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TRASANA

TECHNICAL REPORT NO. 6-75

M113A1 DAY/NIGHT MOVEMENT RATE ANALYSIS

PREPARED BY

R. B. COOPER

JUNE 1975

DEPARTMENT OF THE ARMY
US ARMY TRADOC SYSTEMS ANALYSIS ACTIVITY
WHITE SANDS MISSILE RANGE
NEW MEXICO 88002

DISPOSITION

This report was prepared for the US Army Armor School (USAARMS) in support of the Armored Reconnaissance Sc[redacted]t Vehicle Task Force (ARSVTF). [redacted]

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position.

WARNING

Information and data contained in this document are based on the input available at the time of preparation. The results may be subject to change and should not be construed as representing the TRADOC position unless so specified.

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ARMORED SYSTEMS DIRECTORATE

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1.0 PURPOSE

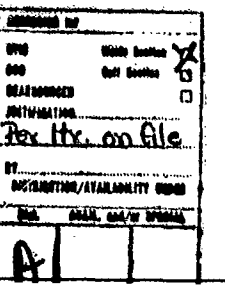
This report describes the analysis that the US Army TRADOC Systems Analysis Activity (TRASANA) performed of the results of the M113A1 Armor Personnel Carrier (APC) day and night mobility tests. The objective was to determine whether there was any degradation in the night movement rates of the vehicle as compared to day movement rates. The tests were conducted over a defined field test course.

2.0 DISCUSSION

2.1 Background

a. The night test data gathered during the CY 74 Armored Reconnaissance Scout Vehicle (ARSV) Force Development Test and Experimentation (FDTE) phase was suspect in some areas due to the varied conditions under which the test data was obtained, i.e., lights on, lights off, and checkpoints missed. Further, the 1974 FDTE day/night tests were conducted on different terrain, which precluded an analysis whereby day and night traverse rates could be compared directly.

b. The test described in this report was conducted to alleviate the problem areas mentioned above and to provide the magnitude of degradation between day and night movement rates for input to the ARSV cost and operational effectiveness analysis (COEA).



2.2 Test Procedures

a. Two M113A1 APCs, 14 drivers, and 14 Tank Commanders (TCs) were used for the test conducted at Fort Knox, KY, during the period 12-15 May 75. The test course was the ARSV FDTE night course, Events 8, 9, and 10.

b. The 14 drivers and TCs were equally divided into Groups A and B. Each group traversed the course once during the day and once during the night, for a total of 14 iterations each for day and night comparisons.

c. Optical aids were not used during the test runs, and blackout markers were the only vehicle lights used during the night runs (for safety in case of other vehicular traffic in the area).

d. Each vehicle traversed the course using the path of the preceding vehicle, i.e., no "free play" in selecting a route was permitted. The test course varied from cross-country, hilly, and wooded terrain to secondary, level gravel roads. Events 8, 9, and 10 were 1.3, 4.2, and 4.6 miles long, respectively, for a total course length of 10.1 miles. The test crews started each run separated by 30-minute intervals. A data collector was aboard each vehicle to record event-traverse times and to insure the vehicle stayed on course.

2.3 Environment

Each day and night course was run under dry weather conditions except for light rain during the second day of testing. For the night runs, the moon was one day into the first quarter, thereby providing minimal ambient light conditions. Night lumen levels were not measured during the test.

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2.4 Method of Analysis

The data analysis consisted of statistical comparisons involving a two-way analysis of variance (ANOVA) to determine whether there was a significant difference across course events and day-versus-night traverse rates, a one-way ANOVA across course events, and a one-way ANOVA between day-versus-night traverse rates. The associated least significant differences were also calculated in each case.

2.5 Analysis Summary

a. Analysis of the May 75 data showed that the day traverse rates were significantly faster than the night rates and that there was no significant difference between the two night runs. However, significant differences were noted when the two day runs were analyzed, as shown in Table I.

TABLE I

EVENT SPEEDS (MPH)

EVENT	8	9	10	OVERALL AVERAGE
Day	12.40	12.50	16.26	13.39
Night	9.68	8.65	10.71	9.68

The average speeds indicate that overall, the night runs were 27% slower than the day runs. Group B traversed the day course in the rain, and it was thought that traverse rates would be significantly slower than those of Group A under dry conditions. Group B had prior knowledge of the course since this group had traversed it during the first night of

testing. This could possibly indicate some "course learning" or a lessening of normal caution on the course since the crews had already negotiated it under blackout conditions.

b. Since Group A had prior knowledge of the day course, it was felt that this group would be able to traverse the course at night much faster than Group B. However, no significant differences were noted between the two groups, thereby indicating a possible limit when driving under blackout conditions.

c. A later data comparison between the M113A1 ARSV night traverse speeds for Events 8, 9, and 10 during CY 74 and the M113A1 night runs in May 75 shows no overall significant difference in the speeds. The average speeds for FY 74 and May 75 were 9.87 and 9.68 mph, respectively. However, a significant difference did exist between Events 8 and 10 when analyzing the results on an event-by-event basis (See Table II).

d. The statistical analyses for the day/night tests are summarized in Tables II and III, and reduced event data is listed in Table IV. The raw test data is listed in Tables V through VIII.

3.0 CONCLUSIONS

Based on the foregoing discussion, it is concluded that:

a. A definite degradation in driving speed is noted when crews are subjected to blackout, night driving conditions as opposed to the speed over similar terrain during the daylight hours.

b. During night driving operations, limited prior knowledge of the course does not necessarily result in significantly faster movement rates, i.e., a visual or mental limit of night driving capability may exist irrespective of the vehicle speed capabilities for a given terrain.

c. Course learning or increased driver confidence level was evident when there was prior course knowledge applied to daytime driving conditions.

TABLE II

MEAN COMPARISON SUMMARY – SPEED

	DAY 75		NIGHT 75		NIGHT 74
EVENT 8	$\bar{x}$ = 12.40	>	$\bar{x}$ = 9.68	>	$\bar{x}$ = 8.17
	s = 1.18		s = 1.52		s = 1.90
	n = 14		n = 14		n = 9
EVENT 9	$\bar{x}$ = 12.50	>	$\bar{x}$ = 8.65	=	$\bar{x}$ = 8.98
	s = 1.63		s = 1.12		s = 1.92
	n = 14		n = 14		n = 8
EVENT 10	$\bar{x}$ = 15.26	>	$\bar{x}$ = 10.71	<	$\bar{x}$ = 12.48
	s = 1.44		s = 1.09		s = 1.52
	n = 14		n = 14		n = 9
ACROSS EVENTS	$\bar{x}$ = 13.39	>	$\bar{x}$ = 9.68	=	$\bar{x}$ = 9.87
	n = 42		n = 42		n = 26

$\bar{x}$ - mean speed, mph
s - standard deviation
n - sample size
> - significantly greater than
< - significantly less than
= - not significant

TABLE III

COMPARISON SUMMARY – GROUPS FOR DAY/NIGHT

	DAY 75 GROUP A		DAY 75 GROUP B		NIGHT 75 GROUP A		NIGHT 75 GROUP B
EVENT 8	$\bar{x}$ = 12.04	<	$\bar{x}$ = 12.77		$\bar{x}$ = 9.58	≈	$\bar{x}$ = 9.77
	s = 1.45		s = 0.66		s = 1.76		s = 1.23
	n = 7		n = 7		n = 7		n = 7
EVENT 9	$\bar{x}$ = 12.08	≈	$\bar{x}$ = 12.93		$\bar{x}$ = 8.24	≈	$\bar{x}$ = 9.07
	s = 1.99		s = 0.98		s = 0.99		s = 1.09
	n = 7		n = 7		n = 7		n = 7
EVENT 10	$\bar{x}$ = 14.39	<	$\bar{x}$ = 16.13		$\bar{x}$ = 10.44	≈	$\bar{x}$ = 10.98
	s = 1.32		s = 0.93		s = 1.33		s = 0.68
	n = 7		n = 7		n = 7		n = 7
ACROSS EVENTS	$\bar{x}$ = 12.83	<	$\bar{x}$ = 13.94		$\bar{x}$ = 9.42	≈	$\bar{x}$ = 9.94
	n = 21		n = 21		n = 21		n = 21

$\bar{x}$ - mean speed, mph

s - standard deviation

n - sample size

\> - significantly greater than

< - significantly less than

≈ - not significant

TABLE IV

REDUCED EVENT DATA

M113 DAY/NIGHT	EVENT 8		EVENT 9		EVENT 10	
DAY RUNS	TIME (MIN SEC)	SPEED (MPH)	TIME (MIN SEC)	SPEED (MPH)	TIME (MIN SEC)	SPEED (MPH)
FIRST DAY RUN						
TEAM 1A	5.47	13.49	17.20	14.54	19.34	14.11
2A	6.32	11.94	20.13	12.46	18.34	14.87
3A	5.48	13.45	18.41	13.49	16.59	16.25
4A	6.21	12.28	20.32	12.27	18.52	14.63
5A	7.53	9.89	27.49	9.06	20.50	13.25
6A	5.52	13.29	18.39	13.51	17.43	15.58
7A	7.51	9.94	27.23	9.20	22.59	12.01
SECOND DAY RUN						
TEAM 1B	5.54	13.22	19.44	12.77	17.29	15.79
2B	6.34	11.88	20.44	12.15	17.48	15.67
3B	6.9	12.68	19.25	12.98	16.16	16.97
4B	6.10	12.65	21.26	11.76	17.44	15.56
5B	5.51	13.33	17.53	14.09	18.1	15.32
6B	6.34	11.88	20.42	12.17	17.34	15.71
7B	8.41	13.72	17.15	14.61	16.18	18.04
FIRST NIGHT RUN						
TEAM 1B	6.40	11.7	27.10	9.27	27.8	10.22
2B	9.15	8.43	23.54	10.54	23.20	11.83
3B	7.45	10.06	24.40	10.22	22.59	12.01
4B	9.24	8.3	29.40	8.49	26.23	10.46
5B	8.83	8.78	36.13	6.46	26.40	10.35
6B	7.47	10.02	27.53	9.04	25.57	10.64
7B	7.1	11.12	28.9	8.95	24.22	11.33
SECOND NIGHT RUN						
TEAM 1A	7.29	10.42	29.27	8.56	26.11	10.54
2A	8.54	8.76	31.24	8.03	26.19	10.44
3A	6.15	12.48	25.50	9.75	23.18	11.85
4A	8.59	8.68	38.4	6.45	35.0	7.89
5A	9.19	8.37	32.0	7.87	24.39	11.20
6A	6.52	11.36	27.27	9.18	23.20	11.83
7A	11.7	7.02	32.8	7.84	29.49	9.26

TABLE V

M113 DAY/NIGHT TEST – NIGHT RUN 1 – 13 MAY 75

	TEAM 1B		TEAM 2B		TEAM 3B		TEAM 4B		TEAM 5B		TEAM 6B		TEAM 7B	
	MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST	
EVENT 8														
START-CP1	1'23	0.4	2:05	0.4	1'05	0.4	2'50	0.4	2'12	0.4	1'25	0.4	1'43	0.4
CP1 - CPA	1'35	0.4	3'07	0.4	3'30	0.4	3'20	0.4	3'27	0.4	3'32	0.4	2'49	0.4
CPA - CP2	2'39	0.3	2'56	0.3	1'55	0.3	2'04	0.3	2'07	0.3	1'47	0.3	1'30	0.3
CP2 - END	1'02	0.2	1'07	0.2	1'15	0.2	1'10	0.2	1'07	0.2	1'03	0.2	0'59	0 2
EVENT 9														
START-CP8	2'44	0.3	2'01	0.3	1'59	0.3	3'0	0.3	2'45	0.3	2'02	0.3	2'09	0.3
CP8 - CP1	2'53	1.0	6'32	1.0	7'19	1.0	9'0	1.0	8'53	1.0	7'29	1.0	7'54	1.0
CP1 - CP2	4'03	0.7	3'56	0.7	4'34	0.7	4'52	0.7	5'05	0.7	4'14	0.7	4'45	0.7
CP2 - CPC	3'30	0.4	2'10	0.4	1'42	0.4	2'09	0.4	3'17	0.4	2'50	0.4	2'14	0.4
CPC - CP9	1'59	0.2	0'35	0.2	0'41	0.2	1'39	0.2	0'37	0.2	0'47	0.2	1'42	0.2
CP9 - END	11'56	1.6	8'40	1.6	8'25	1.6	9'00	1.6	15'36	1.6	10'31	1.6	9'25	1.6
EVENT 10														
START-CP1	3'12	0.6	2'25	0.6	3'21	0.6	3'05	0.6	4'11	0.6	3'32	0.6	3'07	0.6
CP1 - CP2	1'20	0.4	1'25	0.4	1'05	0.4	1'24	0.4	1'27	0.4	1'17	0.4	1'16	0.4
CP2 - CP3	6'49	1.7	6'55	1.7	5'29	1.7	5'20	1.7	5'54	1.7	6'15	1.7	5'43	1.7
CP3 - CPE	7'5	1.0	6'34	1.0	6'39	1.0	8'28	1.0	7'32	1.0	6'58	1.0	7'06	1.0
CPE - CPF	1'37	0.1	0'30	0.1	0'44	0.1	1'45	0.1	0'38	0.1	0'43	0.1	1'45	0.1
CPF - END	6'20	0.8	5'30	0.8	5'41	0.8	6'20	0.8	6'58	0.8	7'12	0.8	5'25	0.8

TABLE VI

M113 DAY/NIGHT TEST – DAY RUN 1 – 13 MAY 75

	TEAM 1A		TEAM 2A		TEAM 3A		TEAM 4A		TEAM 5A		TEAM 6A		TEAM 7A	
	MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST	
EVENT 8														
START-CP1	1'33	0.4	1'25	0.4	1'20	0.4	1'20	0.4	1'31	0.4	1'15	0.4	1'31	0.4
CP1 - CPA	2'00	0.4	2'42	0.4	2'26	0.4	2'44	0.4	2'55	0.4	2'30	0.4	3'15	0.4
CPA - CP2	1'17	0.3	1'15	0.3	1'08	0.3	1'15	0.3	2'05	0.3	1'12	0.3	2'11	0.3
CP2 - END	0'57	0.2	1'10	0.2	0'54	0.2	1'02	0.2	1'22	0.2	0'55	0.2	0'54	0.2
EVENT 9														
START-CP8	1'08	0.3	1'30	0.3	1'20	0.3	1'39	0.3	2'22	0.3	1'31	0.3	2'31	0.3
CP8 - CP1	3'30	1.0	5'41	1.0	5'49	1.0	6'04	1.0	8'15	1.0	5'01	1.0	7'04	1.0
CP1 - CP2	3'09	0.7	3'25	0.7	2'51	0.7	3'09.	0.7	4'26	0.7	3'09	0.7	4'16	0.7
CP2 - CPC	1'41	0.4	2'02	0.4	1'39	0.4	1'52	0.4	2'20	0.4	1'46	0.4	3'41	0.7
CPC - CPD	0'57	0.2	0'25	0.2	0'35	0.2	0'38	0.2	0'41	0.2	0'33	0.2	0'34	0.7
CPD - END	7'15	1.6	7'10	1.6	6'17	1.6	7'10	1.6	9'45	1.6	6'39	1.6	9'17	1.6
EVENT 10														
START-CP1	2'18	0.6	2'34	0.6	2'05	0.6	2'29	0.6	2'52	0.6	2'12	0.6	2'57	0.6
CP1 - CP2	1'02	0.3	1'10	0.3	1'03	0.3	1'05	0.3	1'15	0.3	1'02	0.3	1'07	0.3
CP2 - CP3	4'35	1.7	4'54	1.7	4'26	1.7	4'37	1.7	5'35	1.7	4'57	1.7	5'35	1.7
CP3 - CPE	6'45	1.0	5'30	1.0	4'54	1.0	5'38	1.0	6'09	1.0	5'14	1.0	7'04	1.0
CPE - CPF	0'30	0.1	0'34	0.2	0'35	0.2	0'36	0.2	0'36	0.2	0'34	0.2	0'45	0.2
CPF - END	4'24	0.8	3'52	0.8	3'55	0.8	4'27	0.8	4'23	0.8	3'34	0.8	5'31	0.8

TABLE VII

M113 DAY/NIGHT TEST – NIGHT RUN 2 – 14 MAY 75

	TEAM 1A		TEAM 2A		TEAM 3A		TEAM 4A		TEAM 5A		TEAM 6A		TEAM 7A	
	MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST		MIN/SEC/DIST	
EVENT 8														
START-CP1	0'54	0.4	2'07	0.4	0'41	0.4	1'43	0.4	1'59	0.4	0'57	0.4	2'52	0.4
CP1 - CPA	3'27	0.4	3'27	0.4	3'01	0.4	3'52	0.4	3'30	0.4	3'07	0.4	4'11	0.4
CPA - CP2	2'02	0.3	2'11	0.3	1'33	0.3	2'16	0.3	2'34	0.3	1'42	0.3	2'52	0.3
CP2 - END	1'05	0.2	1'09	0.2	1'0	0.2	1'08	0.2	1'16	0.2	1'06	0.2	1'12	0.2
EVENT 9														
START-CP8	2'02	0.3	2'36	0.3	1'52	0.3	2'41	0.3	2'40	0.3	1'55	0.3	2'10	0.3
CP8 - CP1	8'10	1.0	8'44	1.0	6'56	1.0	10'04	1.0	9'16	1.0	9'15	1.0	8'09	1.0
CP1 - CP2	5'03	0.7	4'34	0.7	3'31	0.7	6'16	0.7	5'01	0.7	4'55	0.7	4'48	0.7
CP2 - CPC	3'07	0.4	2'46	0.4	2'01	0.4	3'35	0.4	3'04	0.4	2'09	0.4	3'22	0.4
CPC - CP9	0'46	0.2	1'49	0.2	0'37	0.2	0'36	0.2	0'55	0.2	0'40	0.2	0'50	0.2
CP9 - END	10'19	1.6	10'55	1.6	10'53	1.6	15'52	1.6	11'03	1.6	8'33	1.6	12'49	1.6
EVENT 10														
START-CP1	3'29	0.6	3'22	0.6	2'45	0.6	4'50	0.6	3'17	0.6	3'55	0.6	3'36	0.6
CP1 - CP2	1'31	0.4	1'28	0.4	1'16	0.4	1'25	0.4	1'20	0.4	1'21	0.4	1'24	0.4
CP2 - CP3	5'47	1.7	5'43	1.7	5'45	1.7	7'46	1.7	5'26	1.7	5'47	1.7	6'04	1.7
CP3 - CPE	8'38	1.0	7'03	1.0	6'17	1.0	11'42	1.0	7'23	1.0	6'27	1.0	10'31	1.0
CPE - CPF	0'37	0.1	0'45	0.1	0'51	0.1	0'43	0.1	0'45	0.1	0'35	0.1	0'32	0.1
CPF - END	6'09	0.8	5'52	0.8	4'24	0.8	8'33	0.8	6'28	0.8	5'15	0.8	7'42	0.8

TABLE VIII

M113 DAY/NIGHT TEST – DAY RUN 2 – 15 MAY 75

	TEAM 1B		TEAM 2B		TEAM 3B		TEAM 4B		TEAM 5B		TEAM 6B		TEAM 7B	
	MIN/SEC	DIST	MIN/SEC	DIST	MIN/SEC	DIST	MIN/SEC	DIST	MIN/SEC	DIST	MIN/SEC	DIST	MIN/SEC	DIST
EVENT 8														
START-CP1	1'11	0.4	1'24	0.4	1'17	0.4	1 17	0.4	1'15	0.4	1'22	0.4	1'15	0.4
CP1 - CPA	2'19	0.4	2'46	0.4	2'42	0.4	2'40	0.4	2.25	0.4	2'47	0.4	2'21	0.4
CPA - CP2	1'30	0.3	1'26	0.3	1'14	0.3	1'15	0.3	1'15	0.3	1'24	0.3	1'11	0.3
CP2 - END	0'54	0.2	0'58	0.2	0'56	0.2	0'58	0.2	0'56	0.2	1'01	0.2	0'54	0.2
EVENT 9														
START-CP8	1'25	0.3	1'38	0.3	1'39	0.3	1'57	0.3	1'30	0.3	1'38	0.3	1'22	0.3
CP8 - CP1	5'55	1.0	5'39	1.0	5'34	1.0	5'32	1.0	5'07	1.0	5'48	1.0	5'04	1.0
CP1 - CP2	3'12	0.7	3'33	0.7	3'33	0.7	3'19	0.7	3'00	0.7	3'16	0.7	2'44	0.7
CP2 - CPC	1'46	0.4	1'57	0.4	1'40	0.4	2'58	0.4	1'44	0.4	1'58	0.4	1'27	0.4
CPC - CPD	0'35	0.2	0'38	0.2	0'29	0.2	0'37	0.2	0'39	0.2	0'32	0.2	0'27	0.2
CPD - END	6'50	1.6	7'19	1.6	6'30	1.6	7'03	1.6	5'53	1.6	7'30	1.6	6'11	1.6
EVENT 10														
START-CP1	2'13	0.6	2'22	0.6	2'07	0.6	2'11	0.6	2'14	0.6	2'20	0.6	2'0	0.6
CP1 - CP2	1'02	0.3	1'06	0.3	1'01	0.3	1'03	0.3	1'00	0.3	0'57	0.3	0'59	0.3
CP2 - CP3	4'45	1.7	4'36	1.7	4'22	1.7	4'54	1.7	4'33	1.7	4'44	1.7	4'20	1.7
CP3 - CPE	4'27	1.0	5'18	1.0	4'44	1.0	5'14	1.0	6'12	1.0	5'08	1.0	4'17	1.0
CPE - CPF	0'31	0.1	0'31	0.1	0'30	0.1	0'32	0.1	0'30	0.1	0'33	0.1	0'33	0.1
CPF - END	4'31	0.8	3'55	0.8	3'32	0.8	3'50	0.8	3'32	0.8	3'53	0.8	3'09	0.8