834.4	1834.4
Chaparral Battery to Artillery Range	4	4	0.0	0.0	1834.4	1834.4
Vulcan Battery to Training Area	2	4	0.0	0.0	1049.8	1049.8
Chaparral Battery to Training Area	2	4	0.0	0.0	1049.8	1049.8
TOTAL ALL UNITS AND MISSIONS			10445.1	6561.0	81198.4	98204.5

TABLE D-4.

ANNUAL TRACKED VEHICLE MILES - FULL RAIL ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	8816.0	912.0	0.0	9728.0
Armor Company to Training Area	4	32	21772.8	0.0	0.0	21772.8
Armor Battalion to Training Area	2	8	11006.1	1138.6	6072.3	18217.0
Composite Battalion to Training Area	2	8	8349.4	3605.4	6262.1	18217.0
Infantry Company to Firing Range	4	16	0.0	5001.6	0.0	5001.6
TOW Company to Firing Range	4	4	0.0	0.0	1000.3	1000.3
Infantry Company to Training Area	4	16	0.0	10108.8	777.6	10886.4
TOW Company to Training Area	4	4	0.0	0.0	3110.4	3110.4
Infantry Battalion to Training Area	3	4	0.0	8539.2	7969.9	16509.1
Cavalry Troop to Firing Range	4	4	0.0	1667.2	0.0	1667.2
Cavalry Troop to Training Area	4.	4	0.0	3651.0	1153.0	4804.0
Engineer Company to Training Area	6	6	0.0	0.0	2575.8	2575.8
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	2402.4	2402.4
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	5790.4	5790.4
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	862.4	862.4
MLRS Battery to Artillery Range	2	2	0.0	0.0	400.4	400.4
8" FA Battalion to Artillery Range	4	2	0.0	0.0	2956.8	2956.8
Vulcan Battery to Artillery Range	4	4	0.0	0.0	2094.4	2094.4
Chaparral Battery to Artillery Range	4	4	0.0	0.0	2094.4	2094.4
Vulcan Battery to Training Area	2	4	0.0	0.0	1613.0	1613.0
Chaparral Battery to Training Area	2	4	0.0	0.0	1613.0	1613.0
TOTAL ALL UNITS AND MISSIONS			49944.3	34623.8	52816.5	137384.7

TABLE D-5.

ANNUAL TRACKED VEHICLE MILES - WEST RAIL ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	16147.2	1670.4	0.0	17817.6
Armor Company to Training Area	4	32	29532.2	0.0	0.0	29532.2
Armor Battalion to Training Area	2	8	14087.0	1457.3	7772.2	23316.5
Composite Battalion to Training Area	2	8	10686.7	4614.7	8015.0	23316.5
Infantry Company to Firing Range	4	16	0.0	6940.8	0.0	6940.8
TOW Company to Firing Range	4	4	0.0	0.0	1388.2	1388.2
Infantry Company to Training Area	4	16	0.0	13711.4	1054.7	14766.1
TOW Company to Training Area	4	4	0.0	0.0	4218.9	4218.9
Infantry Battalion to Training Area	3	4	0.0	10929.6	10201.0	21130.6
Cavalry Troop to Firing Range	4	4	0.0	2313.6	0.0	2313.6
Cavalry Troop to Training Area	4.	4	0.0	4812.3	1519.7	6332.0
Engineer Company to Training Area	6	6	0.0	0.0	6262.9	6262.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	4424.2	4424.2
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	10663.4	10663.4
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	1588.2	1588.2
MLRS Battery to Artillery Range	2	2	0.0	0.0	737.4	737.4
8" FA Battalion to Artillery Range	4	2	0.0	0.0	5445.1	5445.1
Vulcan Battery to Artillery Range	4	4	0.0	0.0	3857.0	3857.0
Chaparral Battery to Artillery Range	4	4	0.0	0.0	3857.0	3857.0
Vulcan Battery to Training Area	2	4	0.0	0.0	2064.5	2054.5
Chaparral Battery to Training Area	2	4	0.0	0.0	2064.5	2064.5
TOTAL ALL UNITS AND MISSIONS			70453.1	46450.1	79201.6	196104.8

TABLE D-6.

ANNUAL TRACKED VEHICLE MILES - WEST RAIL TO CURRY

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	13548.8	1401.6	0.0	14950.4
Armor Company to Training Area	4	32	22740.5	0.0	0.0	22740.5
Armor Battalion to Training Area	2	8	11470.1	1186.6	6328.3	18985.0
Composite Cattalion to Training Area	2	8	8701.4	3757.4	6526.1	18985.0
Infantry Company to Firing Range	4	16	0.0	5616.0	0.0	5616.0
TOW Company to Firing Range	4	4	0.0	0.0	1123.2	1123.2
Infantry Company to Training Area	4	16	0.0	10558.1	812.2	11370.2
TOW Company to Training Area	4	4	0.0	0.0	3248.6	3248.6
Infantry Battalion to Training Area	3	4	0.0	8899.2	8305.9	17205.1
Cavalry Troop to Firing Range	4	4	0.0	1872.0	0.0	1872.0
Cavalry Troop to Training Area	4	4	0.0	3809.1	1202.9	5012.0
Engineer Company to Training Area	6	6	0.0	0.0	2630.9	2630.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	2745.6	2745.6
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	6617.6	6617.6
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	985.6	985.6
MLRS Battery to Artillery Range	2	2	0.0	0.0	457.6	457.6
8" FA Battalion to Artillery Range	4	2	0.0	0.0	3379.2	3379.2
Vulcan Battery to Artillery Range	4	4	0.0	0.0	2393.6	2393.6
Chaparral Battery to Artillery Range	4	4	0.0	0.0	2393.6	2393.6
Vulcan Battery to Training Area	2	4	0.0	0.0	1681.0	1681.0
Chaparral Battery to Training Area	2	4	0.0	0.0	1681.0	1681.0
TOTAL ALL UNITS AND MISSIONS			56460.8	37100.0	56580.8	150141.6

TABLE D-7.

ANNUAL TRACKED VEHICLE MILES - WEST RAIL TO CRITTENBERGER

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	8816.0	912.0	0.0	9728.0
Armor Company to Training Area	4	32	24819.2	0.0	0.0	24819.2
Armor Battalion to Training Area	2	8	12119.7	1253.8	6686.7	20060.2
Composite Battalion to Training Area	2	8	9194.2	3970.2	6895.7	20060.2
Infantry Company to Firing Range	4	16	0.0	5990.4	0.0	5990.4
TOW Company to Firing Range	4	4	0.0	0.0	1198.1	1198.1
Infantry Company to Training Area	4	16	0.0	11523.2	886.4	12405.6
TOW Company to Training Area	4	4	0.0	0.0	3545.6	3545.6
Infantry Battalion to Training Area	3	4	0.0	9403.2	8776.3	18179.5
Cavalry Troop to Firing Range	4	4	0.0	1996.8	0.0	1996.8
Cavalry Troop to Training Area	4.	4	0.0	4091.8	1292.2	5384.0
Engineer Company to Training Area	6	6	0.0	0.0	6032.9	6032.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	2982.7	2982.7
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	7189.1	7189.1
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	1070.7	1070.7
MLRS Battery to Artillery Range	2	2	0.0	0.0	497.1	497.1
8" FA Battalion to Artillery Range	4	2	0.0	0.0	3671.0	3671.0
Vulcan Battery to Artillery Range	4	4	0.0	0.0	2600.3	2600.3
Chaparral Battery to Artillery Range	4	4	0.0	0.0	2600.3	2600.3
Vulcan Battery to Training Area	2	4	0.0	0.0	1776.2	1776.2
Chaparral Battery to Training Area	2	4	0.0	0.0	1776.2	1776.2
TOTAL ALL UNITS AND MISSIONS			54949.1	39141.4	63545.5	157636.1

TABLE D-8.

ANNUAL TRACKED VEHICLE MILES - EXPANDED EXISTING HET ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	M1 Mileage	M2/M3 Mileage	Other Mileage	Total Mileage
Armor Company to Firing Range	4	32	9201.1	951.8	0.0	10153.0
Armor Company to Training Area	4	32	13825.3	0.0	0.0	13825.3
Armor Battalion to Training Area	2	8	7486.6	774.5	13219.8	21481.0
Composite Battalion to Training Area	2	8	5679.5	2452.5	13633.0	21765.0
Infantry Company to Firing Range	4	16	0.0	9993.6	0.0	9993.6
TOW Company to Firing Range	4	4	0.0	0.0	3818.9	3818.9
Infantry Company to Training Area	4	16	0.0	10841.0	1514.2	12355.2
TOW Company to Training Area	4	4	0.0	0.0	6057.0	6057.0
Infantry Battalion to Training Area	3	4	0.0	7172.0	17351.0	24523.0
Cavalry Troop to Firing Range	4	4	0.0	6364.8	0.0	6364.8
Cavalry Troop to Training Area	4	4	0.0	7521.0	2375.0	9896.0
Engineer Company to Training Area	6	6	0.0	0.0	7409.9	7409.9
155mm FA Battery to Firing Range	2	12	0.0	0.0	2592.0	2592.0
155mm FA Battery to Artillery Range	2	12	0.0	0.0	7026.2	7026.2
155mm FA Battalion to Artillery Range	4	4	0.0	0.0	16935.0	16935.0
8" FA Battery to Firing Range	2	4	0.0	0.0	1008.0	1008.0
MLRS Battery to Firing Range	2	2	0.0	0.0	468.0	468.0
8" FA Battery to Artillery Range	2	4	0.0	0.0	2522.2	2522.2
MLRS Battery to Artillery Range	2	2	0.0	0.0	1171.0	1171.0
8" FA Battalion to Artillery Range	4	2	0.0	0.0	8647.7	8647.7
Vulcan Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Chaparral Battery to Artillery Range	4	4	0.0	0.0	6125.4	6125.4
Vulcan Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
Chaparral Battery to Training Area	2	4	0.0	0.0	3511.5	3511.5
TOTAL ALL UNITS AND MISSIONS			36192.6	46071.2	125023.0	207286.7

APPENDIX E. HET AND RAIL MILEAGE COMPUTATIONS

TABLE E-1.

ANNUAL HET MILEAGE - CURRENT HET OPERATIONS

Unit and Mission Type	Units on Post	Total HET Lifts	- HET Mileage by Category - 50+ Ton Vehicles	<50 Ton Vehicles	Deadhead Mileage	Total HET Mileage
Armor Company to Firing Range	32	0	0.0	0.0	0.0	0.0
Armor Company to Training Area	32	896	10133.8	0.0	10133.8	20267.5
Armor Battalion to Training Area	8	1136	13052.0	1204.8	14256.8	28513.6
Composite Battalion to Training Area	8	1120	10240.8	3815.2	14056.0	28112.0
Infantry Company to Firing Range	16	0	0.0	0.0	0.0	0.0
TOW Company to Firing Range	4	0	0.0	0.0	0.0	0.0
Infantry Company to Training Area	16	0	0.0	0.0	0.0	0.0
TOW Company to Training Area	4	0	0.0	0.0	0.0	0.0
Infantry Battalion to Training Area	4	0	0.0	0.0	0.0	0.0
Cavalry Troop to Firing Range	4	0	0.0	0.0	0.0	0.0
Cavalry Troop to Training Area	4	0	0.0	0.0	0.0	0.0
Engineer Company to Training Area	6	0	0.0	0.0	0.0	0.0
155mm FA Battery to Firing Range	12	0	0.0	0.0	0.0	0.0
155mm FA Battery to Artillery Range	12	0	0.0	0.0	0.0	0.0
155mm FA Battalion to Artillery Range	4	152	0.0	1685.7	1685.7	3371.4
8" FA Battery to Firing Range	4	0	0.0	0.0	0.0	0.0
MLRS Battery to Firing Range	2	0	0.0	0.0	0.0	0.0
8" FA Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
MLRS Battery to Artillery Range	2	0	0.0	0.0	0.0	0.0
8" FA Battalion to Artillery Range	2	100	88.7	1020.3	1109.0	2218.0
Vulcan Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
Chaparral Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
Vulcan Battery to Training Area	4	0	0.0	0.0	0.0	0.0
Chaparral Battery to Training Area	4	0	0.0	0.0	0.0	0.0
TOTAL ALL UNITS AND MISSIONS		3404	33515.3	7726.0	41241.2	82482.5

TABLE E-2.

ANNUAL HET MILEAGE - FULL HET ALTERNATIVE

Unit and Mission Type	Units on Post	Total HET Lifts	- HET Mileage by Category - 50+ Ton Vehicles	<50 Ton Vehicles	Deadhead Mileage	Total HET Mileage
Armor Company to Firing Range	32	4096	27450.2	2839.7	30289.9	60579.8
Armor Company to Training Area	32	3584	40535.0	0.0	40535.0	81070.1
Armor Battalion to Training Area	8	2272	26104.0	2409.6	28513.6	57027.2
Composite Battalion to Training Area	8	2240	20481.6	7630.4	28112.0	56224.0
Infantry Company to Firing Range	16	1920	0.0	18998.4	18998.4	37996.8
TOW Company to Firing Range	4	0	0.0	0.0	0.0	0.0
Infantry Company to Training Area	16	1664	0.0	18819.8	18819.8	37639.7
TOW Company to Training Area	4	0	0.0	0.0	0.0	0.0
Infantry Battalion to Training Area	4	1600	2108.4	18072.0	20180.4	40360.8
Cavalry Troop to Firing Range	4	640	0.0	6332.8	6332.8	12665.6
Cavalry Troop to Training Area	4	640	381.8	7253.4	7635.2	15270.4
Engineer Company to Training Area	6	504	5702.8	0.0	5702.8	11405.5
155mm FA Battery to Firing Range	12	288	0.0	1353.6	1353.6	2707.2
155mm FA Battery to Artillery Range	12	288	0.0	3193.9	3193.9	6387.8
155mm FA Battalion to Artillery Range	4	608	0.0	6742.7	6742.7	13485.4
8" FA Battery to Firing Range	4	96	0.0	451.2	451.2	902.4
MLRS Battery to Firing Range	2	72	0.0	338.4	338.4	676.8
8" FA Battery to Artillery Range	4	96	0.0	1064.6	1064.6	2129.3
MLRS Battery to Artillery Range	2	72	0.0	798.5	798.5	1597.0
8" FA Battalion to Artillery Range	2	400	354.9	4081.1	4436.0	8872.0
Vulcan Battery to Artillery Range	4	416	0.0	4613.4	4613.4	9226.9
Chaparral Battery to Artillery Range	4	416	0.0	4613.4	4613.4	9226.9
Vulcan Battery to Training Area	4	208	0.0	2610.4	2610.4	5220.8
Chaparral Battery to Training Area	4	208	0.0	2610.4	2610.4	5220.8
TOTAL ALL UNITS AND MISSIONS		22336	123118.7	114827.9	237946.6	475893.2
Less: Adjustment for Roadmarched Missions		1309				
TOTAL ANNUAL HET LIFTS		21027				

TABLE E-3.

ANNUAL RAIL MILEAGE - FULL RAIL ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	- Railcar - Mileage	Ton-Miles	Trains per Unit	Percent by Rail	Total Trains	- Locomotive Mileage - Loaded	Deadhead	Total
Armor Company to Firing Range	4	32	11991.0	1329507	1	55	141	1498.9	1498.9	2997.76
Armor Company to Training Area	4	32	13404.2	1581691	1	67	172	1914.9	1914.9	3829.76
Armor Battalion to Training Area	2	8	13424.6	1171859	2	86	56	559.4	559.4	1118.72
Composite Battalion to Training Area	2	8	13424.6	1019993	2	86	56	559.4	559.4	1118.72
Infantry Company to Firing Range	4	16	9307.2	390902	1	81	104	1241.0	1241.0	2481.92
TOW Company to Firing Range	4	4	1861.4	40952	1	81	26	310.2	310.2	620.48
Infantry Company to Training Area	4	16	6702.1	270956	1	67	86	957.4	957.4	1914.88
TOW Company to Training Area	4	4	1914.9	41170	1	67	22	239.4	239.4	478.72
Infantry Battalion to Training Area	3	4	12166.1	451823	2	86	42	419.5	419.5	839.04
Cavalry Troop to Firing Range	4	4	3102.4	130301	1	81	26	310.2	310.2	620.48
Cavalry Troop to Training Area	4	4	3244.0	131577	1	77	25	259.5	259.5	519.04
Engineer Company to Training Area	6	6	2930.6	280684	1	95	69	651.2	651.2	1302.48
155mm FA Battery to Firing Range	2	12	0.0	0	1	0	0	0.0	0.0	0
155mm FA Battery to Artillery Range	2	12	3046.7	120461	1	94	46	468.7	468.7	937.44
155mm FA Battalion to Artillery Range	4	4	7343.3	273108	1	94	31	312.5	312.5	624.96
8" FA Battery to Firing Range	2	4	0.0	0	1	0	0	0.0	0.0	0
MLRS Battery to Firing Range	2	2	0.0	0	1	0	0	0.0	0.0	0
8" FA Battery to Artillery Range	2	4	1093.7	45622	1	94	16	156.2	156.2	312.48
MLRS Battery to Artillery Range	2	2	507.8	22420	1	94	8	78.1	78.1	156.24
8" FA Battalion to Artillery Range	4	2	3749.8	166239	1	94	16	156.2	156.2	312.48
Vulcan Battery to Artillery Range	4	4	2656.1	69371	1	94	31	312.5	312.5	624.96
Chaparral Battery to Artillery Range	4	4	2656.1	65621	1	94	31	312.5	312.5	624.96
Vulcan Battery to Training Area	2	4	1188.6	31044	1	86	14	139.8	139.8	279.68
Chaparral Battery to Training Area	2	4	1188.6	29366	1	86	14	139.8	139.8	279.68
TOTAL ALL UNITS AND MISSIONS			116903.8	7664667			1032	10997.4	10997.4	21994.9

Average Train Length	10.6
Average Mileage per Train	10.7
Average Tonnage per Train	697.0

TABLE E-4.

ANNUAL RAIL MILEAGE - WEST LINE ALTERNATIVE

Unit and Mission Type	Missions per Year	Units on Post	- Railcar - Mileage	Ton-Miles	Trains per Unit	Percent by Rail	Total Trains	- Locomotive Mileage - Loaded	Deadhead	Total
Armor Company to Firing Range	4	32	15011.8	1664438	1	55	141	1876.5	1876.5	3752.96
Armor Company to Training Area	4	32	10339.8	1220101	1	44	113	1477.1	1477.1	2954.24
Armor Battalion to Training Area	2	8	11819.5	1031746	2	71	46	492.5	492.5	984.96
Composite Battalion to Training Area	2	8	11819.5	898037	2	71	46	492.5	492.5	984.96
Infantry Company to Firing Range	4	16	8558.4	359453	1	69	89	1141.1	1141.1	2282.24
TOW Company to Firing Range	4	4	1711.7	37657	1	69	23	285.3	285.3	570.56
Infantry Company to Training Area	4	16	5169.9	209012	1	44	57	738.6	738.6	1477.12
TOW Company to Training Area	4	4	1477.1	31758	1	44	15	184.6	184.6	369.28
Infantry Battalion to Training Area	3	4	10711.4	397801	2	71	35	369.4	369.4	738.72
Cavalry Troop to Firing Range	4	4	2852.8	119818	1	69	23	285.3	285.3	570.56
Cavalry Troop to Training Area	4	4	2694.0	109269	1	58	19	215.5	215.5	431.04
Engineer Company to Training Area	6	6	831.1	79597	1	24	18	184.7	184.7	369.36
155mm FA Battery to Firing Range	2	12	0.0	0	1	0	0	0.0	0.0	0
155mm FA Battery to Artillery Range	2	12	2249.5	88943	1	62	30	346.1	346.1	692.16
155mm FA Battalion to Artillery Range	4	4	5421.9	201649	1	62	20	230.7	230.7	461.44
8" FA Battery to Firing Range	2	4	0.0	0	1	0	0	0.0	0.0	0
MLRS Battery to Firing Range	2	2	0.0	0	1	0	0	0.0	0.0	0
8" FA Battery to Artillery Range	2	4	807.5	33685	1	62	10	115.4	115.4	230.72
MLRS Battery to Artillery Range	2	2	374.9	16554	1	62	5	57.7	57.7	115.36
8" FA Battalion to Artillery Range	4	2	2768.6	122743	1	62	10	115.4	115.4	230.72
Vulcan Battery to Artillery Range	4	4	1961.1	51220	1	62	20	230.7	230.7	461.44
Chaparral Battery to Artillery Range	4	4	1961.1	48451	1	62	20	230.7	230.7	461.44
Vulcan Battery to Training Area	2	4	1046.5	27333	1	71	12	123.1	123.1	246.24
Chaparral Battery to Training Area	2	4	1046.5	25855	1	71	12	123.1	123.1	246.24
TOTAL ALL UNITS AND MISSIONS			100634.9	6775119			764	9315.9	9315.9	18631.8

Average Train Length	10.8
Average Mileage per Train	12.2
Average Tonnage per Train	727.3

TABLE E-5.

ANNUAL RAIL MILEAGE - WEST LINE TO CURRY

Unit and Mission Type	Missions per Year	Units on Post	- Railcar - Mileage	Ton-Miles	Trains per Unit	Percent by Rail	Total Trains	- Locomotive Mileage - Loaded	Deadhead	Total
Armor Company to Firing Range	4	32	9379.8	1039990	1	55	141	1172.5	1172.5	2344.96
Armor Company to Training Area	4	32	12803.8	1510853	1	67	172	1829.1	1829.1	3658.24
Armor Battalion to Training Area	2	8	13294.1	1160462	2	86	56	553.9	553.9	1107.84
Composite Battalion to Training Area	2	8	13294.1	1010073	2	86	56	553.9	553.9	1107.84
Infantry Company to Firing Range	4	16	9000.0	378000	1	81	104	1200.0	1200.0	2400
TOW Company to Firing Range	4	4	1800.0	39600	1	81	26	300.0	300.0	600
Infantry Company to Training Area	4	16	6401.9	258820	1	67	86	914.6	914.6	1829.12
TOW Company to Training Area	4	4	1829.1	39326	1	67	22	228.6	228.6	457.28
Infantry Battalion to Training Area	3	4	12047.8	447429	2	86	42	415.4	415.4	830.88
Cavalry Troop to Firing Range	4	4	3000.0	126000	1	81	26	300.0	300.0	600
Cavalry Troop to Training Area	4	4	3160.0	128170	1	77	25	252.8	252.8	505.6
Engineer Company to Training Area	6	6	2922.5	279909	1	95	69	649.4	649.4	1298.88
155mm FA Battery to Firing Range	2	12	0.0	0	1	0	0	0.0	0.0	0
155mm FA Battery to Artillery Range	2	12	2876.6	113738	1	94	46	442.6	442.6	885.12
155mm FA Battalion to Artillery Range	4	4	6933.4	257865	1	94	31	295.0	295.0	590.08
8" FA Battery to Firing Range	2	4	0.0	0	1	0	0	0.0	0.0	0
MLRS Battery to Firing Range	2	2	0.0	0	1	0	0	0.0	0.0	0
8" FA Battery to Artillery Range	2	4	1032.6	43076	1	94	16	147.5	147.5	295.04
MLRS Battery to Artillery Range	2	2	479.4	21169	1	94	8	73.8	73.8	147.52
8" FA Battalion to Artillery Range	4	2	3540.5	156961	1	94	16	147.5	147.5	295.04
Vulcan Battery to Artillery Range	4	4	2507.8	65499	1	94	31	295.0	295.0	590.08
Chaparral Battery to Artillery Range	4	4	2507.8	61958	1	94	31	295.0	295.0	590.08
Vulcan Battery to Training Area	2	4	1177.1	30743	1	86	14	138.5	138.5	276.96
Chaparral Battery to Training Area	2	4	1177.1	29081	1	86	14	138.5	138.5	276.96
TOTAL ALL UNITS AND MISSIONS			111165.6	7198722			1032	10343.8	10343.8	20687.5

Average Train Length	10.7
Average Mileage per Train	10.0
Average Tonnage per Train	695.9

TABLE E-6.

ANNUAL RAIL MILEAGE - WEST LINE TO CRITTENBERGER

Unit and Mission Type	Missions per Year	Units on Post	- Railcar - Mileage	Ton-Miles	Trains per Unit	Percent by Rail	Total Trains	- Locomotive Mileage - Loaded	Deadhead	Total
Armor Company to Firing Range	4	32	18647.0	2067491	1	55	141	2330.9	2330.9	4661.8
Armor Company to Training Area	4	32	16074.2	1896760	1	53	136	2296.3	2296.3	4592.6
Armor Battalion to Training Area	2	8	15913.0	1389069	2	71	46	663.0	663.0	1326.1
Composite Battalion to Training Area	2	8	15913.0	1209053	2	71	46	663.0	663.0	1326.1
Infantry Company to Firing Range	4	16	8980.8	377194	1	69	89	1197.4	1197.4	2394.9
TOW Company to Firing Range	4	4	1796.2	39516	1	69	23	299.4	299.4	598.7
Infantry Company to Training Area	4	16	8037.1	324929	1	53	68	1148.2	1148.2	2296.3
TOW Company to Training Area	4	4	2296.3	49371	1	53	17	287.0	287.0	574.1
Infantry Battalion to Training Area	3	4	14421.1	535571	2	71	35	497.3	497.3	994.6
Cavalry Troop to Firing Range	4	4	2993.6	125731	1	69	23	299.4	299.4	598.7
Cavalry Troop to Training Area	4	4	3866.0	156805	1	62	20	309.3	309.3	618.6
Engineer Company to Training Area	6	6	1119.4	107216	1	24	18	248.8	248.8	497.5
155mm FA Battery to Firing Range	2	12	0.0	0	1	0	0	0.0	0.0	0.0
155mm FA Battery to Artillery Range	2	12	3956.2	156420	1	78	38	608.6	608.6	1217.3
155mm FA Battalion to Artillery Range	4	4	9535.4	354634	1	78	25	405.8	405.8	811.5
8" FA Battery to Firing Range	2	4	0.0	0	1	0	0	0.0	0.0	0.0
MLRS Battery to Firing Range	2	2	0.0	0	1	0	0	0.0	0.0	0.0
8" FA Battery to Artillery Range	2	4	1420.2	59241	1	78	13	202.9	202.9	405.8
MLRS Battery to Artillery Range	2	2	659.4	29113	1	78	7	101.4	101.4	202.9
8" FA Battalion to Artillery Range	4	2	4869.1	215864	1	78	13	202.9	202.9	405.8
Vulcan Battery to Artillery Range	4	4	3449.0	90079	1	78	25	405.8	405.8	811.5
Chaparral Battery to Artillery Range	4	4	3449.0	85210	1	78	25	405.8	405.8	811.5
Vulcan Battery to Training Area	2	4	1409.0	36799	1	71	12	165.8	165.8	331.5
Chaparral Battery to Training Area	2	4	1409.0	34810	1	71	12	165.8	165.8	331.5
TOTAL ALL UNITS AND MISSIONS			140213.7	9340875			832	12904.6	12904.6	25809.2

Average Train Length	10.9
Average Mileage per Train	15.5
Average Tonnage per Train	723.8

TABLE E-7.

ANNUAL HET MILEAGE - EXPANDED EXISTING HET ALTERNATIVE

Unit and Mission Type	Units on Post	Total HET Lifts	- HET Mileage by Category - 50+ Ton Vehicles	<50 Ton Vehicles	Deadhead Mileage	Total HET Mileage
Armor Company to Firing Range	32	3072	20587.7	2129.8	22717.4	45434.9
Armor Company to Training Area	32	2688	30401.3	0.0	30401.3	60802.6
Armor Battalion to Training Area	8	1536	17469.6	1807.2	19276.8	38553.6
Composite Battalion to Training Area	8	1512	13252.8	5722.8	18975.6	37951.2
Infantry Company to Firing Range	16	960	0.0	9499.2	9499.2	18998.4
TOW Company to Firing Range	4	0	0.0	0.0	0.0	0.0
Infantry Company to Training Area	16	832	0.0	9409.9	9409.9	18819.8
TOW Company to Training Area	4	0	0.0	0.0	0.0	0.0
Infantry Battalion to Training Area	4	960	0.0	12048.0	12048.0	24096.0
Cavalry Troop to Firing Range	4	0	0.0	0.0	0.0	0.0
Cavalry Troop to Training Area	4	0	0.0	0.0	0.0	0.0
Engineer Company to Training Area	6	0	0.0	0.0	0.0	0.0
155mm FA Battery to Firing Range	12	0	0.0	0.0	0.0	0.0
155mm FA Battery to Artillery Range	12	0	0.0	0.0	0.0	0.0
155mm FA Battalion to Artillery Range	4	0	0.0	0.0	0.0	0.0
8" FA Battery to Firing Range	4	0	0.0	0.0	0.0	0.0
MLRS Battery to Firing Range	2	0	0.0	0.0	0.0	0.0
8" FA Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
MLRS Battery to Artillery Range	2	0	0.0	0.0	0.0	0.0
8" FA Battalion to Artillery Range	2	0	0.0	0.0	0.0	0.0
Vulcan Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
Chaparral Battery to Artillery Range	4	0	0.0	0.0	0.0	0.0
Vulcan Battery to Training Area	4	0	0.0	0.0	0.0	0.0
Chaparral Battery to Training Area	4	0	0.0	0.0	0.0	0.0
TOTAL ALL UNITS AND MISSIONS		11560	81711.4	40616.9	122328.2	244656.5

APPENDIX F. DATA SOURCES FOR UNIT COST ESTIMATES

F.1 TRACKED VEHICLE OPERATING AND DEPRECIATION COSTS

Fuel and Parts -- M1 Tank

	SDC*	TACOM**	Fort Hood***
Fuel	$5.18/mile	$7.80/mile	$6.58/mile
Parts (OMA Account)	$26.52/mile	$58.26/mile	$76.18/mile

*Source: PECO Enterprises, "Sample Data Collection Report," 20 December 1985. These are actual data from one tank battalion at Fort Hood. These figures represent the cost of parts actually used in repairing the M1 tanks belonging to that battalion. They do not include parts ordered for spares (which the TACOM and "Fort Hood" numbers do), parts used in depot maintenance (none do), nor parts charged to the procurement account (none do). It is not known whether the cost of parts ordered for spares would account for the wide difference between the SDC and TACOM numbers.

**Source: TACOM, "Baseline Cost Estimate," 30 April 1985. The TACOM figures represent the average annual cost for a 20-year life of the tank, based on 850 miles per year. The TACOM number (as does SDC) includes DOL maintenance parts, but the Fort Hood number does not. Actual DOL maintenance parts charged to the units adds only about $0.95/mile to the parts cost, however. The TACOM and Fort Hood numbers should be comparable in other respects.

***Source: FORSCOM, "Cost Factor Handbook," July 1985. Phone conversations were held with various individuals regarding the possible reasons for the differences between the Fort Hood and TACOM parts cost. Potential causal factors identified included:

- mileage differences (TACOM - 850 versus Fort Hood - 1130);
- type of terrain over which tanks operate;
- Fort Hood dust;
- spare parts stockpiled;
- weapons system designator code errors.

TABLE F-1.
TACOM BASELINE COST ESTIMATE -- BASIC M1 TANK
(1986 Constant Dollars)

CATEGORY		COST/VEHICLE
5.0	Sustainment	
5.01	Replenishment Spares	
5.011	OMA/ASF Repair Parts*	$58.258/mile
5.012	Procurement Spares*	$25.377/mile
5.02	POL	$7.80/mile
5.04	Depot Maintenance	
5.041	Depot Maintenance - Civilian Labor	
5.0411	Depot Maintenance - Civ Labor (Veh)	$7,672/year
5.0412	Depot Maintenance - Civ Labor (Comp)*	$6,788/year
5.042	Depot Maintenance - Materiel (OMA)	
5.0421	Depot Maintenance - Materiel (Veh)	$18,498/year
5.0422	Depot Maintenance - Materiel (Comp)*	$16,378/year
5.043	Depot Maintenance - Materiel (Proc)	$6,380/year
5.044	Depot Maintenance Support Activity	$1,874/year
5.06	Transportation	
5.061	Vehicle Transportation	$625/year
5.062	Component Transportation	$146/year
5.063	Other Transportation	$32/year
5.08	Military Personnel	
5.082	Maintenance Pay and Allowances	$19,316/year

Using the TACOM figure of 850 miles per tank per year, the following costs are derived:

5.01	Replenishment Spares	$83.63/mile
5.02	POL	7.80/mile
5.04	Depot Maintenance	67.75/mile
5.06	Transportation	0.95/mile
5.08	Military Personnel	22.72/mile
		$182.85/mile
5.081	Crew Pay (4 per tank)	$73.28/mile

*Automotive Portion Only

TABLE F-2.
TACOM BASELINE COST ESTIMATE -- M2/M3 LIGHT COMBAT VEHICLES
(1986 Constant Dollars)

CATEGORY		COST/VEHICLE
5.0	Sustainment	
5.01	Replenishment Spares	
5.011	OMA/ASF Repair Parts*	$36.703/mile
5.012	Procurement Spares**	$4.767/mile
5.02	POL	$1.605/mile
5.04	Depot Maintenance	
5.041	Depot Maintenance - Civilian Labor	
5.0411	Depot Maintenance - Civ Labor (Veh)	$5,931/year
5.0412	Depot Maintenance - Civ Labor (Comp)**	$2,287/year
5.042	Depot Maintenance - Materiel (OMA)	
5.0421	Depot Maintenance - Materiel (Veh)	$12,206/year
5.0422	Depot Maintenance - Materiel (Comp)**	$8,506/year
5.043	Depot Maintenance - Materiel (Proc)	$0
5.044	Depot Maintenance Support Activity	$5,460/year
5.06	Transportation	
5.061	Vehicle Transportation	$479/year
5.062	Component Transportation	$34/year
5.063	Other Transportation	$920/year
5.08	Military Personnel	
5.082	Maintenance Pay and Allowances	$14,709/year

Using the TACOM figure of 850 miles per tank per year, the following costs are derived:

5.01	Replenishment Spares	$41.47/mile
5.02	POL	1.61/mile
5.04	Depot Maintenance	40.46/mile
5.06	Transportation	1.69/mile
5.08	Military Personnel	17.30/mile
		$102.53/mile

Total Unit Costs -- Basic M1 Tank and M2/M3 Light Combat Vehicles

Baseline cost estimates prepared by TACOM are presented in Tables F-1 and F-2. These estimates are for the continental US. Where possible, automotive costs have been separated from non-automotive costs.

Only some costs are based on field data. Others are based on engineering estimates, specifications, or budgetary data.

Costs per mile are based on 850 miles per tank per year, and on a 20-year life cycle for tanks. Costs are average annual costs for the 20-year period in current (1986) dollars.

Initial Purchase Price of Tracked Vehicles

Source: Conversation with Michael Johnson, Ft. Hood
  Basic M1 Tank -- $1,817,000.
  M2/M3 Light Combat Vehicle -- $1,497,312.

F.2 HEAVY EQUIPMENT TRANSPORTER (HET) CAPITAL COSTS

Assumed cost for study: $160,000 for the tractor and $100,000 for the semi-trailer.

Source: Conversation with Mr. Ochap, TACOM.
  Tractor/Model M911 -- $160,000 (estimated cost of purchasing a new tractor; the last purchase was in 1977.
  Trailer/Model XM1000 (prototype) -- >$100,000. (The XM1000 trailer will be the replacement for the M747 trailer, which is obsolete. The M747 generates excessive axle loads when carrying an M1 tank, and its four adjacent fixed axles caused cornering problems which resulted in broken axles and blown tires. The new trailer will have greater load capacity and steerable axles.)

Source: Conversation with Col. Page, TACOM.
  Tractor/Model M911 -- $166,000.
  Trailer/Model M747 -- $75,000.

Source: Conversation with Lee Washington, TACOM
  Tractor/Trailer Combination -- $259,000.

F.3 HEAVY EQUIPMENT TRANSPORTER (HET) OPERATING COSTS

Military Staffing of Division HET Companies

Military staffing requirements for a division-based HET company at Ft. Hood were derived from the most recent MTOE for the 96th Transportation Company, and were scaled down to a level consistent with a primary mission being the on-post transportation of tracked vehicles. Table F-3.1 presents a position-by-position comparison of the full HET authorization and that proposed for a division HET company.

Commercial Hauler Operation

In the commercial hauler alternative, it was assumed that the Army would contract with a commercial company to provide the equipment and personnel to perform the required heavy tracked vehicle transportation service. A multi-year contract was deemed necessary to attract sufficient contractor interest and a lower annual cost contract. However, in order to keep the cost within reasonable bounds, changes would have to be made in the manner in which field exercises are scheduled. The ideal situation would be a schedule which required the movement of the same number of heavy tracked vehicles to training areas each day. This would maximize the utilization of HET equipment and minimize the cost to the Army. It is recognized that this is not possible due to the varied training requirements of the units on Post. However, the scheduling goal would be to come as close as possible to this ideal, while not imposing undue inconvenience on the units.

Since a schedule of training moves developed to optimize the use of commercial transporters was not available, the approach taken in this analysis was to establish a fixed vehicle requirement based on a reasonable number of heavy tracked vehicles to be moved in one direction in a half-day segment. The number selected was one battalion size move and one company size move. This would require 42 transport units making two round trips in a morning or afternoon period. It is recognized that not all 42 transporters would be needed each day.

In order to estimate the cost of providing the transport service, a number of assumptions had to be made concerning heavy tracked vehicle movements and operational considerations. These assumptions are listed below.

- o Heavy tracked vehicle movements to training areas would be scheduled to utilize the transporters as efficiently as is practical;
- o A maximum of 84 heavy tracked vehicle movements in one direction would be scheduled in any single morning or afternoon period;
- o Heavy tracked vehicle movements would be spread over six days per week, if necessary, to keep the peak load within the upper bound;

TABLE F-3.1
PROPOSED STAFFING FOR A DIVISION-BASED HET COMPANY

Description	Gr	Salary & BAS	Authorized in MTOE	Proposed in Study
Company Headquarters				
Company Commander	03	30,900	1	1
First Sargent	E8	26,400	1	1
Food Service Sargent	E7	22,900	1	0
Truckmaster	E7	22,900	1	1
Assistant Truckmaster	E6	19,300	1	0
First Cook	E6	19,300	1	0
Supply Sargent	E6	19,300	1	0
First Cook	E5	16,200	1	0
Unit Clerk	E5	16,200	1	1
NBC Operations Officer	E5	16,200	1	0
Armorer	E4	13,700	1	0
Cook	E4	13,700	2	0
Dispatcher	E4	13,700	2	1
CBT Signaler	E4	13,700	1	0
Vehicle Driver	E4	13,700	1	1
Cook	E3	11,500	1	0
Supply Specialist	E3	11,500	1	1
			----	----
			19	7
Maintenance Section				
Auto Maintenance Technician	WO	25,000	1	1
Motor Sargent	E7	22,900	1	1
Heavy Vehicle Mechanic	E5	16,200	2	1
Recovery Vehicle Operator	E5	16,200	1	0
Equipment Maintenance Clerk	E4	13,700	1	1
Vehicle Driver	E4	13,700	3	1
Welder	E4	13,700	1	1
Heavy Vehicle Mechanic	E4	13,700	3	1
Heavy Vehicle Mechanic	E3	11,500	3	1
POL Clerk	E3	11,500	1	1
Recovery Vehicle Operator	E3	11,500	1	1
			----	----
			18	10
Truck Platoon Headquarters				
Platoon Leader	02	26,600	3	1
Platoon Sargent	E7	22,900	3	1
Assistant Platoon Sargent	E6	19,300	3	1
Vehicle Driver	E4	13,700	3	1
			----	----
			12	4

TABLE F-3.1 (Continued)

Description	Gr	Salary & BAS	Authorized in MTOE	Proposed in Study
Truck Squads				
Squad Leader	E6	19,300	6	3
Heavy Vehicle Driver	E6	19,300	6	3
Heavy Vehicle Driver	E5	16,200	18	9
Heavy Vehicle Driver	E4	13,700	24	11
Assistant Vehicle Driver	E3	11,500	48	22
			----	----
			102	48
			=====	=====
COMPANY TOTAL			151	69

Staffing Summary by Grade

Grade	Salary & BAS	Authorized in MTOE Number	Authorized in MTOE Cost	Proposed in Study Number	Proposed in Study Cost
03	30,900	1	30,900	1	30,900
02	26,600	3	79,800	1	26,600
WO	25,000	1	25,000	1	25,000
E8	26,400	1	26,400	1	26,400
E7	22,900	6	137,400	3	68,700
E6	19,300	18	347,400	7	135,100
E5	16,200	24	388,800	11	178,200
E4	13,700	42	575,400	18	246,600
E3	11,500	55	632,500	26	299,000
		-----	----------	-----	----------
		151	2,243,600	69	1,036,500
fringe benefits @40%			897,400		414,600
			===========		===========
TOTAL SALARY & FRINGE BENEFITS			3,141,000		1,451,100

- o Use of transporters in excess of 8 hours per day would be minimized;
- o Transporters are assumed to be able to make 2 round trips to or from training areas per morning or afternoon period;
- o A fleet of 42 tractor/trailer combinations plus 2 spares would be required to provide the maximum transport service;
- o Drivers would work a 40 hour regular week and would average 8 hours a week of overtime;
- o One day round trips to training areas would not be accomplished using heavy tracked vehicle transporters;
- o All bridges, except over Owl Creek, are assumed to accept transporter axle loadings of equal magnitude to those now experienced with military HETs carrying M1A1 tanks;
- o A contract for heavy tracked vehicle transportation would have a three year duration;
- o Work schedules could vary on a weekly basis, but would be scheduled at least 2 weeks in advance;
- o Heavy tracked vehicles being transported to training areas would have preference in the morning; heavy tracked vehicles being transported from training areas would have preference in the afternoon;
- o Space for the contractor's truck storage, truck maintenance, and administrative offices would be furnished by Ft. Hood;

Based on the above assumptions, the estimated annual cost of personnel, transporter operations, and equipment over the three year duration of the contract is contained in Table F-3.2. This estimate should be considered conservative, although it falls within the range of estimates provided by commercial haulers contacted in the investigation of this alternative. Three companies supplied rough estimates of service costs on the basis of the assumptions outlined above. All were between $4 and $5 million per year.

For purposes of this analysis, the cost of equipment was accounted for by an annual depreciation and opportunity cost charge. Depreciation was estimated at $0.45 per mile for the tractor based upon a purchase price of $90,000 and an estimated useful life of 200,000 miles, and $0.38 per mile for the trailer based upon a purchase price of $75,000 and an estimated life of 200,000 miles. The annual opportunity cost of the money used to purchase the equipment was calculated using the percentage of the remaining lifetime of each piece of equipment and a discount rate of 7 percent. It was assumed that 2 spare tractors and trailers would be needed.

TABLE F-3.2
ESTIMATE OF ANNUAL COST FOR COMMERCIAL TRANSPORTER

Personnel Cost

1	manager	$45,000
1	chief of transportation	40,000
1	dispatcher	35,000
42	drivers	1,470,000
1	chief of maintenance	40,000
8	mechanics	280,000
1	radio repairman	32,000
1	clerk	25,000
		$1,967,000

Operations Cost

$3.94 X 475,893 = $1,875,402

Equipment

Depreciation of tractors: $\frac{\$90{,}000}{200{,}000 \text{ mi}}$ X 475,893 miles = $214,151/year

Depreciation of trailers: $\frac{\$75{,}000}{200{,}000 \text{ mi}}$ X 475,893 miles = $178,459/year

Opportunity cost for tractors:

$$\$90{,}000 \times [1 - \frac{475{,}893}{44 \times 200{,}000}] \times .07 \times 44 = \$262{,}210/\text{year}$$

Opportunity cost for trailers:

$$\$75{,}000 \times [1 - \frac{475{,}893}{44 \times 200{,}000}] \times .07 \times 44 = \$218{,}508/\text{year}$$

Total depreciation and opportunity cost: $873,328/year

Annual Cost

The above estimates total as follows:

Personnel	$1,967,000
Operations	1,875,018
Equipment	873,328
	$4,715,346
Profit (8%)	377,228
	$5,092,574

No readily available information was uncovered during this study concerning the cost of operating a commercial HET tractor/trailer unit. Consequently, an estimate of the operational cost was developed using the military HET unit costs for replenishment spares and POL. This total was $3.94 per mile.

There are a number of reasons why the actual cost of this alternative would be lower than the conservative estimate outlined in Table F-3.2. First, the purchase price used for tractors was the highest of the prices quoted by tractor manufacturers and commercial haulers contacted. One manufacturer claimed that a tractor with a special rear axle was necessary to carry the M1A1 tank. Others felt that a lesser tractor, costing in the range of $50,000, would be adequate. Without an engineering assessment of tractor requirements, the higher figure was used for estimating equipment cost. If a less costly tractor would suffice, the depreciation and opportunity cost charges would be lower.

Another possibility for cost reduction would be to purchase used equipment. If available, used tractors and trailers could be purchased for one-third to one-half the cost of new equipment. However, used equipment was not employed in the cost calculations because the availability of sufficient used equipment was not investigated and therefore is unknown.

One of the commercial haulers proposed using owner-operators who would supply their own tractors and would be responsible for maintaining them. These operators would be guaranteed a flat rate of $200 per day, regardless of the number of hours worked, for a certain number of days per year. Additional days would be at the same rate. Under this approach, scheduling would be much more flexible since union workrules would not be applicable. Use of owner-operators almost certainly would be less expensive than the approach used in this analysis, since maintenance of the tractors is included in the flat rate figure.

The operating cost per mile used for tractor/trailer units was based on the unit costs for military HETs. Since military HETs are intended to be used in a theater of combat, they have additional requirements that would not be necessary for routine on-post operation. These added requirements almost certainly make the operational cost of the HETs higher than the operational costs of the equipment that a contractor would provide. Consequently, operating cost of commercial service would likely be lower than that in Table F-3.2.

Another potential cost saving measure would be for the Army to supply the fuel for the transporters. The Army should be able to procure fuel at a lower price than a contractor would charge. The POL component of HET operations cost would be about $740,000 for the amount of service to be provided.

Even though there are several ways in which costs can be reduced, the prime method of reducing costs would be to reduce the number of transporters required. Potential service providers felt that fewer transporters would be needed than the 42 assumed necessary in this analysis. Efficiency would be greatly improved if a lesser amount of equipment would suffice, since 42 transporters would not be needed on a daily basis and the Army would be paying for capacity not being used. Although there may be flexibility in using some transporters on Saturdays and Sundays instead of midweek (union work rules might make this difficult without paying overtime), there would still be excess capacity on some days. Reducing the number of transporters to 30 would reduce the cost by about 25 to 30 percent. However, the provision of fewer transporters would mean that moves to training areas would take longer. Depending on the number of transporters provided, it would take three or more trips (at 2 1/2 hours per trip) to move a battalion's heavy equipment instead of the two trips assumed for this cost estimate. If lengthier moves would be acceptable, substantial cost reduction would be possible. A reduction in the number of transporters required also might be possible by efficient scheduling. For example, movement of a battalion could be accomplished in two trips with 35 transporters as long as no other troop components had to be moved during the same time period. In order to determine precisely how many transporters would be required, a complete schedule of training moves would have to be developed which would minimize the number of transporters required, while being operationally feasible and acceptable to troop commanders.

Unit Cost Estimates

Source: Conversation with Lee Washington, TACOM (1981 TACOM study based on 15 HETs, factored to 1986 costs).

Replenishment spares --	$2.38/mile
POL --	1.56/mile
Maintenance (civilian labor) --	2.18/mile
Transportation --	0.15/mile
Maintenance (military labor) --	0.71/mile

	6.98/mile
Crew Pay	3.54/mile

Total	10.52/mile

Source: Conversation with Capt. Marshall, Ft. Hood (Partial Estimate FY85).
M911 Tractor organizational parts cost -- $184,000
M911 Tractor direct support parts cost -- $289,000.
Tractor mileage -- 93,640.

Parts cost per mile -- $289,000/93,640 miles = $3.08/mile DS parts.
-- $184,000/93,640 miles = $1.96/mile Org. parts.

F.4 RAIL CAPITAL COSTS

Locomotives

Assumed cost for study: $250,000 for rebuilt 3600 horsepower locomotives.

Source: Conversation with A.T. Newfell, Transportation Systems Center (TSC).
New 3600 horsepower locomotive -- $1,600,000.
Used 3600 horsepower locomotive -- $250,000 with complete rebuild.

Source: Conversation with Mr. Gounley, Chief of Rail Fleet Division, Military Traffic Management Command (MTMC).
New 3600 horsepower locomotive -- "well over $1,000,000."
New 2000 horsepower locomotive -- $850,000.
Used 2000 horsepower locomotive (15 years old, in generally good shape) -- $75,000-90,000.
Useful life of a locomotive -- 25 years at 200,000 miles per year.

Source: Conversation with Daniel Dornan, Peat, Marwick, Mitchell & Co. (PMM&Co.).
Used 3600 horsepower locomotive -- $250,000 with complete rebuild.

Source: Load/Speed/Grade Table, Product Application Section, Electro-Motive Division, General Motors, La Grange, Illinois
On a 1.75% grade, a 3600 HP locomotive (SD 45) can pull a maximum trailing load of 1906 tons on a continuous basis; higher loads can be carried for short periods of time, i.e., 2165 tons for 15 minutes. On this basis, two 3600 HP locomotives would be unable to pull a fully loaded 40-car train weighing 5,600 tons up a 1.75% grade. Three locomotives would be required. Two locomotives would be required for a 2,800 ton load, or a 20-car train.

DODX Flatcars

Assumed cost for study: $90,000 per flatcar.

Source: Conversation with Mr. Gounley, Chief of Rail Fleet Division, Military Traffic Management Command (MTMC).
Cost of $90,000 per flatcar based on a mid-1984 contract for delivery of 324 cars by the end of 1985.

High Rail Pickup Trucks for Track Inspection and Repair

Assumed cost for study: $24,000 for 2 trucks.

Source: Conversation with Chip Hale, T.K. Dyer & Associates, Lexington, MA.
High rail set costs $5,000 each (plus the pick-up trucks). Trucks cost about $7,000 each.

Tools for Track Repair

Assumed cost for study: $10,000.

Source: Conversation with the President of Central States Railroad Service Co. in Iowa.
Basic tools -- rail drill @ $1,300; rail saw @ $1,300; vibrators @ $5,000; miscellaneous @ $2,000.

Source: Conversation with A.T. Newfell, Transportation Systems Center.
Tools -- $1,000 per 5 track miles.

F.5 RAIL OPERATING COSTS

Personnel

Assumed annual costs for study (based on step 3 of 5 for WS and WG employees, and step 4 of 10 for GS employees):

1 Yardmaster WS 7	@ $26,400	$ 26,400
3 Locomotive Engineers WG 9	@ $21,500	64,500
3 Switchmen/Brakemen WG 7	@ $19,600	58,800
3 Blocking/Bracing Inspector WG 9	@ $21,500	64,500
1 Heavy Equipment Mechanic WG 10	@ $22,300	22,300
1 Mechanic Assistant* WG 9	@ $21,500	21,500
2 Track Inspectors WG 9	@ $21,500	43,000
4 Track Laborers WG 5	@ $17,700	70,800
2 Clerk GS 4	@ $14,200	28,400
		$400,200
35 percent fringe:		140,070
		$540,270

*Also a qualified locomotive engineer.

Source: Conversation with Howard Croft, President of the American Short Line Railroad Association.
Operating personnel costs for short line railroad: locomotive engineer @ $12/hour; yardmaster/conductors/switchmen/brakemen/mechanics @ $10/hour; track crew foreman @ $9; track workers @ $5/hour; clerks @ $6.50.
Recommend 3-man train crews, 5-man track crew, 1 yardmaster, 1 mechanic, and 1 clerk.

Source: Conversation with Harry Scott, Transportation Officer, Fort Stewart.
For 2 locomotives--but generally only one in operation at any one time--they have the following personnel: 1 yardmaster; 1 engineer; 2 brakemen/switchmen; and 1 mechanic.

Source: Conversation with Mr. Bishop, Transportation School, Fort Eustis.
For 2 locomotives, they have the following personnel: 1 yardmaster; 2 engineers; 4 brakemen; and 1 mechanic.

Source: Conversation with the Transportation Officer, Fort Lewis.
For 2 locomotives--but generally only one in operation at any one time--they have the following personnel: 1 yardmaster; 2 engineers; 1 brakeman; and 1 mechanic.

Source: Conversation with Charles Austin, Transportation Oficer, Red River Army Depot.
For 3 locomotives--but generally only two in operation at any one time--they have the following personnel: 1 yardmaster; 3 engineers; 2 brakemen; 3 conductors; 2 maintenance personnel; and 1 clerk.

Source: Conversation with Peter Ward, Charles River Associates, Inc., Boston, MA (former short line operator).
For 50 miles of line, 360-day operations, and 2 locomotives, would recommend the following: 1 superintendant; 1 chief of transportation; 1 chief of maintenance; 1 clerk; 3 engineers; 3 switchmen; 1 mechanic; and 5 track maintainers.

Source: Conversation with the President of Central States Railroad Service Co. in Iowa.
Recommend 4-man track crew; $2,400/month for supervisor and $1,250/month for laborers.

Track Inspection

Assumed cost for study: $25,000/year for full loop. (Based on 50 miles x $400/mile + 4 setoffs @ $1,200).

Source: Conversation with A.T. Newfell, Transportation Systems Center.
Sperry rail car costs $300-500/mile plus $1,200 each time the car has to be moved off the track (setoff) to allow passage of a train.

Locomotive Inspection (Mobile Rail Team)

Assumed cost for study: $10,000 ($5,000 per locomotive) per year:

$ 100	-- initial inspection
1,100	-- follow-up inspection and repairs
2,700	-- per diem
400	-- parts
700	-- travel
$5,000	-- total cost per locomotive

Source: Conversation with Monroe Walker and Wade Roberts, TROSCOM.
Initial inspection -- 1 inspector ($12.50/hour); 4 hours/locomotive.
Follow-up inspection -- 4 people per team ($46/hour); average of 3 days per locomotive inspection and repair; $300-500 in parts for routine maintenance.

Operation of High Rail Trucks

Assumed cost for study: $4,000 ($2,000 per truck) per year. (Computed as follows, using $.20/mile:

50 miles/day x 360 days/year =	18,000	miles
additional mileage for track repairs =	2,000	miles
	20,000	miles/year).

Source: Conversation with Peter Ward, Charles River Associates, Inc., Boston, MA (former short line operator).
Lease of high rail pick-up trucks -- $500/month.
Operating cost of high rail pick-up trucks -- $.20/mile.

Fuel

Assumed cost for study: $120,320 per year for two locomotives. (Based on 52 weeks per year, $1/gallon, calculated as below:

South Ft. Hood	
150 moves of 2800 tons, averaging 17.5 miles (117 gal each) =	17,550 gal
900 moves of 1000 tons, averaging 10 miles (35 gal each) =	31,500 gal
350 moves of 300 tons (unloaded cars), averaging 10 miles (10 gal each) =	3,500 gal
700 moves of 200 tons (engine deadheading) averaging 10 miles (7 gal each) =	4,900 gal
	57,450 gal
North Ft. Hood	
100 moves of 1000 tons, averaging 14 miles (39 gal each) =	3,900 gal
100 moves of 200 tons (engine deadheading to South Ft. Hood overnight between moves), averaging 8 miles (7 gal each) =	650 gal
100 moves of 200 tons (engine deadheading to North Ft. Hood before and after moves), averaging 20 miles (9 gal each) =	900 gal
	5,450 gal
Idling	
14,400 hours at 4 gallons per hour =	57,600 gal
Total Fuel Consumption =	120,500 gal

Source: Material received from Don Oltmann, CONRAIL, Philadelphia
Assumptions used in calculations for fuel consumption for a 10 mile move using General Motors SD 45 locomotives: 8 miles of approximately level track; 1 mile of 2% upgrade and 1 mile of 1.5% downgrade; 1 mile of 10 degree curve; and maximum speed of 20 mph. Proportional increase for 17.5 mile move.

Source: Table - Electro-Motive Division, General Motors Corp., La Grange, Illinois, 3600 HP Model SD 45-2 locomotive.
SD 45-2 locomotive, fuel rate at idle -- 3.8 gallons/hour.

Source: Conversation with Howard Croft, President of the American Short Line Railroad Association.
Diesel fuel cost -- $1.11/gallon.

Source: Conversation with A.T. Newfell, Transportation Systems Center. Diesel fuel costs about $.869/gallon.

Materials, Supplies and Other Expenses

Assumed cost for study: $250 per year per railcar, $5000 per year per locomotive, $300 per year per track-mile.

Source: Conversation with Peter Ward, Charles River Associates, Inc., Boston, MA (former short line operator).
Materials and supplies cost is roughly equal to the direct cost of operating workers, excluding supervisors and back-up personnel. (With proposed staffing, this cost would be $216,400).

Source: Association of American Railroads, Railroad Facts, 1984 Edition.
Materials, supplies, and other expenses (includes: other materials and supplies and miscellaneous; equipment and joint facility rents; current taxes other than payroll and income taxes; and rent for leased equipment) in 1983 for all railroads were about 47 percent of total labor costs, including benefits. (With proposed staffing, this cost would be $218,400).

Potential Contract with Private Operator

Source: Discussions with several people revealed a consensus that a contract with a "short line" operator would be cheaper than operating with civilian, civil service personnel. A reduction of perhaps 20% in personnel expense might be realized. Other costs would be about the same. The major railroad officials contacted stated that they would be much more expensive than a short line operator.

Source: Dick Webb, President of WATCO, a switching operator located in Kansas. His estimate for operating the Ft. Hood rail system would be in the vicinity of $50,000 per month or $600,000 per year, exclusive of major track materials or parts for the railcars. This figure includes the furnishing of three locomotives (one as a spare) and all maintenance on the locomotives. Labor included in this estimate are 3 train crew personnel, 1 supervisor, 2 mechanics, and 2-3 track maintenance personnel. Track and railcar parts are estimated to be between $100,000 and $150,000 per year.

Source: Dr. Edwin Patton and Dr. John Langley, Jr., "Handbook for Preservation of Local Railroad Service," DOT-TST-77-34, January 1977. Calculation of a short line railroad operating cost for the Fort Hood situation using this report resulted in an operating cost of $516,000 in 1974 dollars. Applying "Railroad Facts, 1984 Edition" cost inflation factors from 1974 to 1983 would result in a 1983 total operating cost of

$1,278,000. In view of the age of this report and the long period over which the inflation factors would be applied, this was not deemed to be an accurate representation of current railroad costs.

F.6 RAIL CONSTRUCTION COSTS

Source: Robert M. Brown Associates and HDR Infrastructure, Inc., operating under contract to the Transportation Systems Center, prepared the following construction cost estimates for the Ft. Hood railroad. Design criteria were based on Federal Railroad Administration standards for a Class 2 railroad. Alignment of the mainline trackage and locations of railheads and sidings were developed with the objective of minimizing overall construction costs subject to recommendations and limitations proposed by Ft. Hood staff.

<u>Santa Fe Connector</u> (West Rail Segment to Santa Fe Railroad)

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
<u>Right-of-Way Preparation</u>				
Grading	229,683	CY	$2.75	$631,628
Drainage	1	LS	$50,000	50,000
<u>Mainline Trackage</u>				
Trackwork	17,600	FT	$85.75	1,509,200
Switches:				
#14	3	EA	$42,500	127,500
Range Road Crossings	7	EA	$3,000	21,000
Crossing Approaches	0.31	MI	$500,000	155,000
Tank Crossings	3	EA	$2,000	6,000
				============
TOTAL				$2,500,328

West Line Segment (South Ft. Hood Railhead to North Ft. Hood Railhead)

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Right-of-Way Preparation				
Grading	4,260,419	CY	$2.75	$11,716,152
Drainage	1	LS	$1,100,000	1,100,000
Mainline Trackage				
Trackwork	106,700	FT	$85.75	9,149,525
Range Road Crossings	21	EA	$3,000	63,000
Crossing Approaches	0.8	MI	$500,000	400,000
Tank Crossings	22	EA	$2,000	44,000
Bridges:				
House Creek	1,200	FT	$2,000	2,400,000
W.Cowhouse Creek	1,600	FT	$2,000	3,200,000
Henson Creek	600	FT	$2,000	1,200,000
Field Sidings				
Trackwork (3 sidings)	35,800	FT	$85.75	3,069,850
Switches:				
#14	6	EA	$42,500	255,000
# 9	12	EA	$27,850	334,200
Offloading Ramp	3	EA	$62,000	186,000
Lighting	3	LS	$70,000	210,000
Staging Area	3	LS	$30,000	90,000
Range Road Relocation	1.8	MI	$500,000	900,000
				============
TOTAL				$34,317,727

South Ft. Hood Railhead

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Grading	293,320	CY	$2.75	$806,630
Drainage	1	LS	$30,000	30,000
Trackwork	24,355	FT	$85.75	2,088,441
Switches:				
#14	2	EA	$42,500	85,000
# 9	10	EA	$27,850	278,500
Offloading Ramp	1	EA	$62,000	62,000
Lighting	1	LS	$100,000	100,000
Staging Area	1	LS	$30,000	30,000
Locomtive Service Pit	1	LS	$31,000	31,000
Range Road Relocation	0.53	MI	$500,000	265,000
				============
TOTAL				$3,776,571

North Ft. Hood Railhead

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Grading	19,202	CY	$2.75	$52,806
Drainage	1	LS	$10,000	10,000
Trackwork	16,900	FT	$85.75	1,449,175
Switches:				
#14	2	EA	$42,500	85,000
# 9	11	EA	$27,850	306,350
Offloading Ramp	1	EA	$62,000	62,000
Lighting	1	LS	$70,000	70,000
Staging Area	1	LS	$30,000	30,000
Range Road Crossings	6	EA	$3,000	$18,000
Crossing Approaches	0.01	MI	$500,000	5,000
				============
TOTAL				$2,088,331

Crittenberger Segment (North Ft. Hood to Crittenberger Siding)

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Right-of-Way Preparation				
Grading	1,452,761	CY	$2.75	$3,995,093
Drainage	1	LS	$400,000	400,000
Mainline Trackage				
Trackwork	29,000	FT	$85.75	2,486,750
Range Road Crossings	3	EA	$3,000	9,000
Crossing Approaches	0.22	MI	$500,000	110,000
Tank Crossings	5	EA	$2,000	10,000
Field Sidings				
Trackwork	12,000	FT	$85.75	1,029,000
Switches:				
#14	2	EA	$42,500	85,000
# 9	4	EA	$27,850	111,400
Offloading Ramp	1	EA	$62,000	62,000
Lighting	1	LS	$70,000	70,000
Staging Area	1	LS	$30,000	30,000
Range Road Relocation	1.2	MI	$500,000	600,000
				============
TOTAL				$8,998,243

Curry Segment (South Ft. Hood Railhead to Curry Siding)

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Right-of-Way Preparation				
Grading	2,170,852	CY	$2.75	$5,969,843
Drainage	1	LS	$500,000	500,000
Mainline Trackage				
Trackwork	45,800	FT	$85.75	3,927,350
Range Road Crossings	5	EA	$3,000	15,000
Crossing Approaches	0.11	MI	$500,000	55,000
Tank Crossings	12	EA	$2,000	24,000
Field Sidings				
Trackwork	11,300	FT	$85.75	968,975
Switches:				
#14	2	EA	$42,500	85,000
# 9	4	EA	$27,850	111,400
Offloading Ramp	1	EA	$62,000	62,000
Lighting	1	LS	$70,000	70,000
Staging Area	1	LS	$30,000	30,000
Range Road Relocation	3.0	MI	$500,000	1,500,000
				============
TOTAL				$13,318,568

Cowhouse Creek Segment (Curry Siding to Crittenberger Siding)

	NO. UNITS	UNIT MEAS.	COST PER UNIT	TOTAL COST
Right-of-Way Preparation				
Grading	1,768,391	CY	$2.75	$4,863,075
Drainage	1	LS	$450,000	450,000
Mainline Trackage				
Trackwork	38,500	FT	$85.75	3,301,375
Bridges:				
E. Cowhouse Creek	1,700	FT	$2,000	3,400,000
Range Road Crossings	3	EA	$3,000	9,000
Crossing Approaches	0.23	MI	$500,000	115,000
Tank Crossings	7	EA	$2,000	14,000
Range Road Relocation	0.7	MI	$500,000	350,000
				============
TOTAL				$12,502,450

Summary of Railroad Construction Costs by Segment

Railroad Segment	Total Cost
West Line Segment	$34,317,727
Santa Fe Connector	2,500,328
South Ft. Hood Railhead	3,776,571
North Ft. Hood Railhead	2,088,331
Crittenberger Segment	8,998,243
Curry Segment	13,318,568
Cowhouse Creek Segment	12,502,450
	=============
TOTAL RAILROAD CONSTRUCTION COSTS	$77,502,218

APPENDIX G. INSTRUCTIONS FOR USE OF COMPUTER PACKAGE FOR FORT HOOD TRANSPORTATION EVALUATION

The analysis package consists of a set of separate programs written in Basic that are linked to each other through a Main Menu, and a group of files. The program structure has three levels:

Main Menu	- a single program (called MENU) that permits selection of Submenus.
SubMenus	- eight separate programs (named FTHOD1 to FTHOD8), one for each line in the Main Menu, each containing a SubMenu and a set of Tables. A SubMenu and its Tables is referred to as a "section."
Tables	- Tables or spreadsheets that allow for data entry and display of results.

Menus may or may not display numerical information, but they only permit choices to be selected rather than allowing for entry of numerical information. Because the SubMenus (with their Tables) are separate computer programs, passing data and results among them requires storing the information on diskette or hard disc, and reading it back in. Some choices are offered at various points as to whether current data are saved or not.

SUBMENUS

The eight sections and their functions are briefly described in Table G-1. Notes on each section are explained below. Numbers in parentheses after headings in the report refer to table numbers in the computer program.

1. Descriptions of Alternatives. Other than a small amount of explanatory information, the only purpose of this table is to choose a label with which to describe the rail alternative being studied. This label is printed in all tables with rail data.

   Most data are stated relative to whatever base alternative is chosen (an exception is tracked vehicle roadmarch mileage to and from field areas). One alternative is always a HET and

TABLE G-1.
DESCRIPTION OF FORT HOOD ANALYSIS SUBPROGRAMS

Program Section	Inputs	Outputs	Function
1. Descriptions	none	automatic	Select name of rail alternative
2. Demand	automatic	automatic	Construct tracked vehicle inventory Enter tracked vehicle roadmarch mileages under three alternatives
3. Capital Expenditures	press I	[F1] save [F9] abort	Enter new capital (vehicle and facility) requirements
4. Tracked Vehicle Operation	"	"	Enter costs and cost rates
5. Transportation Systems Operation	"	"	Enter cost of HET and Rail operations
6. Right-of-Way Costs	"	"	Enter guideway maintenance costs
7. Other Benefits	"	"	Enter values for selected rail cost savings
8. Evaluation	"	none	Select evaluation parameters and calculate net benefits, etc.

one is always a rail; two rail alternatives, for example, cannot be evaluated at the same time.

2. <u>Vehicle Movements (Demand)</u>. Annual vehicle miles of travel for three classes of tracked vehicles, and tracked vehicle miles carred on HETs or on rail cars, are entered here. The number of tracked vehicles in each category is taken from the vehicle inventory, and the annual average per vehicle is calculated, so these numbers cannot be entered directly.

3. <u>Direct Capital Expenditures</u>. All "new" capital costs are entered in this section. Tables work forwards or backwards, depending upon where data are entered. Total fleet sizes must be determined, and the shares that are new purchases, but only new capital is given a dollar value in this section. Peak movements are for information only. Grading costs for the rail alternative must be separated, as these are assumed to have an infinite life, whereas track and structures are depreciated.

4. <u>Tracked Vehicle Operating Costs</u>. All avoidable automotive costs are entered here, whether for operation or for depot maintenance. Labor costs can be included and valued as preferred.

   Numbers of vehicles and average roadmarch miles are taken from previous tables, but can also be entered here. Doing so is likely to make the results inconsistent, and it is recommended that these values be changed at the source (section 2) rather than here. Scheduling and movement control costs should be entered as appropriate.

5. <u>Transportation Systems Operation</u>. Operating costs for all transportation equipment and depreciation for existing equipment are entered in this section. Mileage data are taken from previous sections and should not be changed unless the results are not saved.

6. <u>Right-of-Way Costs</u>. These are additional costs of operating the transportation systems, including opportunity costs for land.

7. <u>Other cost Savings and Benefits</u>. Four categories of additional rail benefits (other than reduction of tracked vehicle roadmarch mileage) can be added in here. The names of the categories are unimportant for evaluation purposes, but the "=" lines must be stated in annual terms and should be net of any non-tracked-vehicle HET benefits. Time savings and quality impacts are not currently enterable.

8. <u>Summary Evaluation Tables</u>. Initially, all previous results should be entered into this section. It is then possible to

subsequently go back and change only the table of evaluation parameters, if desired. The discount rate should not be set at zero, as it makes benefits infinitely large.

Measures of present value, B/C ratios, and other indicators are displayed by exiting [F1] from the SubMenu. These calculations depend upon the computations carried out in the HET- and Rail-base tables (8.1 and 8.2, but not the Rail-HET table, 8.3), so these tables should be screened first. After the third page of table 8.4, [F1] will return to the main menu and [F9] will return to the Evaluation SubMenu.

DATA INPUTS

For sections 3-8, data may be input at the user's option. If no data are input, the data files will be constructed fresh if the results from the section are saved. Input options are given according to three categories:

Data from other routines	- Basic data and parameters (average miles per track per year, cost rates, etc.) that appear in more than one section.
Specific parameters	- Data that pertain only to the section being operated. These data plus the previous are sufficient to determine all results for the section, but the results will not appear until each Table is looked at (the calculations are performed as the Table is entered).
Previous results	- Adding these inputs to the previous two categories covers all the numerical data used or produced by the section.

In the Summary Tables section, an additional input option appears on the input menu. This table contains parameters used in evaluation, which can be altered as desired. It must be explicitly read in each time the SubMenu is entered.

The first time the program is used, it is recommended that only the first data category be read in and that all files be written fresh. This will then make it clear which inputs and outputs are passed from section to section, and which ones are discretionary within each section. A complete set of results can be saved by copying all of the .DAT files to a another diskette or directory.

ENTERING DATA

In the Main Menu, up and down cursor keys will move the highlight to the various sections, and return or [enter] will call up the marked section. For SubMenus accepting inputs, typing "I" (or i) will call up a mini-menu for selecting input options as described above. Moving the cursor and touching [enter] will switch the options on and off. Exiting from the mini-menu [F1] will read in the inputs.

Tables can be selected from the SubMenus in the same way. Exit from the Tables (return to the SubMenu) or from the SubMenu (return to the Main Menu) is done with the [F1] key, plus the [F1] or [F9] key, as described below.

If a Table shows a highlighted number field, the highlight ("cursor") can be moved around and numbers entered at the marked location. Entry is completed by touching the return or [enter] key. Incorrect digits can be erased while entering using the backup key (except the first digit; if this is wrong, enter it and start over). If other numbers in the table are numerically related to the number entered, they will be recalculated immediately, as in a spreadsheet.

FILING DATA AND RESULTS

When leaving SubMenus 3-7, the user has the option of saving (with the [F1] key) or not saving (with the [F9] key) the results generated in that section. The option is exercised for these SubMenus after the exit key [F1] from the SubMenu is pressed and the summary table of results from that section is displayed.

PROCEDURES

Programs (with a .BAS extension) and files (with a .DAT) extension) must be housed in a subdirectory called FTHOD. With a hard disk, the subdirectory is created by typing

```
        MKDIR FTHOD
or      MD FTHOD
```

in response to the C> prompt, and copying all files into the subdirectory, e.g.,

```
COPY A:*.* FTHOD
```

The same procedures can be used to create a subdirectory on a floppy diskette and copy the programs and files into the floppy subdirectory.

Once the programs are installed, the Basic interpreter is called up with

```
BASICA FTHOD\MENU
```

which will load and run the Main Menu. Alternatively, this can be broken into three steps, by typing

```
BASICA
LOAD"FTHOD\MENU
RUN
```

In Basic, the [F2] key types RUN (including the [enter]) and [F3] types LOAD". If the Function Key line appears at the bottom of the screen, type KEY OFF.

For one reason or another, the display may get messed up, particularly while entering data. The first response should be to touch [enter], and, if that is not adequate, exit with [F1] and come back. If things are more badly messed up, it may be necessary to reload the main manu and go from there.

Colors (whether on a color monitor or B&W) can be altered by touching the [F2] key while the Main Menu is displayed, and entering the appropriate codes. Touching [F1] returns to the Main Menu.

Any of the sections can be loaded separately by typing

```
LOAD"FTHOD\FTHOD1
RUN
```

where the number on FTHOD is the line number in the Main Menu. The program can be interupted at any point with control-break or [CTRL][BREAK] held simultaneously; [CTRL][HOME] or CLS will then clear the screen. Program execution can be resumed with CONTINUE or GOTO 1036, or restarted with RUN.

EQUIPMENT

The programs run on an IBM compatible with DOS 2.0 or higher and at least 256K of core storage (RAM). One floppy drive or a hard disk plus floppy are needed. Screen graphics (an additional chip) are required to run the TNKCQ or TNKAT (for the IBM AT or equivalent) intro routines, and the exit [F1] routine from the Main Menu. Tables and menus can be printed while they are displayed by holding the shift key and touching the printscreen [PRTSC] key.

For assistance, contact Doug Lee, 617/494-2762 (FTS 837-2762).

APPENDIX H.

ESTIMATES INDEX FROM ORIGINAL FT. HOOD RAIL ANALYSIS

ESTIMATES INDEX

ESTIMATES

COST OF DRIVING TRACKED VEHICLES 300 MILES

Vehicle Code	Number of Vehicles		Cost Factor Per Mile		
M1	464	X	$82.36	=	$38,215.04
M2(J81750)	208	X	36.74	=	7,641.92
M3(C76335	133	X	36.74	=	4,886.42
M48	24	X	18.61	=	446.64
M88	90	X	26.58	=	2,392.20
M109	72	X	15.22	=	1,095.84
M110	24	X	25.87	=	620.88
M113	76	X	7.64	=	580.64
M163	24	X	28.32	=	679.68
M577	8	X	7.64	=	61.12
M578	4	X	15.64	=	62.56
AVLB(20414)	6	X	35.19	=	211.14
			Total per mile driven		$56,894.08
					X 300 miles
			Total per year		$17,068,224

Vehicle Code	Number of Vehicles		POL Cost Per Mile		
M1	464	X	$7.11	=	$3,299.04
M2(J81750)	208	X	.96	=	199.68
M3(C76335)	133	X	.96	=	127.68
M48	24	X	.88	=	21.12
M88	90	X	1.93	=	173.70
M109	72	X	.98	=	70.56
M110	24	X	.90	=	21.60
M113	76	X	.58	=	44.08
M163	24	X	.58	=	12.48
M577	8	X	.52	=	4.64
M578	4	X	.9~~7~~ ~~[illegible]~~	=	~~5.76~~
AVLB(20414)	6	X	.96(?)		5.76
			Total POL Costs/Mile		$3,984.22
					X 300 miles*
			Total POL Costs/Year		$1,195,266

Total Cost per year	$17,068,224
-Total POL Cost/year	1,195,266
Total Repair Parts/yr	$15,872,958

* A set miles driven was suggested by III Corps and Fort Hood, Comptroller. G3 felt that it might be low.

[NOTE: DIO combat vehicle associated total costs not included were:
- o Labor $2.1 million (FY84)
- o Repair Parts $4.5 million (FY84)]

ESTIMATES

RAILROAD TRACK MILEAGE	Chief, Roads and Railroads, DEH, estimated the following: • 45 miles of track following in close proximity to East, West, and South Range Roads. • 5 miles for sidings, "Y", and railheads. • 5 miles for spur to new DIO Complex.

ESTIMATES

TRACK CONSTRUCTION

- The following estimates were obtained:
  - $1,000,000/mile - Chief, Roads and Railroads, DEH.
  - $1,000,000/mile - Reserve Combat Engineer.
  - $1,000,000/mile - Estimator, Civil/Arch, DEH. (This was figuring $100/foot for track and a $500,000 bridge every mile.)
  - $2,376,000 - Fort Worth Districk, Corps of Engineers. (This was not an estimate for Fort Hood, but the consensus of three bids on 7,268' of track.)
  - $405,789/mile - Chief Engineer, Katy Railway. (This was the only itemized estimate that was obtained.)
- Justification of Estimate Used. There were four rought estimates of $1,000,000. The high figure of $2.376,000 was not an estimate of this track but only a consensus of bids for 1½ miles of track. The low figure was the only itemized estimate done. However, felt that number of major cuts, level of needed bed given to him were not accurate enough. The $1,000,000/mile figure was the highest realistic figure.

ESTIMATES

MAXIMUM LOAD REQUIREMENT

- The heavest load is an Armor Battalion going for maneuver. It takes:
  - 3 companies of its own
  - 1 company of infantry.
- Weight was calculated on the following:

• M1	44	X	59 Tons	=	2,596 Tons	
• M2	13	X	21 Tons	=	273	
• M3	6	X	21 Tons	=	126	
• M88	7	X	54 Tons	=	378	
• M113	4	X	10 Tons	=	40	
• M106/A2	6	X	11 Tons	=	66	
• M577	6	X	11 Tons	=	66	
	86					3,545 Tons

- With the assumption that each railcar will carry 2 vehicles and each railcar weighs 30 tons:

86 vehicles ÷ 2 = 43 railcars X 30 Tons = 1,290 Tons

TOTAL GROSS WEIGHT 4,835 Tons

ESTIMATES

LOCOMOTIVES

- The following estimates were obtained:

  - $800,000 for 135 Ton, 4 axle, 2,000-2,300 horsepower, 2,550 Ton gross pulling capacity - Chief Mechanical Officer, Katy Railway, Dallas, Texas.

  - $800,000 for 135 Tone, 4 axle, 2,000-2,300 horsepower, 2,550 Ton gross pulling capacity - Assistant Manager of Locomotive Maintenance and Performance, Atchison, Topeka, and Santa Fe Railway, Chicago, Illinois.

  - $50,000 - $75,000 for 135 Ton completely reconditioned locomotive with 15 years service life (Same service life as a new locomotive.) - Assistant Superintendent, Atchison, Topeka, and Santa Fe Railway, Temple, Texas.

  - $10,000 - $75,000 for 135 Ton reconditioned locomotive - Assistant Manager of Locomotive Maintenance and Performance, Atchison, Topeka, and Santa Fe Railway, Chicago, Illinois.

  - Equipment Specialist, AMC recommended getting TDA authorization for 2 new Alcos in cocoon storage within the Army system which have the following data:

    - Vintage - 1953
    - Original Cost - $210,000
    - Lin # - L 80769
    - Nomenclature - Locomotive diesel, 120-131 Ton
    - Stock number - 2210-00-814-5291
    - Accessory - Steam generator (For passenger car use).

ESTIMATES

BLOCK HEATERS	The estimate of $800 for block heaters was obtained from Equipment Specialist, AMC for a total investment of $1,600.

TANK TRAIL MAINTENANCE SAVINGS

Chief, Roads and Railroads, DEH, estimated the following:

- Blading of Tank Trails (4-5 times/year) (1/3 of cost saved <u>if</u> railroad is used.)

  $46/mile to Blade
  <u>X 45</u> miles
  $2070 saved/blading
  <u>X 4</u> times/year
  $8,280/year X 1/3 = $2,760/year

- Rehabilitation of Tank Trail (Every 2 - 3 years) (1/3 of cost saved <u>if</u> railroad is used.)

  $2,000/mile
  <u>X 45</u> miles
  $90,000/yr ÷ 3 years = $30,000/yr X 1/3 = $10.000/year

- Total Cost

  $ 2,760/yr for Blading
  <u>10,000</u>/yr for Rehabilitation
  $12,760/year saved on Tank Trail Maintenance

HET ALTERNATIVE

- Current HET strngth at Fort Hood is:
  - 22 - 13th SUPCOM
  - 8 - 1st Cav
  - 6 - 2nd AD
- HET strength by 1987 will probably be:
  - 24 - 1st Cav
  - 24 - 2nd AD
- Current population is not sufficient to support transportation of all Fort Hood units at this time.
- However, assuming that every vehicle that could be transported by HET was, the cost would be:
  - Vehicles that could be transported by HET's:

	Vehicle Code	Number of Vehicles		
	M1	464		
Bradley -	M2	208		
" -	M3	133		
	M88	90		
155 Howitzer -	M109	72		
8" Howitzer -	M110	24		
	M578	4		
	AVLB	6		HET cost factor
		1001	X 300 miles X 2 X $3.85	= $2,312,310

  - Vehicles that would have to be driven out:

	Vehicle Code	Number of Vehicles	Cost Factor		
	M48	24	X $18.61	=	$446.60
APC -	M113	76	X 7.64	=	580.64
APC -	M163	24	X 28.32	=	679.68
	M577	8	X 7.64	=	61.12
					$1768.04 X 300 mi =
					$530,412

Total HET Alternative **$2,842,722**

ESTIMATES

PERSONNEL

- The number and grades of the Railroad Maintenance crew were recommended by Chief, Roads and Railroads, DEH.

  - 4 Railraod Repairer, WG-5 @ $18,395* — $73,580

  - 1 Leaderman Railroad Repairer, WL-7 @ $23,135* — 23,135

- The number and grades of a train crew were recommended by Chief of Transportation and Chief, Material Movement, DIO. Two additional crews were added to enable train to work more than 8 hours per day.

  - 1 Railroad Yardmaster, WG-9 @ $25,894* — 25,894
  - 3 Locomotive Engineer, WG-9 @ $25,894* — 77,682
  - 3 Heavy Mobil Equipment Repairer, WG-9 @ $25,894* — 77,682
  - 3 Braker/Switcher, WG-7 @ $21,060* — 63,180

- The number and grade of personnel were recommended by Unit Movement, DEH.

  - 3 E6's @ $30,013** — 90,039
  - 3 E5's @ $25,330** — 75,990

- The number and grade of Inspector personnel were recommended by Operations, DEH.

  2 Blocking, Bracing Inspectors, WG-9 @ $25,894* — 51,788

Total Personnel Cost Increase — $558,970

* From 28 Oct 84 Schedule at Step 4 plus 13% Fringe Benefits.
** From 1 Oct 84 Composite Standard Rates.

TRACK MAINTENANCE	• The following estimates were obtained: • Katy Railway's Chief Engineer felt that over the first five years there would be no costs other than labor. After five years, he estimated a high of \$132,000/year or \$.50/foot. • Chief, Roads and Railroads felt that \$20-30,000/year tracked vehicle damage in addition to the above estimate. • Justification of Estimate Used. Because of anticipated breaks due to tracked vehicles, motorcycles, cattle, etc., the \$30,000/year for the first five years was used.

TRAIN TRIPS AND MILES

- It was estimated that each company, troop, or battery went to the firing range once a quarter.

• Armor -	8 Bn	X 4 Co	=	32
• Infantry -	4 Bn	X 4 Co	=	16
• Cav Squadron -	2 Sqdn	X 4 Trp	=	8
• Artillery -	6 Bn	X 3 Btry	=	18
• Engr Bn -	2 Bn	X 3 Co	=	6
• Air Defense Artillery	2 Bn	X 4 Btry	=	8
				88
				X 4 Qtrs

352 Trips

- It was estimated that each battalion or squadron went to the field to maneuver once a quarter. The total was multiplied by two to figure an empty run to pick up the battalion.

• Armor -	8 Bn
• Infantry -	4 Bn
• Cav Squadron -	2 Sqdn
• Artillery -	6 Bn
• Engr Bn -	2 Bn
• Air Defense Artillery -	2 Bn

24 X 2 X 4 Qtr = 192Trips

Total Trips/Year 544

- With an estimated 300 miles driven a year to get to and from the field and making eight trips/year would result in an average round trip of 37.5 miles.

544 Trips/year
X 37.5 miles/trip
20,400 miles/year

LOCOMOTIVE FUEL

- Although it was estimated that the locomotive would have a maximum speed of 40 miles/hour with an average speed of 20 miles/hour, the estimate was done on Santa Fe's tables which figures their average speed of 55 miles/hour.

- Method of computation was recommended by Manager and Assistant Manager, Locomotive Maintenance, Atchison, Topeka and Santa Fe Railroad, Topeka, Kansas.

  - Moving Fuel

    20,400 mi/yr X 5,000 Tons = 102,000,000 Gross Ton Miles

    102,000,000 GTM X .08663* Horsepower = 883,626 HP to move 5,000Tons of mixed freight 20,400 miles.

    (Look up on a table the type of locomotive and find how much fuel it burns at 100% horsepower rate.)

    2,500 Gross Mechanical HP 4 axle locomotive burns a maximum of 139 gallons/hour.

    2,500 HP ÷ 139 gal = 17.985612 Hours/gallon burned

    883,626 HP ÷ 17.985612 hr/gal = 49,129.606 gallons of fuel/yr

  - Idle Fuel

    365 days/yr X 24 Hhr/day = 8,760 hrs/yr

    8,760 hrs/yr X 2 locomotives = 17520 hrs/yr

    49,129.606 gal/yr ÷ 139 gal/hr = 353 hrs at 100% horsepower

    17,520 hrs/yr
    \- 353 hrs at 100% horsepower/yr
    17,167 hrs of idle time/yr
    X 5 gallons of fuel/hr
    85,835 gallons of fuel at idle/yr

  - Total Cost

    49,129 gallons of fuel at 100% horsepower/yr
    85,835 gallons of fuel at idle/yr
    134,965 gallons of fuel/yr
    X $1.03 /gallon
    $139,013.95 Total fuel cost/yr

* Horsepower needed to move 1 Gross Ton Mile of mixed freight. (This is from table worked up by Santa Fe.)

LOCOMOTIVE MAINTENANCE

- The following estimates were obtained:
  - $3,381/mo - Assistant Manager of Locomotive Maintenance and Performance, Atchison, Topeka, and Santa Fe Railway, Chicago, Illinois.
  - $3,000/mo - Chief Mechanical Officer, Katy Railway, Dallas Texas.
- Estimate Used.
  The High figure of $3,381/month or $40,572/year was used.

(NOTE: This was maintenance costs for large locomotives with air conditioning and bathrooms.)

ESTIMATES

CONCRETE LOADING AREA	• Ken Slaughter, Master Planning, DEH, gave and estimate of $7.2/ sq ft for concret to support M1's. • Wesley Byrd, Operations Planning, DEH, recommended the size of the 8 sidings concrete pads. • Willis Ament, Roads & Railroads Mnt, DIO, recommended the size of the concrete pads at the two large railheads. • Total cost of concrete loading areas:

• 2 pads 500 ' sq at $1,800,000@	$3,600,000
• 8 pads 50' X 400' sq at $144,000@	1,152,000
Total concrete pad cost	$4,752,000

ESTIMATES

RAMP COSTS

- Ken Slaughter, Master Planning, DEH, estimated 100' ramps at $15,700/ramp. He obtained his estimte from Fort Polk and the figure includes a 4½% inflation factor.
- Ramps located at:
  - 2 at North Fort Hood
  - 2 at South Range
  - 8 individual sidings
- Total ramp cost:

  $15,700 X 12 = $188,400.

ESTIMATES

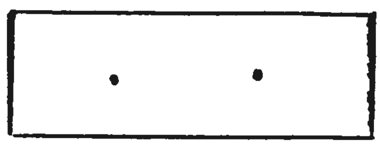
LIGHTING COST

- Lighting estimtes came from Ed Wood, Mechanical and Electrical Engr Br, EPS Div, DEH, with the following assumptions:

  - 5 foot candles are sufficient.
  - Electrical power will be close by (Gene Varner looked at the map that Ted Welsh had marked with recommended locations and said, "Yes, there would be electricity available."
  - Physical arrangements are satisfactory.

    - Small pads (50' X 400' sq)
      4 poles 40' high with overhead wires.

    - Large pads (500' X 500' square)
      2 high mass lights.



- Cost estimates were:

• 2 large pads @ $100,000	$200,000
• 8 small pads @ $ 10,000	80,000
Total lighting costs	$280,000

APPENDIX I.

SUMMARY COMPARISONS OF HET AND RAIL ALTERNATIVES UNDER 10 PERCENT AND 4 PERCENT DISCOUNT RATES

TABLE I-1

SUMMARY COMPARISON OF HET ALTERNATIVES TO ROADMARCH BASE
(at 10 Percent Discount Rate)

Discount Rate = .10	Current HET Operation	Expanded Existing HET	- Full HET Alternatives - 2-Company	1-Company	Commercial
Capital Costs (annualized)					
New HET Equip./Facil. Depreciation	0	250,000	1,191,130	949,162	301,000
New HET Equip./Facil. Opportunity Cost	0	337,298	956,908	803,821	406,107
Existing HET Equip./Facil. Depreciation	222,943	661,121	412,702	643,675	785,242
Existing HET Equip./Facil. Opportunity Cost	294,500	649,000	201,000	311,000	286,000
Land Opportunity Cost	0	0	2,500	2,500	2,500
TOTAL ANNUALIZED CAPITAL COSTS	$517,443	$1,897,419	$2,764,240	$2,710,158	$1,780,849
Annual Operating Costs					
HET Operations and Administration	1,034,263	3,025,313	5,966,913	5,966,913	3,877,018
Division Scheduling and Movement Control	0	50,000	50,000	50,000	50,000
Tracked Vehicle Crew Transportation	50,858	151,625	294,523	294,523	294,523
Highway Maintenance and Repair	728,547	1,823,274	2,863,076	2,863,076	2,863,076
Commercial HET Profit					377,230
TOTAL ANNUAL OPERATING COSTS	$1,813,668	$5,050,212	$9,174,512	$9,174,512	$7,461,847
Annual Benefits and Cost Savings					
Tracked Vehicle Operating Cost Savings	5,930,946	18,071,310	29,339,344	29,339,344	29,339,344
Tank Trail Maintenance Cost Savings	3,416	10,185	19,785	19,785	19,785
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$5,934,362	$18,081,495	$29,359,129	$29,359,129	$29,359,129
Annualized Net Benefits of HETs Compared to Full Roadmarch Base	$3,603,251	$11,133,864	$17,420,377	$17,474,459	$20,116,433

TABLE I-2

SUMMARY COMPARISON OF RAIL ALTERNATIVES TO ROADMARCH BASE
(at 10 Percent Discount Rate)

Discount Rate = 0.10 * Lag Period = 2 yr	Full Rail	West Rail to Curry	West Rail to Critten.	West Rail Only
Capital Costs (annualized)				
New Rail Equip./Facil. Depreciation	21,053	20,165	24,814	18,201
New Rail Equip./Facil. Opportunity Cost	207,551	208,172	204,731	209,774
New Track & Structures Depreciation	1,098,025	826,962	793,322	693,244
New Track & Structures Opportunity Cost	6,785,833	4,882,329	4,480,896	3,672,105
* Existing Rail Equipment Depreciation	30,155	29,476	35,723	26,684
Existing Rail Equipment Opportunity Cost	210,000	210,000	210,000	210,000
Land Opportunity Cost	35,300	26,700	24,700	20,500
TOTAL ANNUALIZED CAPITAL COSTS	$8,387,917	$6,203,804	$5,774,186	$4,850,508
Annual Operating Costs				
* Rail Operations and Administration	468,711	467,609	476,702	392,114
* Division Scheduling and Movement Control	82,645	82,645	82,645	82,645
* Tracked Vehicle Crew Transportation	200,988	187,178	179,064	137,416
* Track and Structures Maintenance	175,479	164,818	163,579	95,136
TOTAL ANNUAL OPERATING COSTS	$927,823	$902,250	$901,990	$707,311
Annual Benefits and Cost Savings				
* Tracked Vehicle Operating Cost Savings	15,786,055	14,489,304	14,355,869	10,968,857
* Tank Trail Maintenance Cost Savings	13,502	12,574	12,029	9,231
* MATES On-Post Vehicle Cost Savings	1,118,506	1,085,736	997,178	941,387
* MATES Shipment Cost Savings	664,182	664,182	664,182	664,182
* Vehicle Outloading Cost Savings	460,918	460,918	460,918	460,918
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$18,043,163	$16,712,714	$16,490,175	$13,044,575
Annualized Net Benefits of Rail Compared to Full Roadmarch Base	$8,727,423	$9,606,660	$9,814,000	$7,486,756

TABLE I-3

SUMMARY COMPARISON OF HET ALTERNATIVES TO ROADMARCH BASE
(at 4 Percent Discount Rate)

Discount Rate = .04	Current HET Operation	Expanded Existing HET	- Full HET Alternatives - 2-Company	1-Company	Commercial
Capital Costs (annualized)					
New HET Equip./Facil. Depreciation	0	250,000	1,191,130	949,162	301,000
New HET Equip./Facil. Opportunity Cost	0	117,909	346,066	289,469	141,963
Existing HET Equip./Facil. Depreciation	222,943	661,121	412,702	643,675	785,242
Existing HET Equip./Facil. Opportunity Cost	122,900	274,600	91,800	139,400	114,400
Land Opportunity Cost	0	0	1,000	1,000	1,000
TOTAL ANNUALIZED CAPITAL COSTS	$345,843	$1,303,630	$2,042,698	$2,022,698	$1,343,605
Annual Operating Costs					
HET Operations and Administration	1,034,263	3,025,313	5,966,913	5,966,913	3,877,018
Division Scheduling and Movement Control	0	50,000	50,000	50,000	50,000
Tracked Vehicle Crew Transportation	50,858	151,625	294,523	294,523	294,523
Highway Maintenance and Repair	728,547	1,823,274	2,863,076	2,863,076	2,863,076
Commercial HET Profit					377,230
TOTAL ANNUAL OPERATING COSTS	$1,813,668	$5,050,212	$9,174,512	$9,174,512	$7,461,847
Annual Benefits and Cost Savings					
Tracked Vehicle Operating Cost Savings	5,930,946	18,071,310	29,339,344	29,339,344	29,339,344
Tank Trail Maintenance Cost Savings	3,416	10,185	19,785	19,785	19,785
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$5,934,362	$18,081,495	$29,359,129	$29,359,129	$29,359,129
Annualized Net Benefits of HETs Compared to Full Roadmarch Base	$3,774,851	$11,727,653	$18,141,919	$18,161,911	$20,553,677

TABLE I-4

SUMMARY COMPARISON OF RAIL ALTERNATIVES TO ROADMARCH BASE
(at 4 Percent Discount Rate)

Discount Rate = 0.04 * Lag Period = 2 yr	Full Rail	West Rail to Curry	West Rail to Critten.	West Rail Only
Capital Costs (annualized)				
New Rail Equip./Facil. Depreciation	23,553	22,559	27,760	20,361
New Rail Equip./Facil. Opportunity Cost	84,037	84,383	81,881	85,571
New Track & Structures Depreciation	1,098,025	826,962	793,322	693,244
New Track & Structures Opportunity Cost	2,478,027	1,774,961	1,621,627	1,319,649
* Existing Rail Equipment Depreciation	33,735	32,975	39,964	29,851
Existing Rail Equipment Opportunity Cost	84,000	84,000	84,000	84,000
Land Opportunity Cost	14,120	10,680	9,880	8,200
TOTAL ANNUALIZED CAPITAL COSTS	$3,815,497	$2,836,520	$2,658,434	$2,240,876
Annual Operating Costs				
* Rail Operations and Administration	524,353	523,120	533,293	438,663
* Division Scheduling and Movement Control	92,456	92,456	92,456	92,456
* Tracked Vehicle Crew Transportation	224,848	209,398	200,321	153,729
* Track and Structures Maintenance	196,311	184,384	182,997	106,430
TOTAL ANNUAL OPERATING COSTS	$1,037,968	$1,009,358	$1,009,067	$791,278
Annual Benefits and Cost Savings				
* Tracked Vehicle Operating Cost Savings	17,660,067	16,209,374	16,060,099	12,271,005
* Tank Trail Maintenance Cost Savings	15,104	14,066	13,457	10,327
* MATES On-Post Vehicle Cost Savings	1,251,287	1,214,628	1,115,555	1,053,142
* MATES Shipment Cost Savings	743,029	743,029	743,029	743,029
* Vehicle Outloading Cost Savings	515,635	515,635	515,635	515,635
TOTAL ANNUAL BENEFITS AND COST SAVINGS	$20,185,122	$18,696,733	$18,447,775	$14,593,138
Annualized Net Benefits of Rail Compared to Full Roadmarch Base	$15,331,657	$14,850,855	$14,780,274	$11,560,984