AMSAA

TECHNICAL REPORT NO. 374

MOBILITY AND TRANSPORTATION ANALYSIS IN SUPPORT
OF
THE LIGHT ATTACK BATTALION (LAB) STUDY

VOLUME I: MOBILITY AND TRANSPORTATION ANALYSES

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A mobility analysis of the 12 vehicles which are used in the light attack battalion (LAB) was made in support of a study being conducted by the US Army Infantry School. The Army Mobility Model was used to exercise the vehicles in Mid-East and European scenarios which included operation on primary and secondary roads as well as on trails and cross country. Runs were made on dry, wet and snow covered surfaces to obtain data on maximum attainable speeds under each condition. Additional analyses were conducted to determine probability of being hit while crossing typical gaps and to examine logistic requirements of moving the LAB from point to point.

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MOBILITY AND TRANSPORTATION ANALYSIS IN SUPPORT OF
THE LIGHT ATTACK BATTALION (LAB) STUDY

1. INTRODUCTION.

The High Technology Light Division (HTDL) is being developed to capitalize on technological advances in a myriad of areas to include vehicles, weapons and communications. As a result of this effort, new concepts of fighting and new organizations to execute these concepts are beginning to emerge. The Light Attack Battalion (LAB) is one of these new organizations. The LAB will implement the Air/Land Battle doctrine by execution of deep strike missions. It is revolutionary in concept and is designed to be lightweight, highly mobile and self sustaining for the duration of its mission. The ability of the LAB to perform its mission and survive is crucial to the success of the HTLD.

As a result of a discussion between personnel of the High Technology Test Bed (HTTB) of the HTLD and the Combined Arms Center (CAC), it was agreed that TRADOC would provide analytical assistance to HTTB. CAC prepared a study directive designating the U.S. Army Infantry School (USAIS) as the study agency and in turn, USAIS requested that AMSAA provide support for the study. Since mobility and rapid movement are a requirement of the LAB, part of the AMSAA effort was to be directed toward a mobility analysis of the various vehicles which constitute the organic elements of the LAB. A study was also to be undertaken to determine the times or movement rates involved in transporting certain elements of the LAB by several modes of transportation. The Mobility Analysis Branch of AMSAA was requested to conduct this part of the study. The analysis took the following form.

1.1 Using the Mid-East and European scenarios provided by USAIS for the Close Combat (Light) Mission Area Analysis (Ref 1), the vehicles were exercised in the Army Mobility Model. The off-road module of the model was used to generate speed profiles for the various vehicles, while the on-road module was used to determine speeds on primary and secondary roads and on trails. Movement on dry, wet and snow covered surfaces was considered in Europe and on dry and wet surfaces in the Mid-East.

1.2 Acceleration profiles were developed for the organic vehicles. These were used to determine the hit probability for several different threat weapons against the Fast Attack Vehicle (FAV) and the High Mobility Multipurpose Wheeled Vehicle (HMMWV) when crossing gaps between points of concealment. Range and soil strength were varied.

1.3 As noted USAIS also requested that information be supplied concerning the movement of the LAB and a Task Organized Company by several different modes of transportation. The starting points and destinations were those used in the CC(L)MAA Study in both Europe and the Mid-East. Movement rates, number of trips required, total time and fuel consumed were requested for the organizations and transportation listed below:

a. Task Organized Company by organic vehicles.

b. Task Organized Company by UH-60 (15 each) helicopters.

c. Task Organized Company by UH-60 (15 each) helicopters with block improvement.

d. Task Organized Company by C-130 Aircraft.

e. LAB by organic vehicles.

f. LAB by C-130 aircraft.

As part of this effort, payload-range curves for the UH-60 with block improvement were also generated.

The results of the study are presented in two volumes. In addition to the Introduction, Volume 1 contains a discussion of the mobility investigation, Section 2, an analysis of the movement of the two organizations by the several different modes of transportation, Section 3, and Conclusions and Recommendations, Section 4. Volume 2 contains speed profiles, acceleration profiles and supporting data for the organization movements.

2. MOBILITY ANALYSIS

Since the vehicles assigned to the Task Organized Company are also included in the TO&E of the Light Attack Battalion, only the TO&E vehicles were considered for performance analysis. Of these, only the M816 Wrecker as such appeared in the CC(L)MAA study. The HMMWV addressed in this report is a generic version of the HMMWV and represents the characteristics of all the competing candidate vehicles, but possesses no characteristic peculiar to any of the candidates. The HMMWV analyzed in the CC(L)MAA study had attributes based on very preliminary data. Therefore, the performance of the two versions differs to some extent and should not be compared. The various combinations of towing vehicles and trailers were arrived at by reference to the TO&E and by consultation with USAIS. Selection of towing vehicles was, to some extent, influenced by those vehicles available in relatively small units. Somewhat more effective pairing of towing vehicle and trailer can be obtained by considering vehicles available outside the units, but still within the battalion.

When the Light Attack Battalion was conceptually organized, it included a proposal for use of the fast attack type vehicle. This vehicle has capabilities which in many cases greatly exceed those of the standard Army inventory vehicles. However, when the vehicle is exercised in the Army Mobility Model, these capabilities may not be apparent. When treated in the conventional fashion, and using input data based on information received from the manufacturer, the vehicle responds as a conventional vehicle having the same characteristics. For instance, the vehicle has only two wheel drive, which limits its traction as compared to a four wheel drive vehicle. The FAV has a good approach angle and a fair departure angle and relatively good ground clearance. However, when confronted with obstacles which seriously challenge these characteristics the vehicle will become immobilized just as the conventional vehicle does. Passage on wet and snow covered surfaces in the model is also compromised by the two wheel drive feature.

Fairly extensive testing, primarily of the operation type, has been conducted on this vehicle. It was during this testing that the FAV demonstrated attributes which are not apparent in its performance when played in the Army Mobility Model. It is felt that in order to do the vehicle justice, extensive engineering testing should be carried out. If during this testing capabilities surface that are not properly reflected by model play, then the model can be adjusted to correctly assess these capabilities.

A 1-1/4 ton 4x4 armament truck was listed in the LAB TO&E. The truck selected for this role is the diesel powered Commercial Utility/Cargo Vehicle (CUCV) which will be fielded in the near future.

A listing of the vehicles considered and their weights is given below:

VEHICLE	WEIGHT (LBS)
Fast Attack Vehicle (FAV)	2440
High Mobility Multipurpose Wheeled Vehicle (HMMWV)	7750
Commercial Utility/Cargo Vehicle (CUCV)	8460
M559 Fuel Truck	46370
M814 5-Ton Cargo Truck	35574
M816 Wrecker	43529

VEHICLE WITH TRAILER	WEIGHT (LBS)
HMMWV with M101 Trailer	10590
HMMWV with M416 Trailer	8820
M559 with M101 Trailer	49210
M814 with M101 Trailer	38414
M814 with M107 (water) Trailer	41189
M816 with M116 (weld shop) Trailer	46039

2.1 Off-Road Performance.

The off-road performance of the various vehicles in the Mid-East and European scenarios was assessed using the off-road module of the Army Mobility Model (Ref 2). The Army Mobility Model is composed of two modules, the aforementioned off-road or areal patch module and the on-road segment module. The off-road module computes the maximum feasible first-pass speed for a single vehicle in a single areal patch or terrain unit. Terrain units are areas in which certain attributes of the terrain such as soil strength, slope, roughness, obstacles and vegetation fall within certain rather narrow ranges and thereby can be characterized by a single representative value for each feature. These attributes are then considered to be homogeneous throughout the unit.

The vehicle is specified in terms of mechanical, geometric, and inertial characteristics that determine its interaction with the terrain. These include such factors as weight distribution, track or wheel size, approach and departure angles, tractive force as a function of speed, and ride and obstacle performance curves. Driver inputs are considered in terms of his ability to stand shock and vibration and his reaction to certain situations affecting his driving behavior.

With this information at hand the off-road module computes the maximum vehicle speed in each terrain unit. The terrain unit speeds are cumulated in a speed profile. In these profiles, the terrain units are ordered so that they progress from the easiest to the most difficult to negotiate. The profiles show the actual speed as a function of the terrain difficulty and the cumulative average speed as a function of the percentage of the terrain traversed. Cumulative average speed is the average speed a vehicle can sustain as a function of the total area it traverses, assuming it has progressed from the easiest terrain to negotiate towards the increasingly more difficult.

An additional output of the off-road module is a listing of the speed limiting and vehicle immobilizing factors and percentage contribution of each factor.

Certain vehicle data are filed under topical or abbreviated headings. These headings are used on speed and acceleration profiles and appear at other points in the report. A list of the various vehicles or vehicle combinations and their abbreviated form appears below:

VEHICLE/COMBINATION	ABBREVIATED TITLE
CUCV	AIDIESL
Fast Attack Vehicle	FAV
HMMWV (Generic)	HMMWVG
HMMWV (Generic) with M101 Trailer	HMMWV w/M1
HMMWV (Generic) with M416 Trailer	HMMW416
M559 Fuel Truck	M559
M559 Fuel Truck with M101 Trailer	M559101
M814 Cargo Truck	M814WW
M814 Cargo Truck with M101 Trailer	M814101
M814 Cargo Truck with M107 Trailer	M814107
M816 Wrecker	M816WR
M816 Wrecker with M116 Trailer	M81616

The results of the model runs in Europe are shown in Tables 1-3. Two different cumulative average speeds are listed in the tables. The first, V_{50}, is the cumulative average speed the vehicle can achieve in the most trafficable 50 percent of the terrain considered, and the V_{90}, the speed achieved in the most trafficable 90 percent. The "percent no-go" represents the percentage of the total terrain in which the vehicle is immobilized.

Reference to the tables shows that the FAV has the highest V_{50} speeds on dry surfaces in Europe, but has a higher incidence of no-go's than the HMMWV. Those vehicles which were able to retain motion at the 90 percent of area point had less obstacle interference than those immobilized at that point in Europe 1 and better traction than those immobilized at that point in Europe 2. On wet surfaces in Europe 1 and Europe 2, the HMMWV has slightly higher speeds than the FAV, and a substantially lower percentage of no-go's. Even the CUCV is less frequently immobilized than the FAV on this surface. The FAV experiences a greater loss of traction than the two four-wheel drive vehicles in the wet terrain. In snow in Europe, the FAV is immobilized more than any of the other vehicles. Again loss of traction is the governing factor.

Performance of the vehicles in the Mid-East, Table 4, on dry surfaces generally followed the trend for similar surfaces in Europe. However, in wet Mid-East Terrain, the FAV fails to achieve even a V_{50} speed due to decreased traction.

Discussion of off-road performance has centered around the FAV and the HMMWV. The performance of the other organic vehicles should be noted since, by comparison, they did well on dry and snow covered terrain. They should be able to carry out their assigned functions.

2.2 <u>On-Road Performance</u>.

The on-road module of the Army Mobility Model is similar in concept to the off-road module. Factors such as road type, surface strength, curvature and surface roughness are used to characterize road units. Vehicle data include geometric, inertial and mechanical characteristics. The model output is vehicle speed. Three classes of roads are identified. They are:

Class 1 - Primary: surfaced all weather roads, two lanes or more.

Class 2 - Secondary: the balance of all weather roads, generally unpaved but improved, plus paved roads less than two lanes wide.

Class 3 - Trails: unimproved and fair weather roads and trails of at least one vehicle width.

The vehicles were run over dry, wet and snow covered surfaces in Europe and over dry and wet surfaces in the Mid-East. The surfaces were primary and secondary roads and trails in Europe. In the Mid-East area considered, none of the roads qualified as primary roads, consequently performance was assessed only over secondary roads and trails. Tables 5-7 show the performance of the various vehicles in the two areas. There is little reduction in performance in either area when going from a dry to a wet surface. Speeds on snow covered primary roads in Europe show a reduction when compared

TABLE 1

PREDICTED VEHICLE MOBILITY

OFF-ROAD CUMULATIVE AVERAGE SPEEDS

VEHICLE	EUROPE 1 - DRY			EUROPE 2 - DRY		
	V_{50} MPH	V_{90} MPH	PERCENT NOGO	V_{50} MPH	V_{90} MPH	PERCENT NOGO
Al Diesel (CUCV)	15.2	NO-GO	15.8	18.2	NO-GO	11.1
FAV	23.3	NO-GO	12.3	26.2	NO-GO	12.1
HMMWVG W/M101 TRL	19.7	NO-GO	13.3	22.0	NO-GO	15.4
HMMWVG	20.3	NO-GO	10.0	22.9	15.0	8.0
HMMWVG W/M416 TRL	20.1	NO-GO	10.7	22.6	NO-GO	10.1
M559	9.0	5.5	6.8	10.0	6.0	6.0
M559 W/M101 TRL	8.9	5.5	7.6	9.7	5.8	7.4
M814	14.3	NO-GO	12.2	16.0	9.7	7.8
M814 W/M101 TRL	13.9	NO-GO	12.4	15.3	9.3	9.3
M814 W/M107 TRL	13.5	NO-GO	12.8	15.0	NO-GO	10.2
M816WR	14.0	8.4	9.3	15.0	NO-GO	10.3
M816 W/M116 TRL	13.7	8.1	9.7	14.6	NO-GO	11.5

TABLE 2

PREDICTED VEHICLE MOBILITY

OFF-ROAD CUMULATIVE AVERAGE SPEEDS

	EUROPE 1 - WET*			EUROPE 2 - WET*		
VEHICLE	V_{50} MPH	V_{90} MPH	PERCENT NOGO	V_{50} MPH	V_{90} MPH	PERCENT NOGO
Al Diesel (CUCV)	12.1	NO-GO	24.3	14.1	NO-GO	32.0
FAV	15.9	NO-GO	28.3	18.3	NO-GO	35.7
HMMWVG W/M101 TRL	15.4	NO-GO	28.4	17.3	NO-GO	34.0
HMMWVG	16.3	NO-GO	18.3	19.1	NO-GO	26.2
HMMWVG W/M416 TRL	16.1	NO-GO	22.5	18.6	NO-GO	28.3
M559	4.6	NO-GO	48.6	NO-GO	NO-GO	71.9
M559 W/M101 TRL	NO-GO	NO-GO	51.4	NO-GO	NO-GO	73.8
M814	9.6	NO-GO	29.1	8.0	NO-GO	42.3
M814 W/M101 TRL	8.9	NO-GO	39.4	NO-GO	NO-GO	55.8
M814 W/M107 TRL	8.2	NO-GO	44.8	NO-GO	NO-GO	62.2
M816WR	8.7	NO-GO	42.6	NO-GO	NO-GO	64.9
M816 W/M116 TRL	6.5	NO-GO	48.8	NO-GO	NO-GO	71.0

*The wet condition shown is the wet-wet slippery classification as defined by Waterways Experiment Station.

TABLE 3

PREDICTED VEHICLE MOBILITY

OFF-ROAD CUMULATIVE AVERAGE SPEEDS

	EUROPE 1 - SNOW			EUROPE 2 - SNOW		
VEHICLE	V_{50} MPH	V_{90} MPH	PERCENT NOGO	V_{50} MPH	V_{90} MPH	PERCENT NOGO
A1 Diesel (CUCV)	16.2	NO-GO	29.6	15.6	NO-GO	37.2
FAV	NO-GO	NO-GO	52.0	NO-GO	NO-GO	59.9
HMMWVG W/M101 TRL	NO-GO	NO-GO	50.3	NO-GO	NO-GO	59.6
HMMWVG	18.6	NO-GO	25.2	18.5	NO-GO	35.5
HMMWVG W/M416 TRL	16.9	NO-GO	32.4	16.3	NO-GO	43.7
M559	4.4	NO-GO	23.0	4.4	NO-GO	34.3
M559 W/M101 TRL	4.1	NO-GO	26.3	4.1	NO-GO	38.2
M814	7.2	NO-GO	24.2	7.3	NO-GO	35.6
M814 W/M101 TRL	6.6	NO-GO	28.1	6.6	NO-GO	41.6
M814 W/M107 TRL	6.1	NO-GO	32.8	6.1	NO-GO	44.4
M816WR	6.1	NO-GO	23.3	6.1	NO-GO	34.9
M816 W/M116 TRL	5.8	NO-GO	25.8	5.9	NO-GO	38.5

TABLE 4

PREDICTED VEHICLE MOBILITY

OFF-ROAD CUMULATIVE AVERAGE SPEEDS

VEHICLE	MID-EAST 1 - DRY V_{50} MPH	MID-EAST 1 - DRY V_{90} MPH	MID-EAST 1 - DRY PERCENT NOGO	MID-EAST 1 - WET * V_{50} MPH	MID-EAST 1 - WET * V_{90} MPH	MID-EAST 1 - WET * PERCENT NOGO
A1 Diesel (CUCV)	8.7	NO-GO	32.6	6.8	NO-GO	42.5
FAV	23.7	NO-GO	29.8	NO-GO	NO-GO	50.5
HMMWVG W/M101 TRL	15.7	NO-GO	34.0	NO-GO	NO-GO	52.8
HMMWVG	16.8	NO-GO	26.7	14.8	NO-GO	38.8
HMMWVG W/M416 TRL	16.4	NO-GO	29.0	12.5	NO-GO	43.9
M559	6.0	NO-GO	20.9	4.0	NO-GO	43.1
M559 W/M101 TRL	5.8	NO-GO	22.8	3.7	NO-GO	47.3
M814	10.0	NO-GO	28.1	NO-GO	NO-GO	67.9
M814 W/M101 TRL	9.6	NO-GO	29.8	NO-GO	NO-GO	70.6
M814 W/M107 TRL	9.2	NO-GO	30.6	NO-GO	NO-GO	73.1
M816WR	9.1	NO-GO	26.6	6.5	NO-GO	40.3
M816 W/M116 TRL	8.9	NO-GO	28.6	5.2	NO-GO	47.1

*The wet condition shown is the wet-wet slippery classification as defined by Waterways Experiment Station.

TABLE 5

ROAD MOVEMENT SPEEDS (MPH)

	EUROPE - DRY			MID-EAST - DRY		
VEHICLE	PRIMARY	SECONDARY	TRAILS	PRIMARY	SECONDARY	TRAILS
Al Diesel (CUCV)	55.9	28.0	6.9	-	54.9	8.1
FAV	58.3	48.0	18.6	-	60.6	26.7
HMMWVG W/M101 TRL	50.3	36.1	13.7	-	47.5	15.7
HMMWVG	53.5	38.4	14.0	-	53.3	16.0
HMMWVG W/M416 TRL	52.4	37.5	13.9	-	51.1	15.9
M559	26.2	13.8	6.6	-	17.3	6.8
M559 W/M101 TRL	25.1	13.3	6.5	-	16.8	6.7
M814	38.4	23.8	9.7	-	28.7	10.7
M814 W/M101 TRL	38.3	22.4	9.5	-	27.4	10.6
M814 W/M107 TRL	37.6	21.4	9.3	-	26.8	10.4
M816WR	37.0	21.4	9.3	-	26.7	10.3
M816 W/M116 TRL	35.8	21.0	8.8	-	24.7	8.3

TABLE 6

ROAD MOVEMENT SPEEDS (MPH)

VEHICLE	EUROPE - WET* PRIMARY	EUROPE - WET* SECONDARY	EUROPE - WET* TRAILS	MID-EAST - WET* PRIMARY	MID-EAST - WET* SECONDARY	MID-EAST - WET* TRAILS
A1 Diesel (CUCV)	55.9	28.0	6.9	-	54.9	8.1
FAV	58.3	48.0	18.6	-	60.6	26.7
HMMWVG W/M101 TRL	50.3	36.1	13.6	-	47.5	15.7
HMMWVG	53.5	38.4	14.0	-	53.3	16.0
HMMWVG W/M416 TRL	52.4	37.5	13.9	-	51.1	15.9
M559	26.1	13.8	5.6	-	17.3	6.8
M559 W/M101 TRL	25.1	13.3	5.4	-	16.8	6.7
M814	38.4	23.8	9.5	-	28.7	10.6
M814 W/M101 TRL	38.3	22.4	9.1	-	27.4	10.5
M814 W/M107 TRL	37.6	21.4	9.0	-	26.8	10.4
M816WR	37.0	21.4	8.8	-	26.7	10.3
M816 W/M116 TRL	35.8	21.0	8.0	-	24.7	8.0

*The wet condition shown is the wet-wet slippery classification as defined by Waterways Experiment Station.

TABLE 7

ROAD MOVEMENT SPEEDS (MPH)

VEHICLE	EUROPE - SNOW PRIMARY	SECONDARY	TRAILS
A1 Diesel (CUCV)	35.1	32.9	18.7
FAV	52.3	48.5	22.9
HMMWVG W/M101 TRL	26.8	25.4	16.2
HMMWVG	32.9	31.1	18.3
HMMWVG W/M416 TRL	29.8	28.5	17.5
M559	9.5	8.5	6.2
M559 W/M101 TRL	9.0	8.0	5.8
M814	15.6	13.9	9.3
M814 W/M101 TRL	13.9	12.3	8.5
M814 W/M107 TRL	12.7	11.4	8.1
M816WR	10.6	10.0	7.8
M816 W/M116 TRL	10.5	9.8	7.5

to dry road performance. However, for several vehicles, speeds actually increased on snow covered trails. Snow attenuates the surface roughness of the trails. Where surface roughness is tha factor which limits speed, the "smoothing" effect of the snow may actually permit a vehicle to negotiate a trail at a higher speed in the snow than on a dry surface.

The FAV had higher speeds than the other vehicles in both areas for all road conditions. All vehicles were able to negotiate all roads and trails under dry, wet and snow covered conditions. The Europe primary road speeds and the Mid-East secondary road speeds for the slowest vehicle, the M559 with trailer, were used to determine organizational movement times for the LAB, while Task Organized Company movement times were constrained by the HMMWV with trailer. The road speeds utilized were for dry road conditions.

2.3 Hit Probability As a Function of Acceleration.

The influence of acceleration on hit probability was determined for two vehicles, FAV and HMMWV. This was accomplished by accelerating the vehicles from a standing start, behind a point of concealment, across an open gap to another point of concealment. Two gap lengths were used, 829 feet and 1594 feet. These are representative of the shortest and longest mean gap lengths recorded in regions of the Fritzlar area of Germany. Two soil strengths were employed, RCI 60 and RCI 120, representing different degrees of motion resistance. RCI 60 denotes a weak soil and RCI 120, one of moderate strength. The effects of firing three threat weapons were studied. The weapons represent those mounted on various threat vehicles. Ranges for weapons #1 and #3 were 1500 meters and for #2, 800 meters. Firing times for the first and subsequent shots for each of the weapons were determined. Using the range, vehicle speed and target size, the hit probability for that event was computed for each weapon.

Reference to Figures 1 and 2 shows that above 30 mph the acceleration (the slope of the velocity-time curves presented in the figures) of the FAV is substantially higher than that of the HMMWV. In turn, the time required to reach a particular speed is lower for the FAV and the distance covered greater for a given time. Tables 8 and 9 show in detail the hit probabilities, distances covered across the gap at the time of each firing and the speed of the vehicle at that time. Table 10 is presented to show the total number of shots fired against each vehicle by each weapon during each of the two gap crossings and the cumulative hit probability at that number of shots. The effect of increased acceleration in reducing the number of shots fired and the enhancement of the chances for survival are immediately evident. The smaller size of the FAV also contributes to this lower hit probability. However, the lethality of the weapons must be taken into account, since even a single hit by certain weapons would probably have catastrophic results against these vehicles.

3. ORGANIZATIONAL MOVEMENT

A summary of the organizations and the modes of transportation to be used in moving them was presented in the Introduction of this report. For convenience, the tasks outlined there are also repeated below.

FIGURE 1

ACCELERATION OF FAV ON FINE GRAIN SOIL

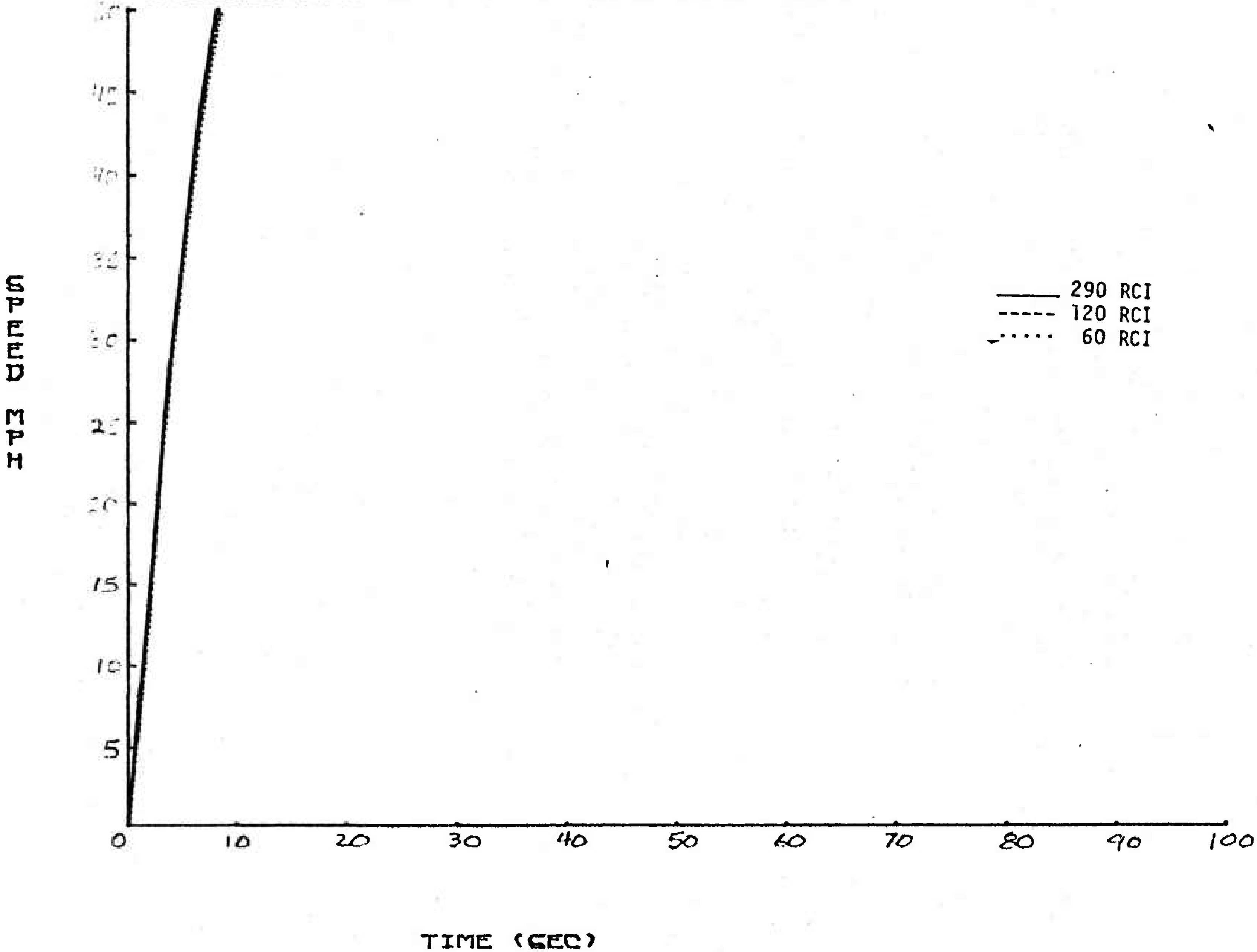

FIGURE 2

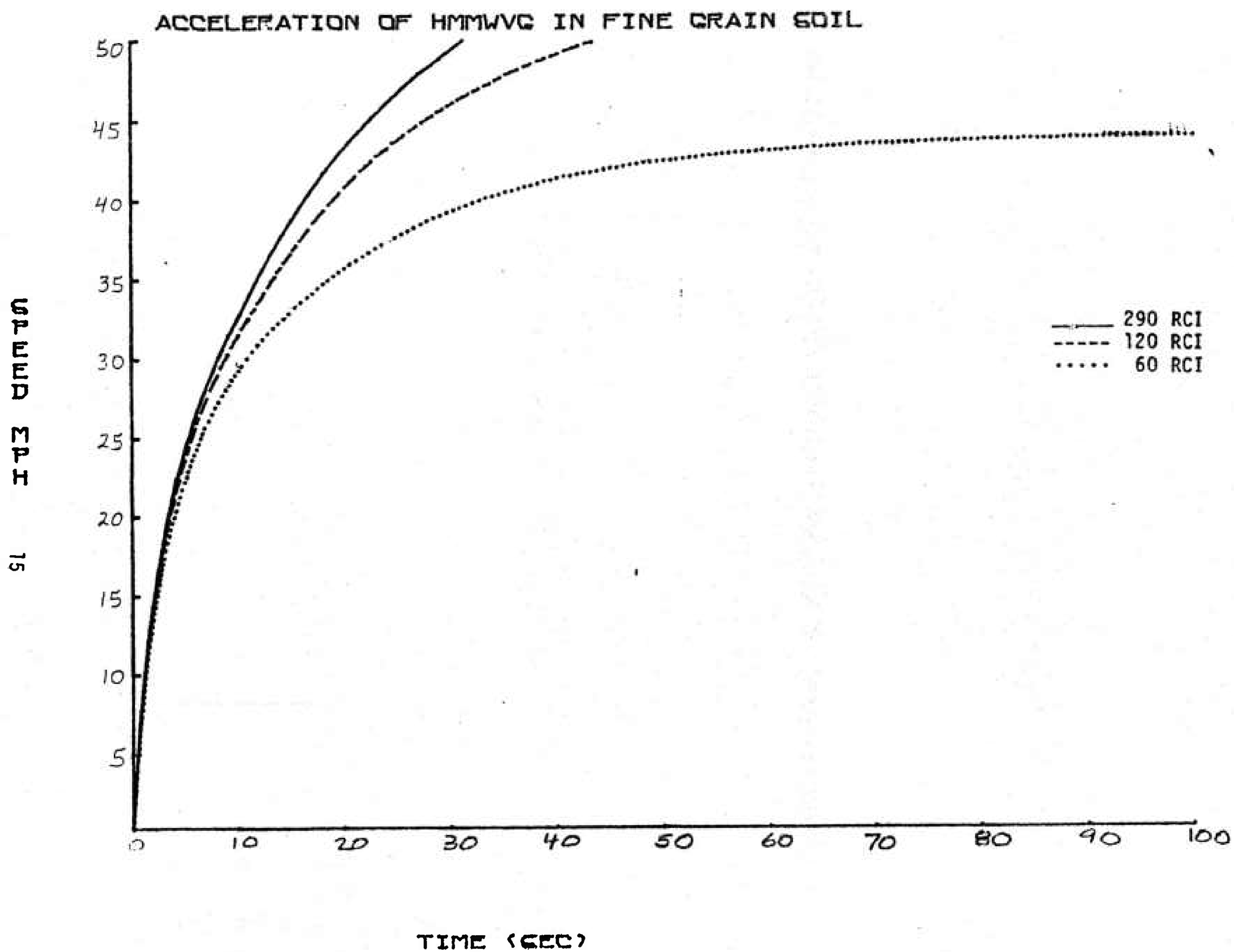
ACCELERATION OF HMMWVG IN FINE GRAIN SOIL
SPEED MPH
TIME (SEC)
290 RCI
120 RCI
60 RCI
50
45
40
35
30
25
20
15
10
5
0
10
20
30
40
50
60
70
80
90
100

TABLE 8

				SURFACE IS FINE GRAIN SOIL							
				RCI = 120				RCI = 60			
TARGET	WEAPON	RANGE	SHOT	DIST (FT)	SPEED (MPH)	P_H	P_{HC}	DIST (FT)	SPEED (MPH)	P_H	P_{HC}
FAV	#1	1500m	1	1009	66.9	.46	.46	997	65.5	.46	.46
FAV	#2	800m	1	536	57.4	.05	.05	525	56.4	.05	.05
			2	1503	73.0	.03	.08	1479	71.1	.03	.08
FAV	#3	1500m	1	437	53.7	.34	.34	429	52.6	.34	.34
			2	661	60.8	.34	.56	655	59.9	.34	.56
			3	911	65.4	.34	.71	901	64.1	.34	.71
			4	1189	69.4	.34	.81	1163	67.7	.34	.81
			5	1460	72.5	.34	.87	1437	70.7	.34	.87

P_H - hit probability at each shot

P_{HC} - cumulative hit probability for specified number of shots

TABLE 9

				SURFACE IS FINE GRAIN SOIL							
				RCI = 120				RCI = 60			
TARGET	WEAPON	RANGE	SHOT	DIST (FT)	SPEED (MPH)	P_H	P_{HC}	DIST (FT)	SPEED (MPH)	P_H	P_{HC}
HMMWV	#1	1500m	1	616	37.4	.60	.60	574	33.4	.60	.60
			2	1252	44.4	.60	.84	1116	38.1	.60	.84
HMMWV	#2	800	1	352	32.3	.05	.05	327	29.8	.06	.06
			2	894	41.1	.04	.08	819	36.0	.04	.10
			3	1532	46.2	.03	.12	1400	39.8	.04	.13
HMMWV	#3	1500m	1	295	30.9	.44	.44	275	28.6	.44	.44
			2	422	33.8	.44	.69	394	31.0	.44	.69
			3	562	36.5	.44	.82	521	32.8	.44	.82
			4	729	39.1	.44	.90	656	34.4	.44	.90
			5	870	40.8	.44	.94	796	35.8	.44	.94
			6	1034	42.5	.44	.97	943	37	.44	.97
			7	1203	44.0	.44	.98	1100	37.9	.44	.98
			8	1401	45.4	.44	.99	1250	39	.44	.99
			9	1584	46.5	.44	.99	1403	39.6	.44	.99
			10					1559	40.2	.44	.99

P_H - hit probability at each shot

P_{HC} - cumulative hit probability for specified number of shots

TABLE 10

NUMBER OF SHOTS FIRED AGAINST TARGET (N) AND CUMULATIVE HIT PROBABILITY (P_{HC})

	WEAPON #1				WEAPON #2				WEAPON #3			
	SOIL STRENGTH				SOIL STRENGTH				SOIL STRENGTH			
	RCI 120		RCI 60		RCI 120		RCI 60		RCI 120		RCI 60	
	N	P_{HC}	N	P_{HC}	N	P_{HC}	N	P_{HC}	N	P_{HC}	N	P_{HC}
FAV												
829 FT GAP	0		0		1	.05	1	.05	2	.56	2	.56
1594 FT GAP	1	.46	1	.46	2	.08	2	.08	5	.87	5	.87
HMMWV												
829 FT GAP	1	.60	1	.60	1	.05	2	.10	4	.90	5	.94
1594 FT GAP	2	.84	2	.84	3	.12	3	.13	9	.99	10	.99

Using the starting points and destinations employed in the CC(L)MAA Study, determine movement rates, number of trips required, total time and fuel consumed for the organizations and transportation listed below:

a. Task Organized Company by organic vehicles.

b. Task Organized Company by UH-60 (15 each) helicopters.

c. Task Organized Company by UH-60 (15 each) helicopters with block improvement.

d. Task Organized Company by C-130 Aircraft.

e. LAB by organic vehicles.

f. LAB by C-130 aircraft.

The distances between the starting points and destinations used in the CC(L)MAA Study are:

	BY ROAD (STATUTE MILES)	BY AIR (NAUTICAL MILES)
EUROPE	93	52
MID-EAST	166	98

The Task Organized Company consists of 109 personnel and 42 vehicles. The vehicle complement is made up of 22 FAV's, 18 HMMWV's and two mortar trailers. Pertinent vehicle data are:

VEHICLE	# VEH	GROSS VEH WT (LBS)	PERS/ VEH	LENGTH (INS)	WIDTH (INS)	HEIGHT (INS)
FAV(TOW II)	9	2400	2	148	78	57
FAV(MK-19)	13	2400	2	148	78	57
HMMWV(MK-19)	3	7750	4	190	85	73
HMMWV(MK-19)	3	7750	5	190	85	73
HMMWV(MK-19,Stinger)	1	7750	2	190	85	73
HMMWV(MK-19,GLH)	2	7750	4	190	85	73
HMMWV(MK-19,GLH)	1	7750	3	190	85	73
HMMWV(MK-19,GLH)	1	7750	2	190	85	73
HMMWV(MK-19,Towed Mortar)	2	10590	3	334	85	73
HMMWV(MK-19,Mortar Ammo)	2	7750	3	190	85	73
HMMWV(MK-19,Mini-copter)	1	7750	4	190	85	73
HMMWV(MK-19,Motorcycles)	1	7750	4	190	85	73
HMMWV(FDC)	1	7750	3	190	85	73

The Light Attack Battalion has 501 personnel and 207 vehicles. Vehicle data for this organization are as follow:

LIN	#VEH	VEHICLE DESCRIPTION	LENGTH (INS)	WIDTH (INS)	HEIGHT (INS)	WEIGHT (LBS)
L28351	2	Kitchen Trailer	183	94	96	5340
008001	70	Light Attack Vehicle	148	78	57	2400
W95400	8	1/4 T Trailer	109	62	83	1080
W95537	5	3/4 T Trailer	147	74	83	2840
W98825	1	1-1/2 T Tank Trailer	162	82	78	5615
X41105	8	5 T Cargo Truck M814	392	97	86	35574
X58093	3	Tank Truck M559	392	138	135	46370
X63299	1	5 T Wrecker M816	355	115	113	3529
Z41532	33	1-1/4 Ton Truck	208	82	73	8460
Z44650	8	2 Wheel Motorcycle	84	36	48	600
Z15790	6	1-1/4 I HMMWV XM966	334	85	73	10590
Z93123	6	1-1/4 T Ambulance	190	85	73	7750
Z94109	51	1-1/4 T HMMWV	190	85	73	7750
Z94110	4	1-1/4 T HMMWV W/W	190	85	73	7750
Z98313	1	Welding Trailer	149	76	95	2510

3.1 Road Movement by Organic Vehicles.

When undertaking road movement, both the task organized company and the LAB are capable of carrying all personnel and equipment on the organic vehicles. Therefore, any road movement can be accomplished by a single convoy traveling from starting point to destination. The convoy will be constrained by the slowest vehicle. Times for the road movements are:

MOVEMENT BY ROAD-STARTING POINT TO DESTINATION

TASK ORGANIZED COMPANY

SCENARIO	(STATUTE MILES)	CONSTRAINING VEHICLE	TIME OF TRIP (HOURS)
EUROPE	93	HMMWV w/Trailer	1.9
MID-EAST	166	HMMWV w/Trailer	3.5

LIGHT ATTACK BATTALION

SCENARIO	(STATUTE MILES)	CONSTRAINING VEHICLE	TIME OF TRIP (HOURS)
EUROPE	93	M559 w/Trailer	3.7
MID-EAST	166	M559 w/Trailer	9.9

These times represent time for the first vehicle to make the trip. The length of the convoy will determine time for the last vehicle. It can be seen that the presence of the M559 significantly increases the movement time of any organization of which it is a part.

3.2 Movement by C-130 Aircraft.

In order to determine the number of aircraft required to move the task organized company and the Light Attack Battalion, it becomes necessary to generate load plans for the aircraft, showing placement of equipment and personnel. These load plans were formulated using the methods outlined in MAC Pamphlet 50-13, dated 10 Oct 80, with guidance from personnel of the U.S. Air Force Loadmaster School at Pope Air Force Base, North Carolina. The load plans take into account the weight of the organizational equipment and personnel, aircraft floor loading, dimensions of the cargo spaces and the center of gravity location of the loaded aircraft. Two of the LAB vehicles, the M559 fuel service truck and the M816 wrecker apparently cannot be carried in the C-130 and will be driven to the destination. The number of sorties required and the times for each sortie for movement by C-130 are shown below:

TASK ORGANIZED COMPANY

EUROPE

Fourteen C-130 aircraft are required to move the company. The flight profile for one aircraft is:

EVENT		TIME (HOURS)
Take-Off		.08
Flight (52 Nmi/225 Knots)		.23
Approach		.12
Landing		.08
Unloading		.25
	TOTAL	.76

The aircraft will take off sequentially so that the take-off time of those planes following the lead plane will have to be added to the total time to compute movement time. It can be expected that 14 aircraft will be provided for this movement. Therefore: .76 + (13 x .08) = 1.8 hours total movement time. This time assumes that unloading can be accomplished without interference with flight operations.

TASK ORGANIZED COMPANY

MID-EAST

Single Sortie

EVENT	TIME (HOURS)
Take-off	.08
Flight (98 Nmi/225 Knots)	.44
Approach	.12
Landing	.08
Unloading	.25
TOTAL	.97

For 14 aircraft .97 + (13 x .08) = 2.0 hours total movement time. It is possible that the interval between take-offs is too large and that it may be adjusted downward depending on local conditions.

LIGHT ATTACK BATTALION

EUROPE

Seventy aircraft are required to move the Light Attack Battalion. In a movement of this urgency, it is probable that 70 aircraft would be furnished to effect the movement. However, the time involved in accomplishing a one sortie per plane movement, and the problems of handling 70 aircraft on what might prove to be a rather primitive airfield led to the decision by USAIS to consider movement at company strength by a squadron of 18 planes. Movement by squadron at company level is shown below:

LIGHT ATTACK BATTALION (COMPANY)

EUROPE

EVENT	TIME (HOURS)
Take-off	.08
Flight (52 Nmi/225 Knots)	.23
Approach	.12
Landing Time	.08
Unloading Time	.25
TOTAL	.76

For 18 aircraft .76 + (17 x .08) = 2. hours total company movement time.

It is evident that when take-off must be accomplished sequentially, the additional time required is substantial.

3.3 Movement of the Task Organized Company by UH-60 & UH-60(BI) Helicopter.

The 15 BLACK HAWKs assigned to transport the task organized company in general do not have the lift capability to move all of the company materiel. Versions of the BLACK HAWK considered were the UH-60A and the block improved UH-60. The block improved UH-60 included the external stores support system (ESSS) without stores and with two 230 gallon fuel tanks. For those cases where the BLACK HAWK cannot lift part of the materiel, the total number of sorties for the C-130 can be reduced by virtue of that part of the materiel and personnel that can be lifted by the BLACK HAWKs.

The payload radius capabilities of the various versions of the BLACK HAWK are shown in Figures 3, 4 and 5. Each figure fully explains the utility mission and highlights the block improvements. The block improved UH-60 is as prescribed in the 15 April 1982 ROC; the transmission limit and the engine power being established per the ROC. For this study, the lift off weight was determined on the basis of a 200 fpm vertical rate of climb (VROC) with 100 percent intermediate rated power (IRP). For slung load operations, VROC capability is certainly necessary. This criterion applied at 4,000 feet, 95°F where the continuous rating of the transmission equaled the IRP. At lower altitudes and temperatures (less than 4,000 feet, 95°F) the IRP exceeds the transmission power so the available power is limited to the transmission rating of 3190 SHP on the block improved UH-60.

From Figures 3, 4 and 5 the lift capabilities of the three BLACK HAWK versions were determined for the European and Mid-East operations. Whether in Europe or the Mid-East, any version of the BLACK HAWK has ample range capability for these operations and can sling load a FAV as well as carry the vehicle crew and additional infantrymen in the cabins. The normal fuel capacity of the BLACK HAWK is 362 gallons. Both in Europe and the Mid-East, the cruise fuel reserve plus mission fuel is considerably less than this normal fuel capacity.

Tables 11 through 17 present the mission capability of the BLACK HAWK. Only the block improved UH-60 (ESSS) without external fuel tanks, in the European operation, can lift all of the vehicles organic to the task organized company as shown in Table 12. It was necessary to decouple the trailers from the HMMWV in order to lift all the vehicles. A total of 43 sorties were needed and there was a potential cargo lift capability of 70,590 pounds. This lift is labeled "potential" because there was no available internal stowage for cargo and the sling was already occupied with the FAV, trailer, or HMMWV. Even the UH-60A had excess lift capability in the European area as can be seen on Table 11. One means of using some of this excess payload capability would be to fill the fuel tanks to their full capacity of 362 gallons and in actual practice this probably would be the procedure as the crews dislike fuel management missions which are required to achieve the payloads shown on Figures 3, 4 and 5. If full fuel is loaded at the start of the mission, then the payload would be flat across the range and correspond to the payload at the sharp break in the curves, shown on Figures 3, 4 and 5.

The external stores support system provides the answer to this excess payload capability of the block improved UH-60. Table 13 shows the mission

FIGURE 3

UH-60A

SLUNG PAYLOAD VERSUS RADIUS

SPECIAL UTILITY MISSION

1. TOTAL FUEL = 2,350 LBS.
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 F.P.M. AT T.O. WEIGHT
4. LIFT OFF AT 200 F.P.M. VERTICAL CLIMB @ IRP
5. CRUISE OUT WITH SLUNG LOAD (24 FT² FLAT PLATE AREA)
6. CRUISE BACK: CLEAN CONFIGURATION
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY = 11,555 LBS.
9. CRUISE AT 125 KNOTS T.A.S.

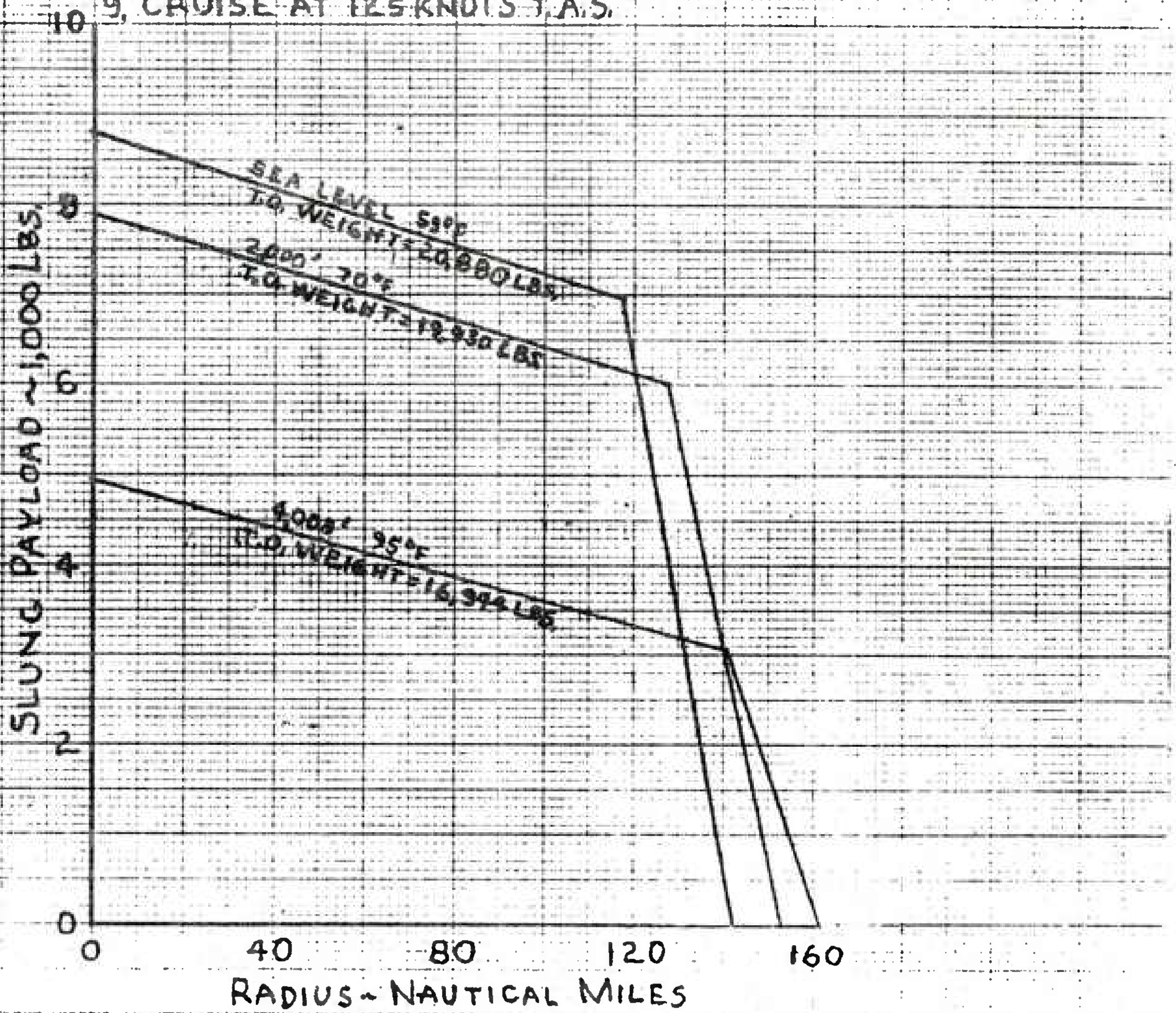

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FIGURE 4

BLOCK IMPROVED UH-60A (ESSS)
SLUNG PAYLOAD VERSUS RADIUS
SPECIAL UTILITY MISSION

1. TOTAL FUEL=2,350 LBS.
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 FPM. AT T.O. WEIGHT
4. LIFT OFF AT 200 F.P.M VERTICAL CLIMB @ IRP
5. CRUISE OUT WITH SLUNG LOAD (24 $\emptyset$ FLAT PLATE AREA)
6. CRUISE BACK: NO SLUNG LOAD
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY=12,531 LBS.
9. CRUISE AT 125 KNOTS TRUE AIRSPEED

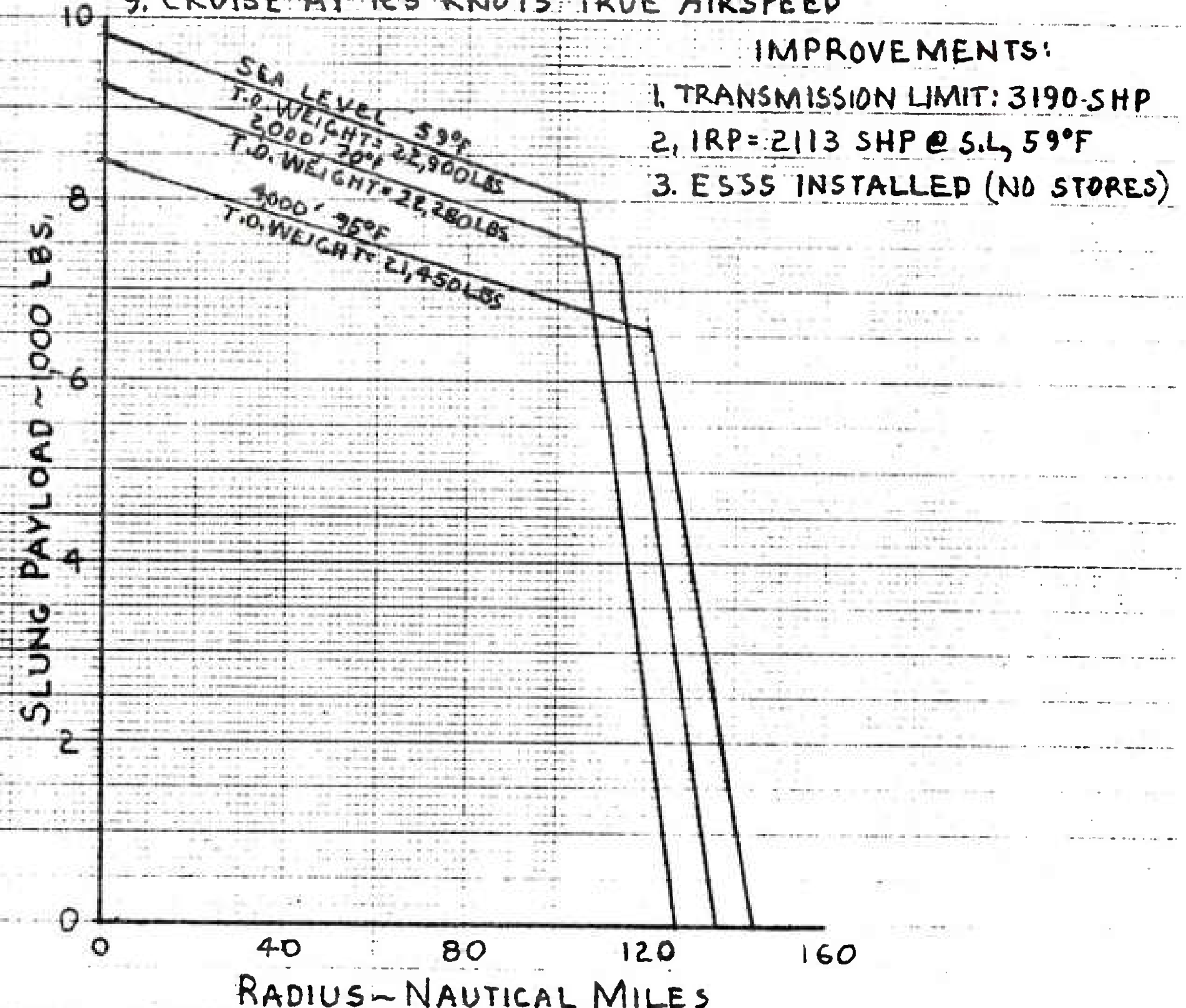

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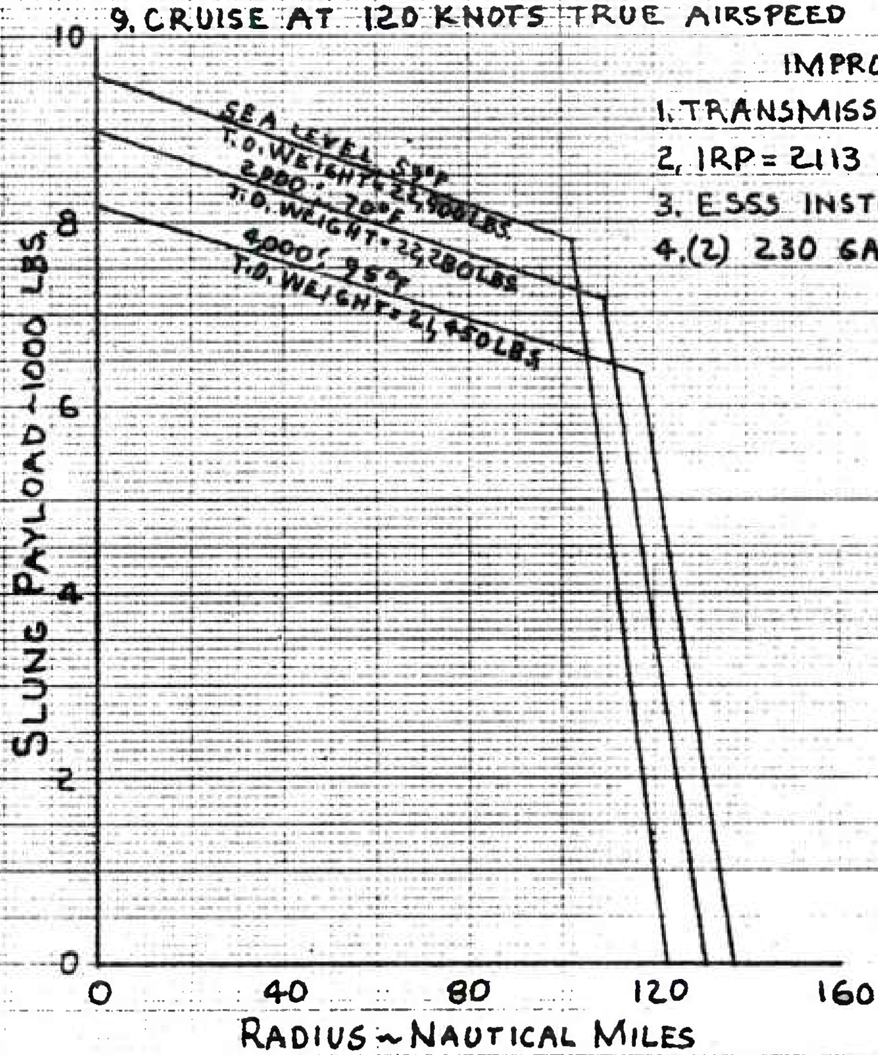
FIGURE 5

BLOCK IMPROVED UH-60A (ESSS+2-230 GAL. TANKS)
SLUNG PAYLOAD VERSUS RADIUS
SPECIAL UTILITY MISSION

1. TOTAL FUEL = 2,350 LBS.
2. 30 MINUTES FUEL RESERVE FOR CRUISE
3. FUEL FOR 2 MINUTES WARM UP AT MCP, 2 MINUTES HOGE AND 1 MINUTE CLIMB AT 200 F.P.M. AT T.O. WEIGHT
4. LIFT OFF AT 200 F.P.M. VERTICAL CLIMB @ IRP
5. CRUISE OUT WITH SLUNG LOAD (24 ☐' FLAT PLATE AREA)
6. CRUISE BACK: NO SLUNG LOAD
7. CRUISE AT T.O. ATMOSPHERIC CONDITIONS
8. OPERATING WEIGHT EMPTY = 12,751 LBS.
9. CRUISE AT 120 KNOTS TRUE AIRSPEED



IMPROVEMENTS
1. TRANSMISSION LIMIT ≤ 3190 SHP
2. IRP = 2113 SHP @ S.L., 59°F
3. ESSS INSTALLED
4. (2) 230 GAL. FUEL TANKS

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TABLE 11

MISSION CAPABILITY IN EUROPE

UH-60A

NO. OF SORTIES	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	0	0	15	30	195	24,000
7 SECOND	0	0	7	14	91	11,200
2 SECOND	0	2	0	0	30	1,440
24 TOTAL	0	2	22	44	316	36,640

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60A = 7,120 LBS
RADIUS =- 52 N. MI.
TOTAL FUEL REQUIRED = 4579 GALS (INCLUDES 1373 GALS, FOR 1/2-HOUR CRUISE RESERVE)
PER SORTIE FLIGHT TIME, LOAD TIME AND REFUEL TIME = 2.89 HOURS
TOTAL ELAPSED TIME FOR 24 SORTIES = 6.27 HOURS

TABLE 12

MISSION CAPABILITIES IN EUROPE

BLOCK IMPROVED UH-60 (ESSS)

NO. OF SORTIES	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	15	0	0	30	30	2,550
3 SECOND	3	0	0	6	6	510
2 SECOND	0	2	0	0	30	4,000
9 SECOND	0	0	9	18	117	25,920
13 THIRD	0	0	13	26	169	37,440
42 TOTAL	18	2	22	82	352	70,420

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60 = 8,400 LBS
RADIUS = 52 N. MI.
TOTAL FUEL REQUIRED = 8864 GALS (INCLUDES 2067 GALS, FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60's USED
PER SORTIE TIME FOR FLIGHT, LOAD/UNLOAD, AND REFUEL = 2.89 HOURS
TOTAL ELAPSED TIME FOR 43 SORTIES = 9.6 HOURS

TABLE 13

MISSION CAPABILITY IN EUROPE

BLOCK IMPROVED UH-60 (ESSS)
WITH TWO 230 GAL FUEL TANKS

NO. OF SORTIES	AVIATION FUEL GALS	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	6,900	0	0	15	30	165	1,050
7 SECOND	3,220	0	0	7	14	77	490
2 SECOND	920	0	2	0	0	18	300
24 TOTAL	11,040	0	2	22	44	260	1,840

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60 = 8100 LBS
RADIUS = 52 N. MI.
TOTAL FUEL REQUIRED = 5206 GALS (INCLUDES 1540 GALS, FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60's
PER SORTIE TIME FOR LIGHT, LOAD/UNLOAD AND REFUEL = 2.89 HOURS
TOTAL ELAPSED TIME FOR 24 SORTIES = 6.27 HOURS

capability with two 230 gallon fuel tanks (filled) mounted on the outboard pylon of the ESSS. While there may not be a need for aviation fuel during the operation, this loading was chosen as an example of the versatility of the ESSS. Alternatively, if vehicle fuel were required, the external tanks possibly could be used for non-aviation fuel. The ESSS can also carry 16 HELLFIRE missiles for supply purposes (but not for actual firing from the BLACK HAWK).

Table 14 shows the block improved BLACK HAWK operating in Europe with and without external tanks. The same total sorties are required as in Table 12 and all the vehicles of the task organized company are transported. The use of external tanks and/or other stores attached to the ESSS does exploit the potential cargo capability of the BLACK HAWK. Comparing Table 12 to Table 14 the potential cargo (read "unused capacity") is considerably reduced when the ESSS is utilized to carry payload.

In Mid-East operations, none of the BLACK HAWK versions can carry HMMWV's so that airlift must include C-130 aircraft at all times. Tables 15 through 17 show the capability of each version of the BLACK HAWK in the Mid-East. Even with the reduced capability due to the 4,000 feet 95°F take off conditions, there is 31,360 pounds potential cargo capability for 24 sorties with the block improved UH-60 (ESSS) as shown in Table 16. The benefit of carrying stores on the ESSS in reducing the unused payload capability is clearly seen on Table 17 where potential cargo is only 1,840 pounds due to transporting fully loaded 230 gallon fuel tanks or equivalent loads attached to the ESSS.

The fuel used, sortie time and total elapsed time for all sorties are given also on Tables 11 through 17. The notes fully explain the fuel used data. Sortie times were based upon information contained in Reference 1. Cargo load/unload time is .2 hours. For most of the missions, a combined payload of cargo and personnel was carried so the load/unload time was taken as 1.2 hours. Refueling time is .09 hours per helicopter and the refueling point can accommodate three aircraft for simultaneous refueling. Total flight time for the European mission is 1.6 hours and for the Mid-East is 2.4 hours. As noted on the appropriate tables, the total sortie time in Europe is 2.89 hours and in the Mid-East is 3.69 hours. Total elapsed times accounted for a maximum of 15 BLACK HAWK's simultaneouly employed.

3.4 Fuel Consumption Estimates.

Very limited data are available on fuel consumption rates of recent and proposed Army vehicles during road marches. The estimates provided in this report were developed by application of engineering judgement and experience to limited data obtained from the following sources:

VEHICLE	DATA SOURCE
FAV	FAV Project Mgr at Emerson Corporation
CUCV	Reference 3
HMMWV	Test Data from DT-II
M814 & M816	YPG Engineering Test Report (Ref 4)
M559	APG IPT Test Report (Ref 5)

TABLE 14

MISSION CAPABILITY IN EUROPE

BLOCK IMPROVED UH-60 (ESSS)

MIXED SORTIES: WITH/WITHOUT TWO 230 GAL. FUEL TANKS

NO. OF SORTIES	AVIATION FUEL GALS	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	0	15	0	0	30	30	2,550
3 SECOND	0	4	0	0	6	6	170
2 SECOND	920	0	2	0	0	18	300
9 SECOND	4,140	0	0	9	18	99	630
13 THIRD	5,980	0	0	13	26	143	910
42 TOTAL	11,040	18	2	22	80	296	4,900

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD WITHOUT EXTERNAL TANKS = 8,400 LBS
PAYLOAD WITH TWO EMPTY 230 GAL. FUEL TANKS = 8,100 LBS
RADIUS = 52 N. MI.
TOTAL FUEL REQUIRED = 9,122 GALS (INCLUDES 2453 GALS FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60's
PER SORTIE TIME FOR FLIGHT, LOAD/UNLOAD, AND REFUEL = 2.89 hours
total elapsed time for 43 SORTIES = 9.6 HOURS

TABLE 15

MISSION CAPABILITY IN MID-EAST

UH-60A

NO. OF SORTIES	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	0	0	15	30	75	300
7 SECOND	0	0	7	14	35	140
2 SECOND	0	2	0	0	6	200
24 TOTAL	0	2	22	44	116	640

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60A = 3,620 LBS
RADIUS = 98 N. MI.
TOTAL FUEL REQUIRED = 6,536 GALS (INCLUDES 1,333 GALS FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60A's
PER SORTIE TIME FOR FLIGHT, LOAD/UNLOAD, AND REFUEL = 3.69 HOURS
TOTAL ELAPSED TIME FOR 24 SORTIES = 7.87 HOURS

TABLE 16

MISSION CAPABILITY IN MID-EAST

BLOCK IMPROVED UH-60 (ESS)

NO. OF SORTIES	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	0	0	15	30	195	20,700
7 SECOND	0	0	7	14	91	9,660
2 SECOND	0	2	0	0	30	1,000
24 TOTAL	0	2	22	44	316	31,360

NOTE:
INFANTRYMAN WEIGHT = 240 LBS
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60 = 6,900 LBS
RADIUS = 98 N. MI.
TOTAL FUEL REQUIRED = 7568 GALS. (INCLUDES 1,496 GALS. FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60's
SORTIE TIIME FOR FLIGHT, LOAD/UNLOAD, AND REFUEL = 4.0 HOURS
TOTAL ELAPSED TIME FOR 24 SORTIES = 7.87 HOURS

TABLE 17

MISSION CAPABILITY IN MID-EAST

BLOCK IMPROVED UH-60 (ESSS) WITH TWO 230 GAL. FUEL TANKS

NO. OF SORTIES	AVIATION FUEL GALS	NO. OF HMMWV'S	NO. OF TRAILERS	NO. OF FAV'S	NO. OF VEHICLE CREWMEN	POTENTIAL NO. OF TROOPS	POTENTIAL CARGO LBS.
15 FIRST	6,900	0	0	15	30	75	1,050
7 SECOND	3,220	0	0	7	14	35	490
2 SECOND	920	0	2	0	0	6	300
24 TOTAL	11,040	0	2	22	44	116	1,840

NOTE:
INFANTRYMAN WEIGHT
ALL VEHICLES SLING LOADED
PAYLOAD PER UH-60 = 6,660 LBS
RADIUS = 98 N. MI.
TOTAL FUEL REQUIRED = 7,568 GALS(INCLUDES 1,496 GALS FOR 1/2-HOUR CRUISE RESERVE)
15 UH-60's
SORTIE TIME FOR FLIGHT, LOAD/UNLOAD, AND REFUEL = 4.0 HOURS
TOTAL ELAPSED TIME FOR 24 SORTIES = 7.887 HOURS

The routes established by the Mid-East and European scenarios were separated into seven conditions. Each of these requires a different rate of fuel consumption. These conditions are shown in Table 18 and amplified on the following page. Fuel consumption rates were estimated for all seven conditions and each of the 10 vehicle or vehicle/trailer combinations and are shown in Table 19. Knowing the distance traveled on each terrain condition, the fuel requirement for each vehicle was calculated. The sum of these requirements was compared to the fuel tank capacity of each vehicle. Only two require refueling, both in the Mid-East scenario. The M559 is a fuel tanker therefore it can refuel itself with only minor delays. The HMMWV should probably carry a 5-gallon can of fuel.

4. CONCLUSIONS

The performance of the Fast Attack Vehicle based on exercising it in the Army Mobility Model requires verification. Unique capabilities which this vehicle possesses may not be adequately expressed in terms of model output, nor is it known whether the conventional model inputs adequately reflect these capabilities. Extensive field testing of the vehicle is indicated.

The selection of the M559 as the fuel service truck for the LAB should be re-examined. This vehicle has a top speed of 30 mph and will certainly slow any planned rapid road movement. Furthermore, it cannot be transported in the C-130 aircraft, necessitating other means to assure its timely arrival at the destination. In general, performance of the organic vehicles showed them having capabilities adequate to perform the assigned transportation task.

The analysis of the effect of acceleration on hit probability shows that an immediate payoff for increased acceleration of a vehicle crossing a gap is a possible reduction of the number of shots fired at it. Increased speed results in a reduction of hit probability. The presented area is also a significant factor in determining hit probability. The small, fast FAV, when crossing the gaps of interest, has not only a lower hit probability than the HMMWV for a given shot, but also has fewer shots fired at it.

When road movement is undertaken, the travel times shown are for the first vehicle of the convoy. It is felt that these are truly representative, since the additional time required for the last vehicle in a convoy of even several miles length to complete the trip adds only several minutes to the trip time shown. On the other hand, movement by C-130 shows a substantial amount of time is required to accomplish a sequential take-off of the aircraft. This time, of course, can vary with the characteristics of the airfields at the points of departure and at the destination, but is included to indicate what conservatively can happen.

Attention is directed to the necessity of augmenting the helicopter lift of the task organized company in the Mid-East by C-130. These are required to carry the HMMWV's, a lift beyond the capability of the helicopters in this scenario.

All vehicles, except the HMMWV and the M559 in the Mid-East, are capable of making the road movements on integrally carried fuel. The M559 is a fuel service truck and can refuel itself. The HMMWV can supplement its fuel supply by fuel carried in cans.

TABLE 18

MOBILITY SCENARIO

All Distances in Kilometers (K)

AREA ONE: MID-EAST

ON-ROAD

265K - UNIMPROVED DIRT & GRAVEL ROAD OF WHICH,

COND 1	80K IS FLAT & OPEN
COND 2	25K IS GENTLE ROLLING
COND 3	160K IS MOUNTAINOUS WITH STEEP GRADES, HAIRPIN TURNS AND SWITCHBACKS

OFF-ROAD

COND 7	MANEUVERING IN ROUGH TERRAIN, MAINLY MOVING FROM ONE FIRING POSITION TO ANOTHER. TOTAL DISTANCE 5K

AREA TWO: EUROPE

ON-ROAD

COND 4	150K SUPERHIGHWAY
COND 5	3-5K SECONDARY ROADS PAVED
COND 6	1-3K TRAILS THROUGH UNDERBRUSH

OFF-ROAD

COND 7	AS ABOVE

(THE RATIONALE FOR THIS SCENARIO IS CONTAINED ON THE FOLLOWING PAGE.)

TABLE 18 RATIONALE
FOR FUEL CONSUMPTION ESTIMATES

CONDITION 1 - Flat, Open, Unimproved Dirt and Gravel Road

Since the slope is negligible, maximum speed will be a function of vehicle ride characteristics and surface roughness. The nature of the mission is such that maximum tolerable speeds will be maintained. The rough surface will hold those speeds to values which may well be near the vehicle's most economical speed range, but the engine must work harder than normally to overcome the high motion resistance of the rough terrain. This added effort shifts the engine to a higher fuel consumption range. Consideration of all these factors leads to the assumption that fuel consumption would be equal to that of a vehicle traversing a paved road at normal highway speeds.

CONDITION 2 - Gentle Rolling Unimproved Dirt and Gravel Roads

Traversing hilly terrain involves continual speed changes, frequent acceleration and constant gear shifting. Average speeds will be lower (less efficient operating range). Fuel consumption will be higher than under Condition 1.

CONDITION 3 - Mountainous Dirt and Gravel Road with Steep Grades, Hairpin Turns and Switchbacks

This is the most severe condition in terms of fuel consumption. Negotiating tight turns and steep grades requires operation in low gear and at low speeds. This combination leads to very poor fuel economy.

CONDITION 4 - Super-highway

Here, speed is limited by vehicle capability only. At top speeds fuel consumption is high because of higher motion resistance (to include air resistance) and higher engine and vehicle mechanical and thermodynamic losses. These losses while higher than those at best fuel economy conditions are still lower than those incurred under conditions 2 and 3.

CONDITION 5 - Secondary Road, Paved

Fuel consumption data for this condition were available from Yuma tests.

CONDITION 6 - Trails Through Underbrush

Yuma data for level cross-country were used. Yuma cross-country is relatively mild and thus equivalent to a trail.

CONDITION 7 - Maneuvering in Rough Terrain - Mainly Moving From One Firing Point to Another

It is very difficult to estimate fuel consumption under this condition. It involves backing, tight turns, rapid accelerations, idling and parking. Neither distance traveled or duration is provided in the scenario. It is unlikely, however, that any vehicle will use more than 3 gallons of fuel for this phase of the operation.

TABLE 19

FUEL CONSUMEO

MOBILITY CONOITION		OISTANCE TRAVELEO		FAV		CUCV		HMMWV		M814		M816		M559		M814 M107		M814 M416		M816 M116		M559 M101	
		KM	MILES	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL	MPG	GAL
MIOOLE EAST	1	80	50	21.0	2.4	13.1	3.8	9.0	5.5	5.5	10.1	5.5	10.1	2.2	25.2	3.0	18.5	3.0	18.5	3.0	18.5	1.2	46.2
	2	25	16	19	0.8	11.9	1.3	11.0	1.5	4.9	3.3	4.9	3.3	2.06	7.8	3.4	4.7	3.4	4.7	3.4	4.7	1.4	11.5
	3	160	100	10	10	8.5	11.8	5.0	20	3.3	30.0	3.3	30	1.65	61.0	2.7	38.0	2.7	38.0	2.7	38.0	1.3	77.0
SUBTOTAL		265	166	-	13.2	-	16.9	-	27	-	43.4	-	43.4	-	94.0	-	61.2	-	61.2	-	61.2	-	134.7
EUROPE	4	150	94	20.0	4.7	14.4	6.5	8.0	11.7	5.9	16.1	5.9	16.1	3.0	31.3	3.9	24.1	3.9	24.1	3.9	24.1	2.0	47.0
	5	5	3.1	21.5	0.14	14.4	0.21	8.0	0.39	5.9	0.53	5.9	0.53	3.0	1.03	3.9	0.8	3.9	0.8	3.9	0.8	2.0	1.55
	6	3	1.8	14	0.13	10.2	0.17	5.0	0.36	4.1	0.44	4.1	0.44	1.7	1.06	3.2	0.56	3.2	0.56	3.2	0.56	1.3	1.38
SUBTOTAL		158	98.9	-	4.97	-	6.88	-	12.45	-	17.07	-	17.07	-	33.39	-	25.46	-	25.46	-	25.46	-	49.93
	7	*		6	0.5	6.9	0.43	2.0	1.5	1.6	1.8	1.6	1.8	1.0	3.0	1.6	1.8	1.6	1.8	1.6	1.8	1.0	3.0
TOTALS		423	264.9	-	18.67	-	24.21	-	40.95	-	62.27	-	62.27	-	130.39	-	88.46	-	88.46	-	88.46	-	187.63
TOTAL FUEL REQUIREO-ME					13.7		17.3		28.5		45.2		45.2		97.0		63.0		63.0		63.0		137.7
TOTAL FUEL REQUIREO-EUR					5.5		7.3		13.9		18.9		18.7		36.4		27.3		27.3		27.3		52.9
FUEL CAPACITY IN GALLONS					16		31		25 EST		78		78		97.5		78		78		78		97.5
REFUELING REQUIRED-ME					NO		NO		YES		NO		NO		NO		NO		NO		NO		YES
REFUELING REQUIRED-EUR					NO		NO		NO		NO		NO		NO		NO		NO		NO		NO

*DISTANCE COVEREO IN CONOITION SEVEN IS NOT GIVEN. THE NATURE OF THE SCENARIO SUGGESTS THAT THE DISTANCE WILL BE VERY SHORT. A MAXIMUM OF 3 MILES WAS ASSUMEO. NOTE THAT THIS CONOITION IS FOUNO IN BOTH THE MID-EAST AND EUROPEAN SCENARIOS.

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