

Research Problem Review 78-9

LEVEL II

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# JUDGMENTAL COMPARISONS AMONG CARGO TRUCKS AND AMONG TRACTOR-TRAILERS

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ARI FIELD UNIT AT FORT HOOD, TEXAS

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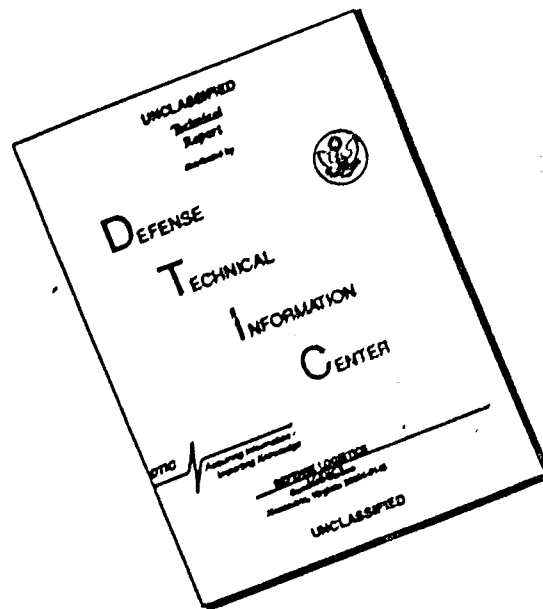
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16 Army Project Number  
2Q763743A775

Human Performance in  
Field Assessment

14 ART - Research Problem Review 78-9

6 JUDGMENTAL COMPARISONS AMONG CARGO TRUCKS  
AND AMONG TRACTOR-TRAILERS

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11 August 1978

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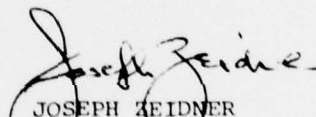
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## FOREWORD

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By assessing the human performance aspects of man/weapons systems in field situations, the Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides evaluation support to Headquarters, TRADOC Combined Arms Test Activity (TCATA), formerly Modern Army Selected Systems Test Evaluation and Review (MASSTER).

This ARI report supports MASSTER Test FM 265A (concerned with the impact of introducing high mobility vehicles into the Army fleet) by assessing the relative suitability of four cargo trucks (Lockheed Dragon Wagon, Caterpillar GOER, M813 5-ton, and M656 5-ton) and three tractor-trailer rigs (tractor-trailer configuration of Lockheed Dragon Wagon, GOER Flatbed, and M818 tractor with M127 semitrailer). The data provide input to mobility programs and are responsive to the objectives of Army Project 2Q763743A775, "Human Performance in Field Assessment."

  
JOSEPH ZEIDNER  
Technical Director (Designate)

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## JUDGMENTAL COMPARISONS AMONG CARGO TRUCKS AND AMONG TRACTOR-TRAILERS

### BRIEF

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The Requirement was

To assess for selected uses: (a) the comparative suitability of four cargo trucks and (b) the comparative suitability of three tractor-trailers. It also suggested additional uses for both types of vehicles.

The Procedure was

To assess the relative suitability of each vehicle, judges (MASSTER officers) ranked the vehicles according to preference for use in accomplishing specific tasks. The judges then suggested additional tasks for which the vehicles might be used. The cargo trucks compared were the Lockheed Dragon Wagon (DW), the Caterpillar GOER, the M813 5-ton truck, and the M656 5-ton truck. The tractor-trailers were the DW (in tractor-trailer configuration), the GOER Flatbed, and the M818 tractor with M127 semitrailer.

The principal findings for cargo trucks were

- The DW and M656 were equally ranked in 13 out of 20 tasks. Both were preferred to the M813 and GOER, which were also equally ranked.
- The DW, M656, and M813 were equally ranked for the other 7 tasks. All three were preferred to the GOER.
- Five additional uses for the cargo trucks were suggested.

The principal findings for tractor-trailers were

- The three tractor-trailers were equally ranked in 9 out of 10 tasks.
- Three additional uses for the tractor-trailers were suggested.

### Utilization of Findings:

The findings of this evaluation have been used in ongoing Army mobility studies and programs and have been incorporated into MASSTER Test Report FM 265A (Advanced Concept Vehicle--Cargo).

# JUDGMENTAL COMPARISONS AMONG CARGO TRUCKS AND AMONG TRACTOR-TRAILERS

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## JUDGMENTAL COMPARISONS AMONG CARGO TRUCKS AND AMONG TRACTOR-TRAILERS

### INTRODUCTION

This report supports MASSTER Test FM 265A ("Advanced Concept Vehicle--Cargo" [ACV-C]) conducted at Fort Hood, Tex., from 7 March to 12 September 1974. The purpose of FM 265A was to "investigate the impact of using 5- to 15-ton payload cargo vehicles with advanced state-of-the-art mobility and ride characteristics in divisional type units" and to "provide input to mobility programs and studies."<sup>1</sup> This test was part of an overall MASSTER program to evaluate high-mobility concepts and the effect of introducing such vehicles into the Army fleet.

### PURPOSE AND OBJECTIVES

The purpose of this study was to provide a judgmental assessment of the comparative suitability of certain cargo trucks and certain tractor-trailers for performing selected tasks within a combat division and to suggest additional uses for the vehicles. The objectives of the study were (a) to identify functional areas in which the capabilities of advanced concept vehicles may significantly enhance mission accomplishment and (b) to identify those functional requirements for which no capability now exists that may be satisfied by ACV-C.

### PROCEDURES

Four cargo trucks and three tractor-trailers were evaluated. The cargo trucks were the Lockheed Dragon Wagon (DW), the Caterpillar GOER, the M813 5-ton, and M656 5-ton. The tractor-trailers were the DW in tractor-trailer configuration, the GOER Flatbed, and the M818 tractor with M127 semitrailer.

To obtain judgmental comparisons among the cargo trucks and among the tractor-trailers, informed judges rank ordered each vehicle according to its perceived suitability for accomplishing certain tasks. Each of 15 judges rank ordered the four cargo trucks on 20 tasks. The tractor-trailers were rank ordered on 10 tasks by 13 different judges. A copy of the ranking form is provided in the Appendix. Two alternate versions of the ranking form were used. These differed only in the order of presentation of the vehicles to be ranked. This procedure was used to counteract any response bias that might result from order of presentation. Approximately half the judges completed the one form; the rest completed the other.

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<sup>1</sup> Berry, L. G. Advanced Concept Vehicle--Cargo (ACV-C). MASSTER Test Report No. FM 265A. Headquarters, MASSTER, Fort Hood, Tex., April 1975.



All judges were MASTER officers with no previous involvement in the ACV-C study. Prior to ranking the vehicles, the officers drove the vehicles. A 5-km driving course with secondary roads, cross-country terrain, and a 60 degree hill climb was used. Each judge traversed the course in each of the cargo trucks or in each of the tractor-trailer rigs. The sequence of vehicles was counterbalanced so that each judge rode the vehicles in a different sequence. After a judge had ridden in all four trucks or all three tractor-trailers, had examined the vehicles, and had all questions answered, the ranking form was compared. The ranking form instructed the judges to not only rank the vehicles but also to indicate which vehicles they believed should not be used for particular tasks. They were also asked to indicate additional tasks for which each vehicle could be used.

## RESULTS

The average (mean) ranks assigned to the vehicles on each task are shown (without parentheses) for cargo trucks in Table 1 and for tractor-trailers in Table 2.

The responses assigned to each item were analyzed by using the Friedman analysis of variance with ranks<sup>2</sup> to determine if the judges as a group tended to rank one vehicle over another on that task. The null hypothesis, tested at the .05 level, was that the mean ranks given to the vehicles were equal. For each item where the null hypothesis was rejected, multiple comparisons of all pairs of vehicles were performed, using the procedure described by Hollander and Wolfe<sup>3</sup> to determine specifically when vehicles were preferred over other vehicles. Again, the .05 level was used. The results of the analyses are presented in Tables 1 and 2 as sets of "derived ranks" (shown in parentheses) for each task.

These derived ranks represent the rank order of the observed means, taking into account the statistical significance of the differences among the observed means. For example, in item 1, Table 1, the mean ranks in columns 1 and 2 (1.57 and 1.70, respectively) were not significantly different from each other; nor were the means in columns 3 and 4 (3.33 and 3.40, respectively). However, the first two means were both significantly smaller (indicating greater preference) than both of the last two means. Therefore, ranks "1" and "2" (indicating "most preferred" and "next most preferred") were split evenly between the first two means by assigning each a derived rank of 1.5. Similarly, ranks "3" and "4" were split between the last two means by assigning both a derived rank of 3.5. Item 2 illustrates an instance in which the first three means were not significantly different from one another but were all significantly different

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<sup>2</sup> Siegel, S. Nonparametric Statistics. New York: McGraw-Hill, 1956.

<sup>3</sup> Hollander, M., and Wolfe, D. A. Nonparametric Statistical Methods. New York: Wiley & Sons, 1973.

Table 1  
Mean Observed Ranks<sup>a</sup> and Derived Ranks<sup>b</sup>  
for Cargo Trucks

Tasks	Trucks			
	DW	M656	M813	GOER
Within battalions				
1. Hauling ammo from supply point to fighting vehicle positions.	1.57 (1.5)	1.70 (1.5)	3.33 (3.5)	3.40 (3.5)
2. Hauling dry bulk supplies from brigade trains area to company/troop trains.	1.97 (2)	1.83 (2)	2.63 (2)	3.57 (4)
3. Delivering petroleum, oils, and lubricants (POL) from brigade trains to individual vehicle positions.	1.73 (1.5)	1.63 (1.5)	3.10 (3.5)	3.53 (3.5)
4. Operating as wrecker for company/troop maintenance section.	2.14 (2)	1.93 (2)	2.43 (2)	3.50 (4)
5. Operating as wrecker for battalion maintenance section.	2.32 (2)	1.82 (2)	2.50 (2)	3.36 (4)
6. Transporting troops.	1.80 (2)	1.70 (2)	2.67 (2)	3.83 (4)
7. Delivering mines/other barrier materials to barrier locations.	1.50 (1.5)	1.63 (1.5)	3.20 (3.5)	3.67 (3.5)
8. Following attacking armored columns with ammo and POL for immediate resupply (including cross-country).	1.33 (1.5)	1.80 (1.5)	3.23 (3.5)	3.63 (3.5)
Within division artillery				
9. Hauling ammo from supply point to batteries.	1.70 (1.5)	1.77 (1.5)	3.00 (3.5)	3.53 (3.5)

Table 1 (cont.)

Tasks	Trucks			
	DW	M656	M813	GOER
Within division artillery (cont.)				
10. Hauling dry bulk supplies to batteries.	1.71 (1.5)	1.57 (1.5)	3.00 (3.5)	3.71 (3.5)
11. Acting as towed artillery prime mover.	1.70 (2)	1.83 (2)	2.70 (2)	3.77 (4)
Within division support command				
12. Hauling dry bulk cargo to brigade trains.	1.71 (2)	2.00 (2)	2.54 (2)	3.75 (4)
13. Delivering mines/other barrier materials to barrier locations.	1.54 (1.5)	1.75 (1.5)	3.00 (3.5)	3.71 (3.5)
14. Operating as wrecker for transportation and ordnance battalion.	2.54 (2)	1.71 (2)	2.25 (2)	3.50 (4)
Within division engineer battalion				
15. Delivering bridging materials to site of water barriers.	1.79 (1.5)	1.82 (1.5)	3.07 (3.5)	3.32 (3.5)
16. Delivering mines/other barrier materials to barrier locations.	1.75 (1.5)	1.71 (1.5)	3.04 (3.5)	3.50 (3.5)
Additional tasks				
17. Carrying equipment that requires soft ride, e.g., computer, radar.	1.20 (1.5)	1.87 (1.5)	3.33 <sup>d</sup> (3.5)	3.60 <sup>c</sup> (3.5)

Table 1 (cont.)

Tasks	Trucks			
	DW	M656	M813	GOER
Additional tasks (cont.)				
18. Serving as mobile command post for brigade or battalion headquarters.	1.37 (1.5)	1.87 (1.5)	3.20 <sup>d</sup> (3.5)	3.57 <sup>c</sup> (3.5)
19. Hauling ammo, fuel, dry cargo beach or other water-sand environment.	1.60 (1.5)	1.87 (1.5)	3.57 <sup>d</sup> (3.5)	2.97 (3.5)
20. Establishing/resupplying forward area rearming/refueling points (FARRP). <sup>e</sup>	1.54 (1.5)	1.57 (1.5)	3.14 (3.5)	3.75 (3.5)

Note. Smaller numerical values indicate more preferred; larger, less preferred.

<sup>a</sup> Shown without parentheses.

<sup>b</sup> Shown in parentheses.

<sup>c</sup> At least 3 of the 15 judges indicated that the GOER should not be used for this task.

<sup>d</sup> At least 3 of the 15 judges indicated that the M813 should not be used for this task.

<sup>e</sup> A FARRP consists of a 14- to 17-man team of specialists with POL, ammo and equipment designed to rapidly refuel and rearm several attack helicopters simultaneously. A FARRP is located closer (10-15 km) to the line of contact than normal aviation support areas and must be able to displace rapidly.



Table 2  
Mean Observed Ranks<sup>a</sup> and Derived Ranks<sup>b</sup>  
for Tractor-Trailers

Tasks	Rigs		
	DW	M818	GOER
Within division artillery			
1. Hauling gasoline tank trailers to the batteries.	2.08 (2)	2.17 (2)	1.75 (2)
2. Hauling stake and platform trailers with ammo.	2.17 (2)	2.00 (2)	1.83 (2)
Within division support command			
3. Hauling gasoline tank trailers from petroleum, oils, and lubricants (POL) point to brigade trains.	2.15 (2)	1.62 (2)	2.23 (2)
4. Hauling gasoline tank trailers from POL point to battalion level.	2.19 (2)	2.19 (2)	1.62 (2)
5. Hauling stake and platform trailers with bulk cargo.	2.17 (2)	1.83 (2)	2.00 (2)
6. Hauling low-boy trailers with heavy equipment.	2.23 (2)	1.85 (2)	1.92 (2)
7. Evacuating damaged vehicles from company/battalion trains area with stake and platform trailer or low-boy.	2.12 (2)	2.12 (2)	1.77 (2)
8. Transporting troops.	1.42 (1)	2.00 (2)	2.58 <sup>c</sup> (3)
Within division engineer battalion			
9. Transporting construction equipment cross-country.	1.92 (2)	2.23 (2)	1.85 (2)

Table 2 (cont.)

Tasks	Rigs		
	DW	M818	GOER
Additional tasks			
10. Hauling tracked vehicles on flatbed semitrailer for rapid movement to forward battle area and extending track life.	2.15 (2)	2.00 (2)	1.85 (2)

Note. Smaller numerical values indicate more preferred; larger less preferred.

<sup>a</sup> Shown without parentheses.

<sup>b</sup> Shown in parentheses.

<sup>c</sup> At least 3 of the 13 judges indicated that the GOER should not be used for this task.

from the fourth mean. Thus a derived rank of "4" was assigned the last mean, and the ranks "1," "2," and "3" were split evenly among the first three means by assigning each a derived rank of "2."

The derived ranks (Table 1) indicate that the DW and the M656 were equally preferred over the M813 and GOER in 13 of the 20 truck tasks. On the remaining 7 truck tasks, the DW, M656, and M813 were equally preferred over the GOER. The GOER was consistently rated lowest on all tasks. Three or more of the 15 judges indicated the GOER to be suitable for each of five different tasks (1, 6, 11, 17, and 18). Three or more of the judges indicated the M813 to be unsuitable for each of three different tasks (17, 18, and 19).

Table 2 indicates that on 9 of the 10 tasks for tractor-trailer rigs, the differences in mean ranks are not significant at the .05 level. However, on task 8 ("transporting troops") the DW was considered most suitable and the M813 was ranked second. The GOER was ranked third and judged not acceptable for the task by 3 or more of the 13 judges.

When completing the ranking forms, judges suggested additional uses for the vehicles under consideration. Those suggestions are presented in Table 3. Each suggestion was made by one or more judges. Table 3 also indicates whether or not a particular vehicle was preferred for the suggested use and, if so, which vehicle was preferred.

#### CONCLUSIONS

The officer-judges preferred the DW and the M656 cargo trucks to both the M813 and GOER for a large number of tasks. The GOER was least preferred overall. When the tractor-trailer rigs were considered, however, a preference difference among vehicles occurred on only one task. Preference on one task is considered insufficient evidence for choosing among the three rigs.

Table 3

## Additional Uses for Vehicles Suggested by Judges

Suggested additional tasks	Preferred vehicle
For cargo trucks	
Within battallions:	
Serving as carrier for mobile field kitchens	None
Within division artillery:	
Transporting nuclear weapons	M656
Transporting missile stages	M656
Within division support command:	
Serving as carrier for various vans (e.g., shop, electronics)	DW
Evacuating wounded to/from medical battalion	DW
For tractor-trailers	
Hauling preloaded ammo trailers from battalion combat trains to company troop area	GOER
Serving as antiaircraft weapons bed	None
Evacuating downed aircraft from limited access areas	GOER



## APPENDIX

### SAMPLE VEHICLE RANKING FORM

#### APPLICATIONS OF HIGH MOBILITY CARGO VEHICLES

Name \_\_\_\_\_ Grade \_\_\_\_\_ SSAN \_\_\_\_\_  
MOS \_\_\_\_\_ Position in unit \_\_\_\_\_

1. Below are listed a number of tasks within a mechanized infantry or armor division in which cargo vehicles (5-ton, Dragon Wagon, GOER, M656) might be used. Based on the information you now have about these vehicles and given the scenario below, complete the following two steps for each task listed.

STEP 1: Rank the vehicles according to which you would prefer for each task. Put a rank of 1 on the line for the vehicle you would most prefer for the task, a rank of 2 on the line for the vehicle you would prefer second, and continue to rank until each vehicle has been given a number. If you have equal preference for two vehicles, give them the same rank. If you do not have sufficient knowledge of a task to rank any of the vehicles on it, put a question mark (?) behind the task.

STEP 2: If you believe that any of the four vehicles should not be used for a particular task, put an X beside the number which you gave to the vehicle on that task (for example, if in your opinion the vehicle you ranked 4th for a task should not be used for that task, you would put 4X on the line).

#### SCENARIO:

The division is deployed in a mid-intensity conflict in Central Europe. The terrain varies from low plains in the north to high steep hills in the south with numerous rivers, streams, and canals. Vegetation varies from sparsely wooded plains to densely covered hills. The climate is generally temperate. Precipitation averages 30 inches annually distributed over four seasons. Slow rains and drizzles are common. During periods of maximum precipitation, areas other than major roads would present difficulties for ground vehicles. Numerous small villages, towns, and cities dot the area. An extensive road network is available, but can be cut or damaged by aggressor aircraft and artillery. Therefore, extensive cross-country travel will be required to reach forward areas of the battlefields.

	DRAGON WAGON	5-TON	GOER	M656
<u>A. Tasks within the battalions.</u>				
(1) In truck mode				
(a) Hauling ammunition from the ammo supply point to fighting vehicle positions.	_____	_____	_____	_____
(b) Hauling dry bulk supplies from brigade trains area to company/ troop trains.	_____	_____	_____	_____
(c) Delivering POL from brigade trains to individual vehicle positions.	_____	_____	_____	_____
(d) Operating as a wrecker for the company/troop maintenance section.	_____	_____	_____	_____
(e) Operating as a wrecker for the battalion maintenance section.	_____	_____	_____	_____
(f) Transporting troops.	_____	_____	_____	_____
(g) Delivering mines and other barrier materials to barrier locations.	_____	_____	_____	_____
(h) Following attacking armored columns with ammunition and POL for immediate resupply (including cross-country).	_____	_____	_____	_____
<u>B. Tasks within the DIVARTY.</u>				
(1) In truck mode				
(a) Hauling ammunition from ammo supply point to batteries.	_____	_____	_____	_____
(b) Hauling dry bulk supplies to batteries.	_____	_____	_____	_____
(c) Acting as a towed artillery prime mover.	_____	_____	_____	_____

	DRAGON WAGON	5-TON	GOER	M656
<u>B. Tasks within the DIVARTY (cont).</u>				
(2) In tractor mode				
(a) Hauling gasoline tank trailers to the batteries.	_____	_____	_____	N/A
(b) Hauling stake and platform trailers with ammunition.	_____	_____	_____	N/A
<u>C. Tasks within the DISCOM.</u>				
(1) In truck mode				
(a) Hauling dry bulk cargo down to brigade trains.	_____	_____	_____	_____
(b) Delivering mines and other barrier materials to barrier locations.	_____	_____	_____	_____
(c) Operating as a wrecker for the transportation and ordnance battalion.	_____	_____	_____	_____
(2) In tractor mode				
(a) Hauling gasoline tank trailers from POL point to brigade trains.	_____	_____	_____	N/A
(b) Hauling gasoline tank trailers from POL point to battalion level.	_____	_____	_____	N/A
(c) Hauling stake and platform trailers with bulk cargo.	_____	_____	_____	N/A
(d) Hauling low-boy trailers with heavy equipment.	_____	_____	_____	N/A
(e) Evacuating damaged vehicles from company/battalion trains area with stake and platform trailer or low-boy.	_____	_____	_____	N/A
(f) Transporting troops.	_____	_____	_____	N/A

DRAGON WAGON	5-TON	GOER	M656
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D. Tasks within the division engineer battalion.

(1) In truck mode

(a) Delivering bridging materials to site of water barriers.

_____	_____	_____	_____
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(b) Delivering mines and other barrier materials to barrier locations.

_____	_____	_____	_____
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(2) In tractor mode

Transporting construction equipment cross-country.

_____	_____	_____	N/A
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2. The listing above may not include all the tasks within a division in which cargo vehicles (trucks and tractor-trailers) could be employed. Please list any additional tasks you are aware of and indicate whether the 5-ton, Dragon Wagon, GOER, M656 or some combination of the four should be used.

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3. In addition to being employed in normal tasks within the division, the high mobility cargo vehicles (Dragon Wagon, GOER, M656) might be used to do new tasks that the 5-ton Truck is not designed for. Some possible new tasks are listed below. Please rank (1, 2, 3, or 4) the vehicles according to which you would prefer for each task. Put an X beside the number for any vehicle that should not be used for the task.

	DRAGON WAGON	5-TON	GOER	M656
<u>In truck mode</u>				
(a) Carrying equipment which requires a soft ride, such as a computer or a radar.	_____	_____	_____	_____
(b) Serving as a mobile command post for brigade or battalion headquarters.	_____	_____	_____	_____
(c) Hauling ammunition, fuel, and dry cargo over the beach or in other water/sand environment.	_____	_____	_____	_____
(d) Establishing and resupplying forward area rearming and refueling points (FARRP).	_____	_____	_____	_____

NOTE: A FARRP consists of a 14-to-17-man team of specialists with POL, ammo, and equipment designed to rapidly refuel and rearm several attack helicopters simultaneously. A FARRP is located closer (10-15 km) to the line of contact than normal aviation support areas and must be able to displace rapidly.

In tractor mode

(a) Hauling tracked vehicles on a flatbed semitrailer for rapid movement to forward battle areas and to extend track life.	_____	_____	_____	N/A
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4. What additional new tasks would you suggest for high mobility cargo vehicles? Indicate whether the Dragon Wagon, GOER, or M656 would be the better vehicle for the task.

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