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VALIDATION OF THE AMC-71 MOBILITY MODEL

Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

March 1976

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VALIDATION OF THE A[illegible] MOBILITY MODEL

by

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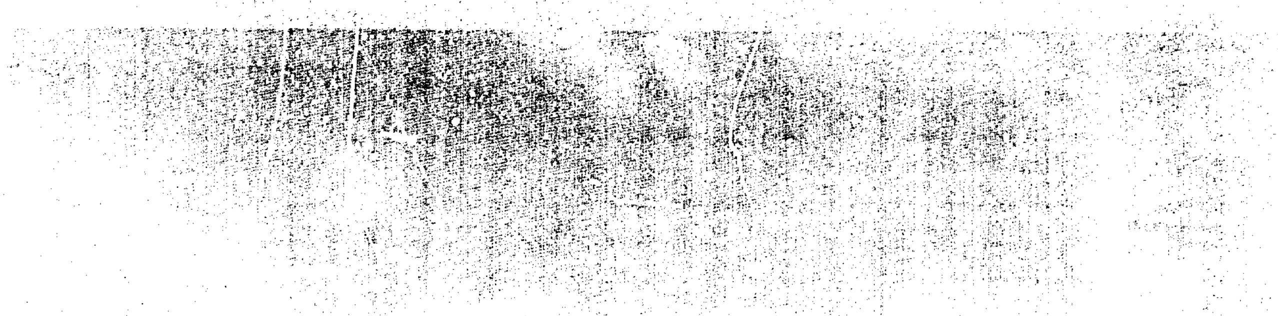
Final Report



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Tests were conducted to validate and evaluate predictions of vehicle performance derived from the AMC-71 Mobility Model for areal terrain. Predicted vehicle performance was compared with measured performance derived from vehicle tests for a variety of areal terrain conditions to determine prediction accuracy. Test vehicles used in all validation tests included two wheeled vehicles (M151, M35A2 modified) and three tracked vehicles (M113A1, M60, and M48). Priority was given to validating predictions of vehicle performance on

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20. ABSTRACT (Continued)

traverses; additional tests were conducted to validate performance predictions in terrain units and in terrain conditions required to verify individual relations used in the formulation of submodels of the mobility model.

Analyses of relations involved in the submodel and single-terrain-unit tests indicate that, although some refinement can be made, the power train, measured surface roughness, soil traction, slope, visibility, obstacle spacing, area denied, and single tree-override relations generally have an acceptable prediction accuracy. The data also show marked improvement is needed in the simulated surface roughness, obstacle override, and especially in the maneuver and vegetation relations. Consideration should be given to include relations for tree override when interference occurs, acceleration-deceleration at terrain unit boundaries, and override of deformable obstacles.

Analysis of the traverse tests data shows an overall relative deviation or prediction error of 30.1 percent. Results indicate that, on the average, predicted speeds are higher than measured speeds by +2.9 mph overall. Therefore, study and revision are needed in some areas of the AMC-71 Mobility Model to improve prediction accuracy. Further analyses show that, if the simulated surface roughness relations used throughout this study were corrected or were replaced by measured relations and the maneuver relations were corrected, AMC-71 would have an overall speed prediction error less than 15 percent for the traverse conditions tested.

Appendices A, B, C, and D which present vehicle data, description of test sites, definitions of terrain terms, and basic terrain data, respectively, are published under a separate cover.

PREFACE

The study reported herein was conducted from September 1971 to April 1974 by the U. S. Army Engineer Waterways Experiment Station (WES) for the U. S. Army Materiel Command (AMC),* under DA Project 1G662601AH91 and Task 01.

The study was conducted under the general supervision of Messrs. W. G. Shockley, Chief, Mobility and Environmental Systems Laboratory (MESL); A. A. Rula, Chief, Mobility Systems Division (MSD), MESL; E. S. Rush, Chief, Mobility Investigations Branch (MIB), MSD; and B. G. Schreiner, Projects Group (PG), MIB. The field tests were under the direct supervision of Messrs. Schreiner, W. E. Willoughby, J. H. Robinson, and C. E. Green, PG. Mr. Green was responsible for the reduction and analysis of the scale-model vehicle-obstacle data. Messrs. S. M. Hodge and R. G. Temple, MIB, contributed to the reduction and analysis of the test data The report was prepared by Messrs. Schreiner and Willoughby.

Acknowledgment is made to Mr. Tibor Czako and other personnel of the U. S. Army Tank-Automotive Command for their help in the field test program. Acknowledgment is also made to personnel of the U. S. Army Artillery Board, Fort Sill, Oklahoma; Yuma Proving Ground, Arizona; Eglin AFB, Florida; Keweenaw Field Station, Michigan; and U. S. Army Armor and Engineer Board, Fort Knox, Kentucky, for their cooperation and support in the field test activities.

BG E. D. Peixotto, CE, and COL G. H. Hilt, CE, were Directors of WES during the study and preparation of the report. Mr. F. R. Brown was Technical Director.

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* Now designated the U. S. Army Materiel Development and Readiness Command.

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* Published under separate cover.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) AND METRIC (SI) TO U. S. CUSTOMARY UNITS OF MEASUREMENT

Units of measurement used in this report can be converted as follows:

Multiply	By	To Obtain
U. S. Customary to Metric (SI)		
inches	2.5	centimetres
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
square inches	6.4516	square centimetres
pounds (mass)	0.4535924	kilograms
pounds (force)	4.448222	newtons
pounds (force) per square inch	6.894757	kilopascals
foot-pounds	1.355818	joules
feet per minute	0.00508	metres per second
miles per hour (U. S. statute)	1.609344	kilometres per hour
horsepower	745.6999	watts
horsepower per ton	83.82	watts per kilonewton
degrees (angle)	0.01745329	radians
Metric (SI) to U. S. Customary		
millimetres	0.0394	inches
centimetres	0.3937	inches
metres	3.2808	feet
metres per second	196.85	feet per minute

VALIDATION OF THE AMC-71 MOBILITY MODEL

PART I: INTRODUCTION

Background

1. The formal study of military mobility problems began during World War II with primary research in the area of vehicle-soil interactions as they affected vehicle negotiations of soft-soil areas during military operations. Research continued as a minimal effort until the early 1950's when military operations during the Korean conflict were slowed by soft-soil areas or stalled by vehicle immobilizations. At that time the research effort gained impetus and has continued to the present.

2. In the 1950's and 1960's the soft-soil investigations were augmented to examine basic vehicle-soil interactions as influenced by vegetation, slope, soil type, and obstacles. These factors were analyzed individually and collectively to determine their effect on ground vehicle mobility. Vehicle-terrain interaction relations were developed which, while empirical, advanced knowledge to the point that some predictions were possible to permit analysis of the effect of the complete terrain complex on mobility. Cost-effectiveness studies and analyses of proposals for new hardware in the 1960's, as well as lunar research programs, provided pressure for a more thorough systematic analysis of the ground mobility problem.

3. In fiscal year 1971, a unified Army Materiel Command (AMC) ground mobility research program was implemented. Capabilities of the three laboratories responsible for conducting AMC ground mobility research, the U. S. Army Tank-Automotive Command (TACOM), the U. S. Army Engineer Waterways Experiment Station (WES), and the U. S. Army Engineer Cold Regions Research and Engineering Laboratory (CRREL), were geared to achieve common goals. Review of military requirements for vehicle mobility data indicated a [illegible] need for an objective

analytical procedure for quantitatively assessing off-road vehicle performance. Technology developed through 25 years of Army-sponsored research, along with engineering knowledge of fundamental terrain-vehicle-man interactions, were incorporated into a first-generation comprehensive computerized analytical ground mobility model called the AMC-71 Mobility Model, or just AMC-71.* During the time the model was assembled and became functional, the need for validation was obvious. Thus, a 3-yr program was initiated in 1971 to validate off-road relations contained in AMC-71 by comparing predicted and measured performance which would hopefully produce results leading to a more refined second-generation model.

AMC-71 and Its Areal Terrain Module

AMC-71

4. A general flow diagram of AMC-71 is presented in Figure 1. AMC-71 postulates that the maximum safe speed of a mechanically sound vehicle at any moment, including zero speed or immobilization, is the proper mobility measurement for any particular place and time. Vehicle performance in cross-country terrain at any instant in time is a function of vehicle characteristics, terrain features in the area of operation, and driver response. Consequently, the individual system parameters potentially involved must be quantified in engineering terms for calculation of probable vehicle speeds as governed by specific terrain-vehicle-driver interactions, as indicated in Table 1.**

5. Terrain can be described in terms of measurable factors that affect vehicle responses. Each grouping of terrain factors that quantify the terrain into a specific array of descriptors forms a terrain

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* U. S. Army Tank-Automotive Command, "The AMC '71 Mobility Model," Technical Report No. 11789 (LL 143), Jul 1973, Warren, Mich.

** A. A. Rula, C. J. Nuttall, Jr., and H. Dugoff, "Vehicle Mobility Assessment for Project WHEELS Study Group," Technical Report M-73-1, Apr 1973, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

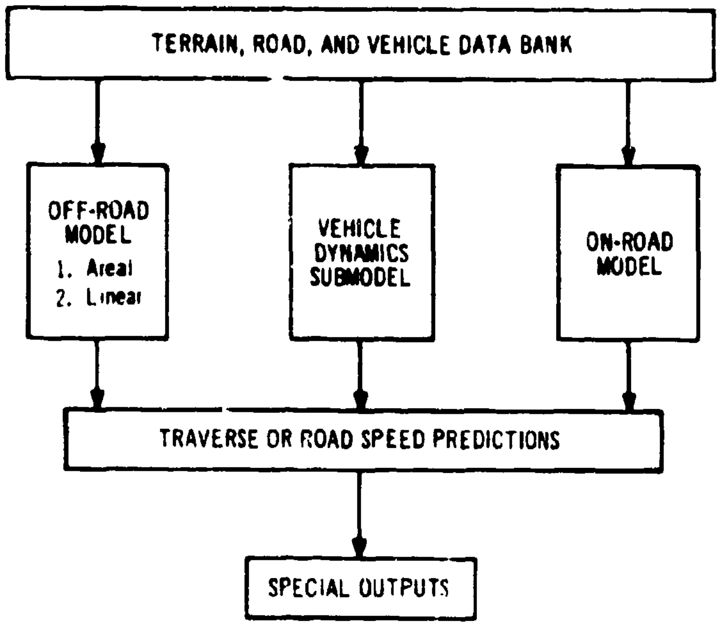

Figure 1. General flow diagram of AMC-71 Ground Mobility Model

unit, either areal, linear, or road, depending on the basic type of terrain described. Areal terrain units are characterized by 13 measurements (or class intervals) that reflect the type and strength of surface materials, slope, prevailing ground roughness, discrete obstacles, and vegetation. Linear terrain units (streams only) are characterized by nine measurements covering type and strength of surface materials, cross section, water depth, and velocity. Road units are described by five measurements expressing surface type, strength, slope, curvature, and roughness. The characteristics that describe each of these three terrain unit types are shown in Table 1.*

6. Maximum safe vehicle speeds in the areal and road units are calculated by AMC-71 using the specific terrain measurements described above as input to engineering or mathematical relations. (No speed

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* A table of factors for converting units of measurement is given on page 4.

predictions are made by AMC-71 for linear units; instead, time penalties are presently assessed to linear units relative to their geometric shape as they influence vehicle movement). The relations in AMC-71 are modeled either to predict vehicle performance along any given path in the terrain, or to accumulate a statistical representation of vehicle performance in the area as a whole, or both. In predicting vehicle speed, terrain units are generally considered homogeneous, i.e., values for each single-factor measurement are considered to be constant, within the same class range, or described by the same probability distribution.

7. Although linear and road unit predictions are important aspects of any mobility prediction model, the major portion of AMC-71 is oriented toward predictions in the more complex and endlessly variable areal terrains. The large number of vehicle and terrain parameters involved and the complex interactions among them require computation of single terrain feature-vehicle interactions that comprise the submodels that make up the areal terrain module of the off-road model of AMC-71 (Figure 2). This report summarizes the results of the validation tests concerned with the areal terrain module of AMC-71.

Areal terrain module

8. A flow diagram of the areal terrain module is presented in Figure 2. The basic components of this module are a series of individual, but interconnected, submodels that contain basic relations designed to model specific vehicle-terrain-driver interactions. These submodels generally use established theoretical or empirical relations, relative to the interactions being modeled, which are coupled to the main body of the model by specific subroutines that either adjust or modify a theoretical vehicle speed or force, for the effects of terrain variations on vehicle performance. The submodels are:

- a. Power train
- b. Soil and slope
- c. Visibility
- d. Obstacle geometry, traction, avoidance, and override
- e. Vegetation override, impact, and avoidance

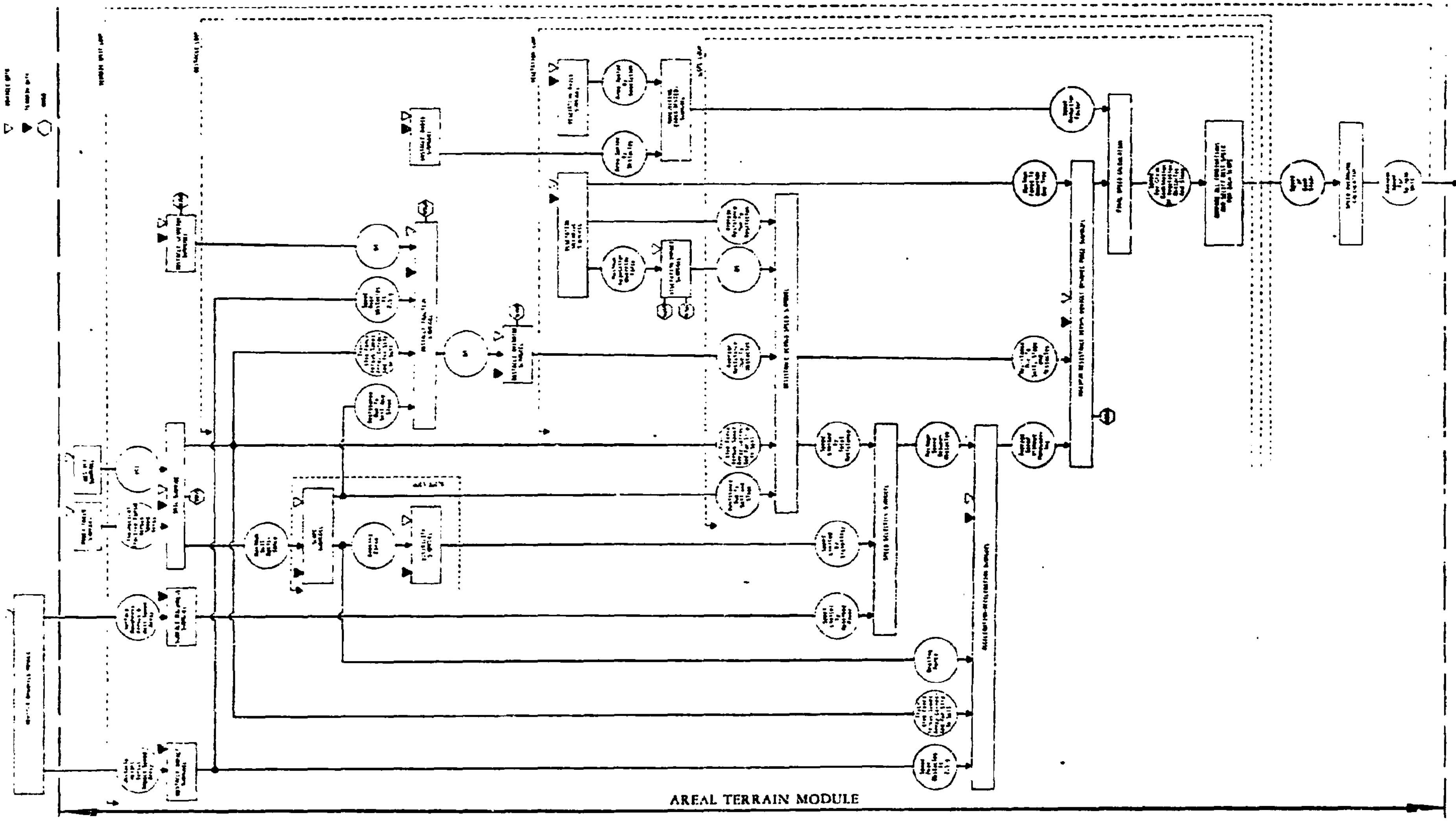

Figure 2. Flow of areal terrain module

f. Maneuvering

g. Acceleration-deceleration

Vehicle dynamics (surface roughness and obstacle height versus vehicle impact speed) is shown in Figure 2 as a module separate from the areal terrain module; however, the dynamics module is so closely related to the submodels in the areal terrain module that it is interfaced with the areal terrain module and may be considered a submodel.

9. In all the submodels listed above except obstacle avoidance, the vehicle is assumed to be moving in essentially a straight line. Other major simplifications are:

a. Terrain is composed of specific attributes that can be described in quantitative terms.

b. The driver enters only as a governor who imposes speed limits upon fixed absorbed power (ride) or acceleration (obstacle-crossing) limits occurring at his seat location.

c. Dynamics, traction, and obstacle negotiation are treated as two-dimensional only, with no yaw or roll motions (except for possible side-slope overturning), i.e., vertical vehicle motions are computed. All obstacles are encountered head-on.

d. All ground roughness and obstacles are treated as unyielding, and no tire or suspension compliance is considered in examining for obstacle interference.

e. Performance is predicted for a single vehicle operating in terrain on a first-vehicle-through basis.

f. Soil surface slipperiness is not considered.

10. Terrain and vehicle data files are accessible to the submodels as needed. The logic incorporated into AMC-71 performs an optimal speed analysis to determine the minimum calculated vehicle speed in the described terrain unit as limited by one of the factors comprising the submodels listed in paragraph 8. After the optimal speed analysis, the predicted minimum speed and the nature of the controlling immobilization (if it occurred) and factor limiting vehicle speed are output for

each described terrain unit. Immobilization and speed-limiting factors that control the speed predictions are:

a. Factors governing immobilization:

(1) Surface strength less than vehicle cone index for one pass.

(2) Available traction less than surface and slope resistances.

(3) Obstacle interference.

(4) Available traction less than total resisting forces.

b. Speed-limiting factors:

(5) Surface roughness.

(6) Combination of surface and slope resistances.

(7) Visibility.

(8) Maneuvering.

(9) Combination of all resisting forces (surface, slope, obstacle, and vegetation).

(10) Acceleration-deceleration between obstacles.

Purpose

11. The purpose of this study was to validate or determine deficiencies in the relations comprising the areal terrain module of AMC-71 by comparing predicted and measured performances of full-size vehicles in the field and scale-model vehicles in the laboratory.

Scope

12. Field tests were conducted with two wheeled and three tracked vehicles at five locations where terrain for testing was easily accessible and where support and variations in terrain were available. Speed tests were conducted over selected single terrain units and over traverses at each location. In addition, the vehicles were tested on specific test lanes to derive data from drawbar-pull, motion-resistance, and slope-climbing tests, and at specific sites to examine obstacle

deformation, area denied by obstacles in terrain units, and tree override. Also, data derived from laboratory tests in another test program with two scale-model vehicles, one wheeled and one tracked, were analyzed to study traction and obstacle negotiations.

13. Detailed terrain data were collected at the time of the tests at each test location. These data, together with vehicle characteristics data, were used to predict vehicle performances with AMC-71. The predicted performances were then compared with performances measured in the test program.

Definitions of Vehicle, Soil, and Mathematical Terms*

14. Vehicle terms used in this report are:

a. Absorbed power. The rate at which vibrational energy is absorbed by a vehicle occupant. It is a measure of ride quality.

b. Immobilization. The inability of a self-propelled vehicle to go forward.

c. Optimum drawbar pull. A point on the drawbar pull versus slip curve at which work output of the track or wheel is the most efficient.

d. Pass. One trip of a vehicle over a test course.

e. Ride. The quality of vibratory motions caused by random terrain irregularities as sensed by a vehicle occupant.

f. Slip. The percentage of track or wheel movement ineffective in thrusting a vehicle forward.

g. Towed motion resistance (MR/W). The amount of force required to tow a test vehicle in neutral gear under given test conditions, expressed as a percentage of the vehicle test weight.

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* Terrain, surface geometry, and vegetation terms used in this report are defined in Appendix C (all appendices under separate cover).

15. Soil terms used are:

a. Fine-grained soil. A soil of which more than 50 percent of the grains, by weight, will pass through a No. 200 U. S. standard sieve (smaller than 0.074 mm* in diameter).

b. Coarse-grained soil. A soil of which more than 50 percent of the grains, by weight, will be retained on a No. 200 sieve (larger than 0.074 mm in diameter).

c. Organic soils (muskeg). A terrain surface composed of a living organic mat of mosses, sedges, or grasses with or without tree or shrub growth. A mixture of partially decomposed and disintegrated organic material, commonly known as "peat" or "muck," is underneath the surface.

d. Cone index (CI). An index of shearing resistance of soil obtained with the cone penetrometer. The value, considered dimensionless, represents the resistance of the soil to penetration of a 30-deg cone of 0.5-in.^{2} base or projected area at a penetration rate of 6 ft/min.

e. Rating cone index (RCI). Product of CI and remolding index (RI). RI is the ratio of remolded soil strength to original strength. RCI expresses the soil strength rating of a soil subjected to vehicular traffic.

f. Unified Soil Classification System (USCS). A soil classification system based on identification of soils according to their textural and plasticity qualities and on their grouping with respect to their engineering behavior.

g. U. S. Department of Agriculture (USDA) Classification System. A soil classification system developed by the United States Department of Agriculture based on identification of soils according to grain sizes or the relative proportions of the sand, silt, and clay fractions, each term being defined as a specific range of sizes.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units and metric (SI) units to U. S. customary is presented on page 4.

16. Mathematical terms used in this report are:

a. Deviation. Predicted value (P) minus the measured value (M), P - M.

b. Mean absolute deviation. The average of the numerical differences between measured and predicted values.

c. Mean algebraic deviation. The average of the algebraic differences between measured and predicted values.

d. Range of deviation. The algebraic extremes in the deviations between measured and predicted values.

e. Relative percent deviation. The absolute deviation of a measured value from a predicted value expressed as a percentage of the measured value, i.e.,

$$\text{Relative deviation, \%} = \sum \frac{P - M}{M}$$

f. Root-mean-square (rms) deviation. The square root of the average of the squares of the deviations of measured from predicted values expressed by the equation

$$\sqrt{\frac{\sum (\text{Deviations})^2}{\text{Number of deviations}}}$$

PART II: TEST PROGRAM

Field Tests

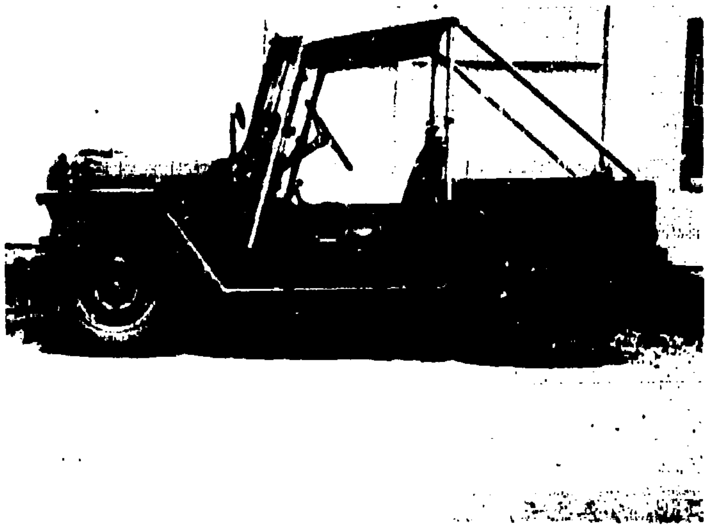
Test vehicles

17. Two wheeled vehicles (an M151 1/4-ton truck and a modified M35A2 2-1/2-ton truck) and three tracked vehicles (an M113A1 armored personnel carrier, an M48 tank, and an M60 tank) were used in the field tests (Figure 3). The modification of the M35A2 truck consisted of replacing the 9.00-20 tires with 11.00-20 tires in single-tandem rear wheels. Vehicle characteristics are listed in Appendix A. (When the M35A2 truck is identified in the balance of this report, it is to be understood that it is the modified version.) The primary tracked vehicles were to have been the M113A1 and the M60; however, when the M60 was unavailable, the M48 was used as an acceptable alternative vehicle. (The M60 was available at only one of the five test locations.)

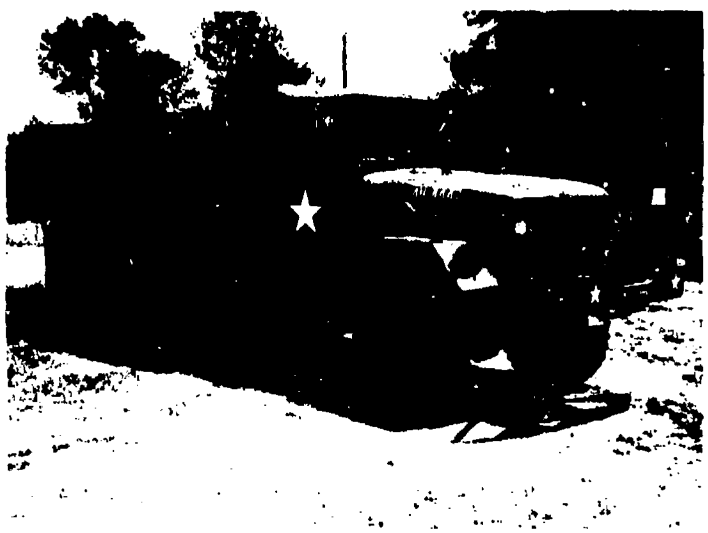
18. The test vehicles were maintained in the best mechanical condition possible to ensure peak performance. Check tests were performed occasionally to determine if the power train of each vehicle was at or near its design performance. The cross-country payload of each vehicle was distributed in its cargo area according to the prescribed vehicle axle loads. Tires were inflated and maintained at their recommended cross-country pressure; tire pressure and deflection were checked periodically. Each vehicle was fitted with necessary safety equipment to ensure reasonable safety to the vehicle occupants.

Test personnel

19. To ensure peak vehicle performance, the test personnel (driver and navigator) were experienced in cross-country testing and were completely familiar with the operation of the test vehicles. It is emphasized that for the measured speed to be comparable with the speed predicted with AMC-71, the driver must operate the vehicle at its maximum safe speed. The average military driver usually is thoroughly familiar with the mechanical aspects of his vehicle, but he lacks the



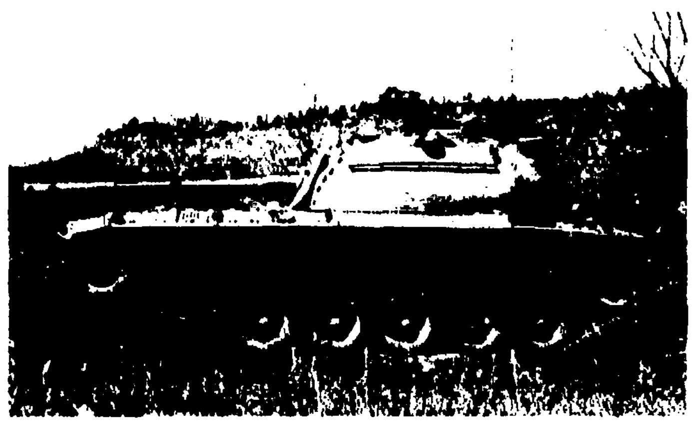
a. M151



b. M35A2 (modified)

Figure 3. Test vehicles (sheet 1 of 2)

c. M113A1



d. M48

e. M60

Figure 3 (sheet 2 of 2)

experience and training necessary to operate it cross-country at maximum safe speeds in changing terrain conditions. Training programs generally are not oriented toward teaching military personnel methods of vehicle operation in the cross-country environment. Furthermore, it was recognized that driving skills and personal motivation among individual drivers will produce varied test results under even the most uniform conditions. To reduce the effects of these variables on vehicle performance, a driver was specially trained in cross-country driving for these tests to qualify him to drive the vehicles at the maximum safe speed attainable for the terrain conditions imposed.

Test sites

20. To validate the performance predictions from AMC-71 satisfactorily, a variety of sites in which to conduct tests was sought. Test sites were finally selected at Fort Sill, Oklahoma; Yuma Proving Ground, Arizona; Eglin AFB, Florida; Houghton, Michigan; and Fort Knox, Kentucky. These locations are identified in some parts of this report as FS, YPG, EAFB, HTN, and FK, respectively. The single terrain units and traverses used for testing at these locations are shown in Figures 4-9. A general description of each test site and a profile with photos of each traverse are presented in Appendix B. Appendix C describes the procedures used in collecting terrain data at the sites, and Appendix D contains the basic terrain data used in the vehicle performance predictions.

Test procedures

21. Speed in single terrain units. A timing zone was marked off in each of the single terrain units with ample distance available before and beyond the zone for acceleration and deceleration, respectively. The driver accelerated to a speed he considered safe for the given terrain conditions and generally maintained that speed throughout the timing zone. Time was obtained for each vehicle in the timing zone of each terrain unit and used, together with the length of the zone, to calculate the speed for each unit.

22. Speed in traverses. Each test traverse was staked out, and the beginning, end, and each terrain unit boundary were marked for easy identification by the driver and navigator. The traverse was laid out

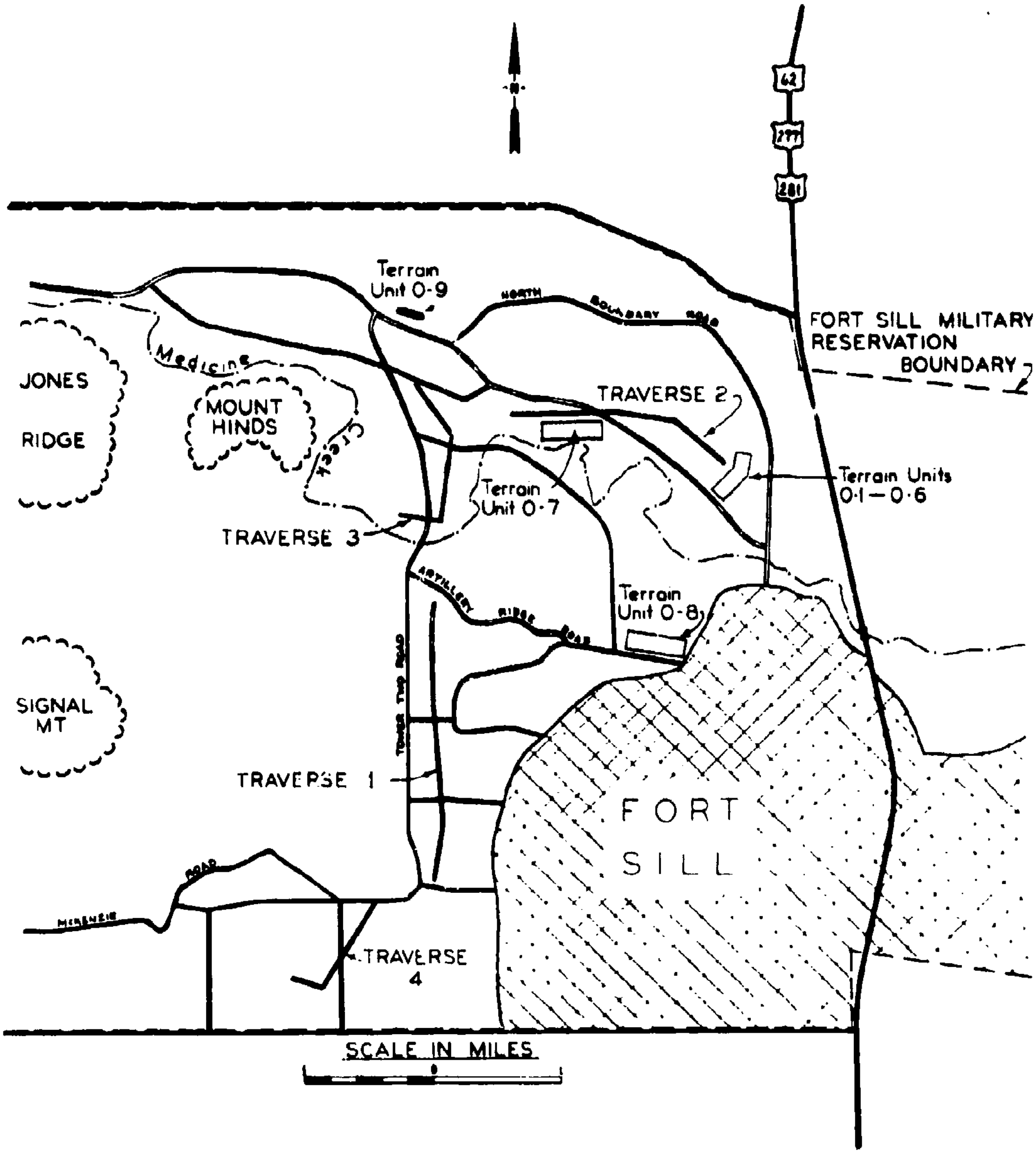


Figure 4. Location of test sites at Fort Sill, Oklahoma

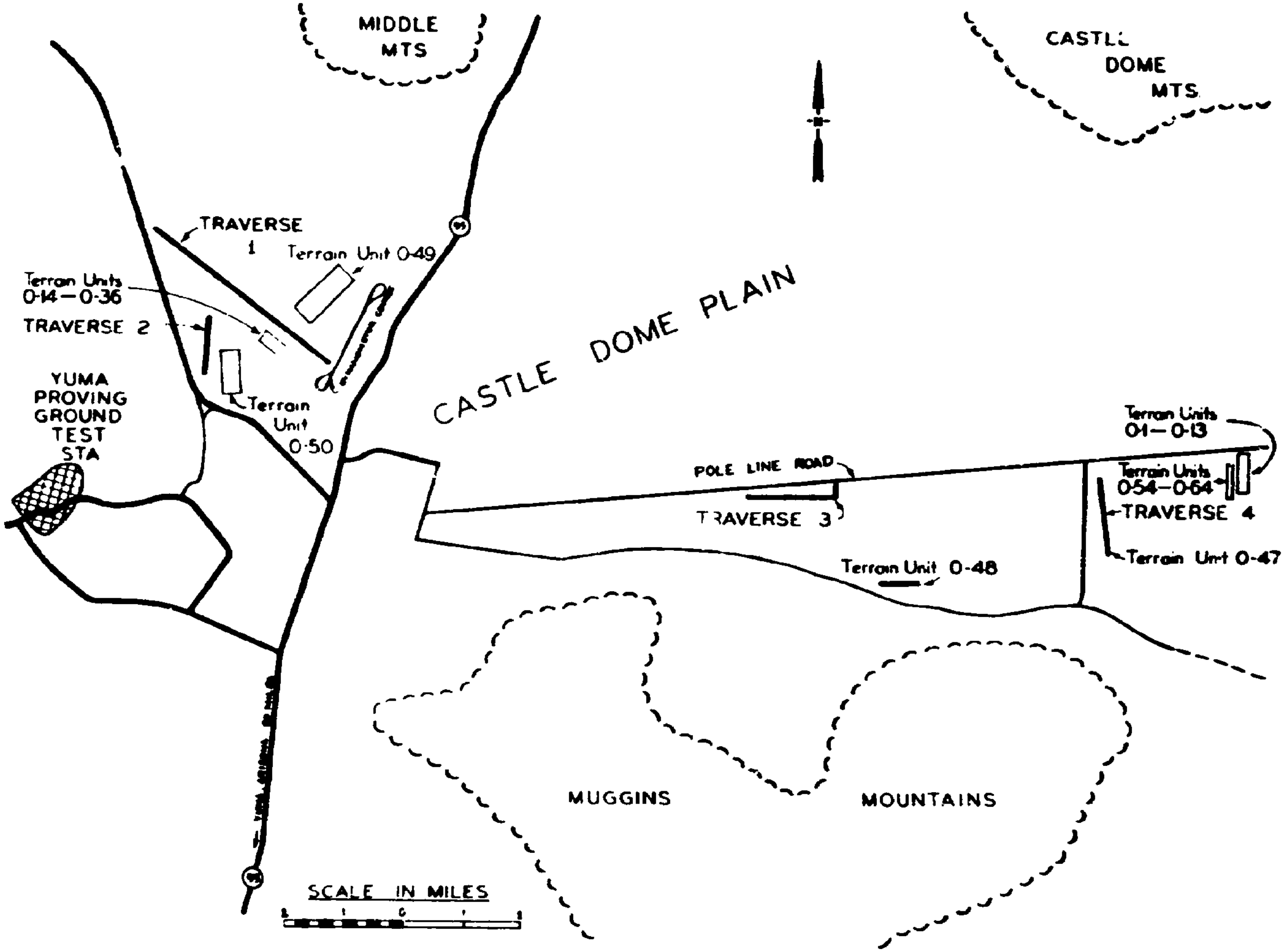


Figure 5. Location of test sites at Yuma Proving Ground near Yuma, Arizona

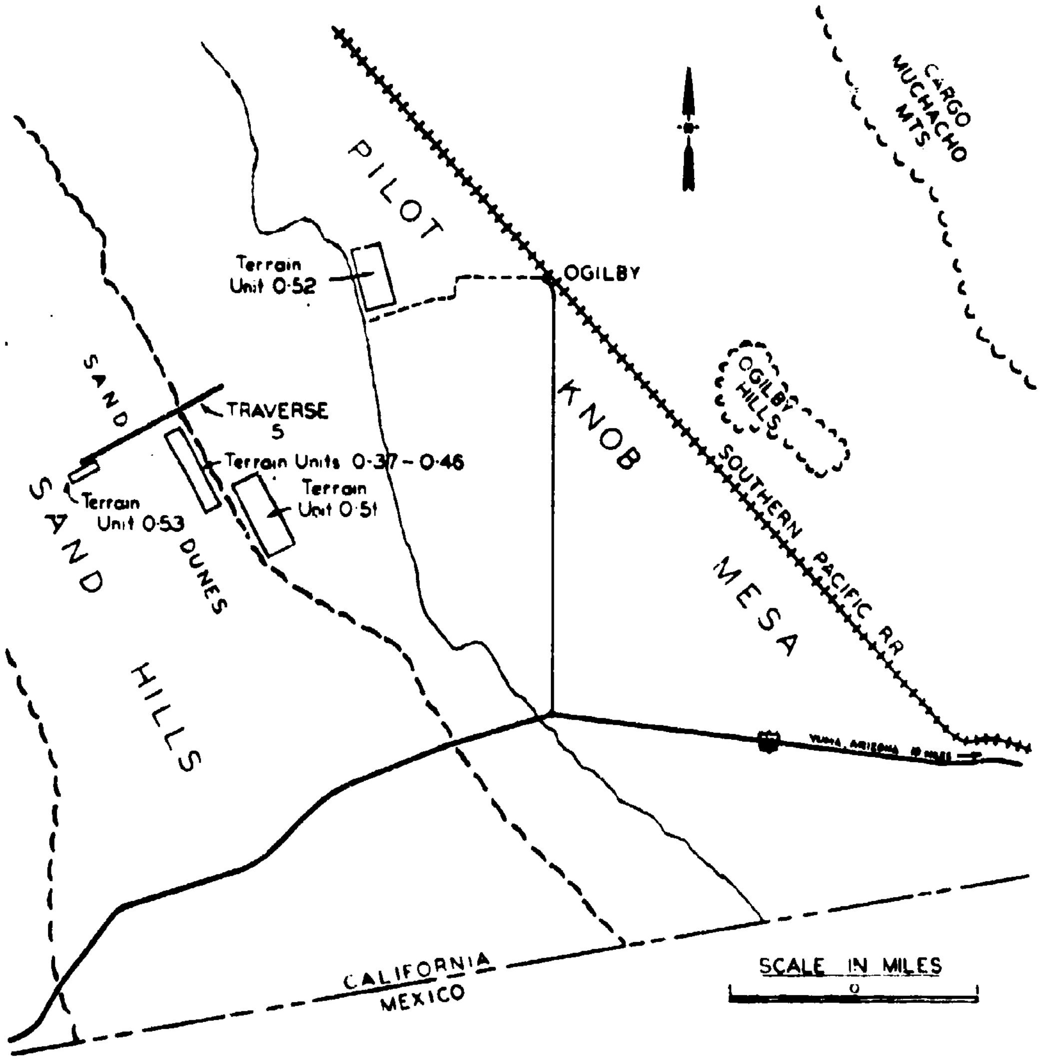


Figure 6. Location of test sites in sand dune area of Sand Hills, California, near Yuma, Arizona

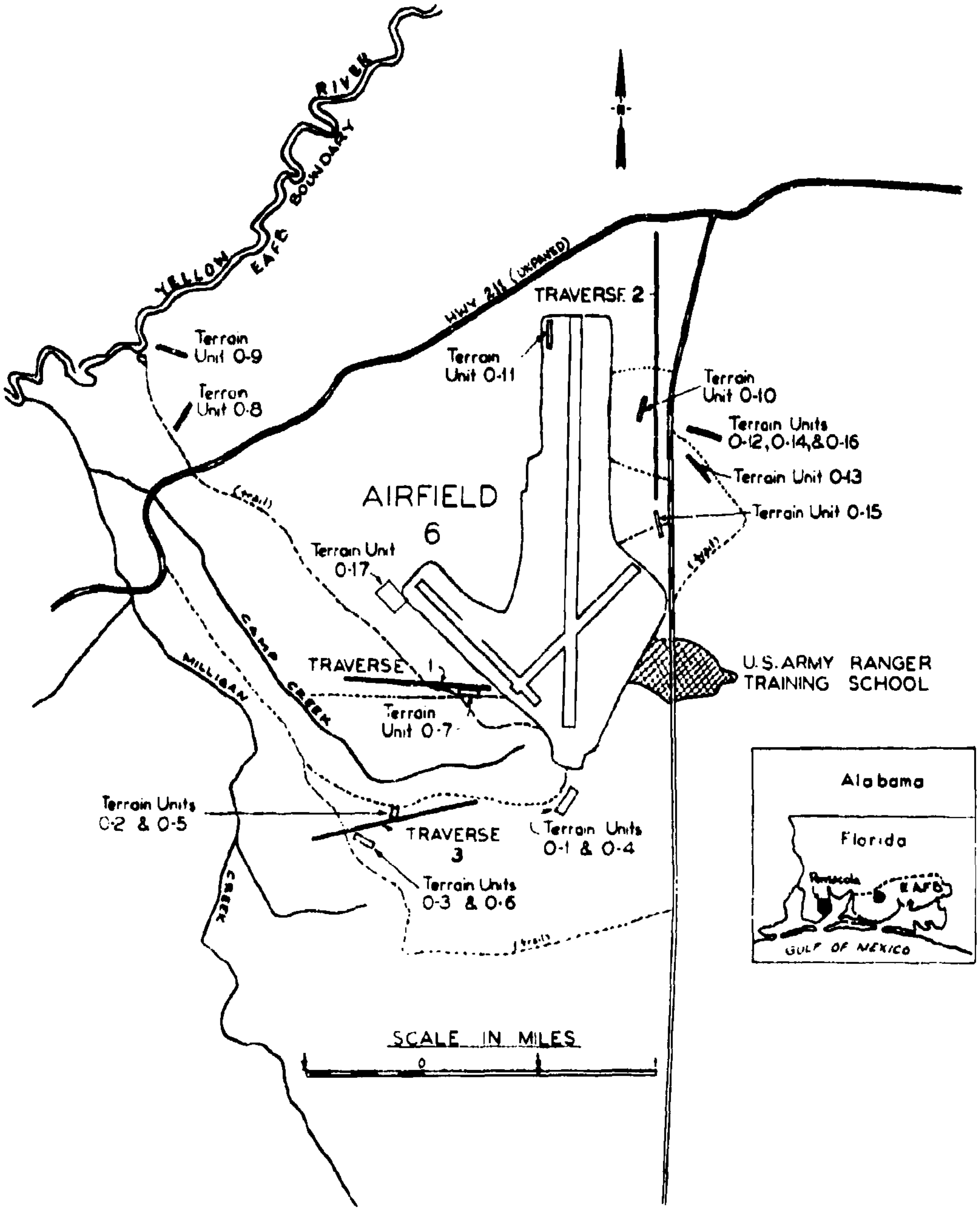


Figure 7. Location of test sites at Eglin AFB, Florida

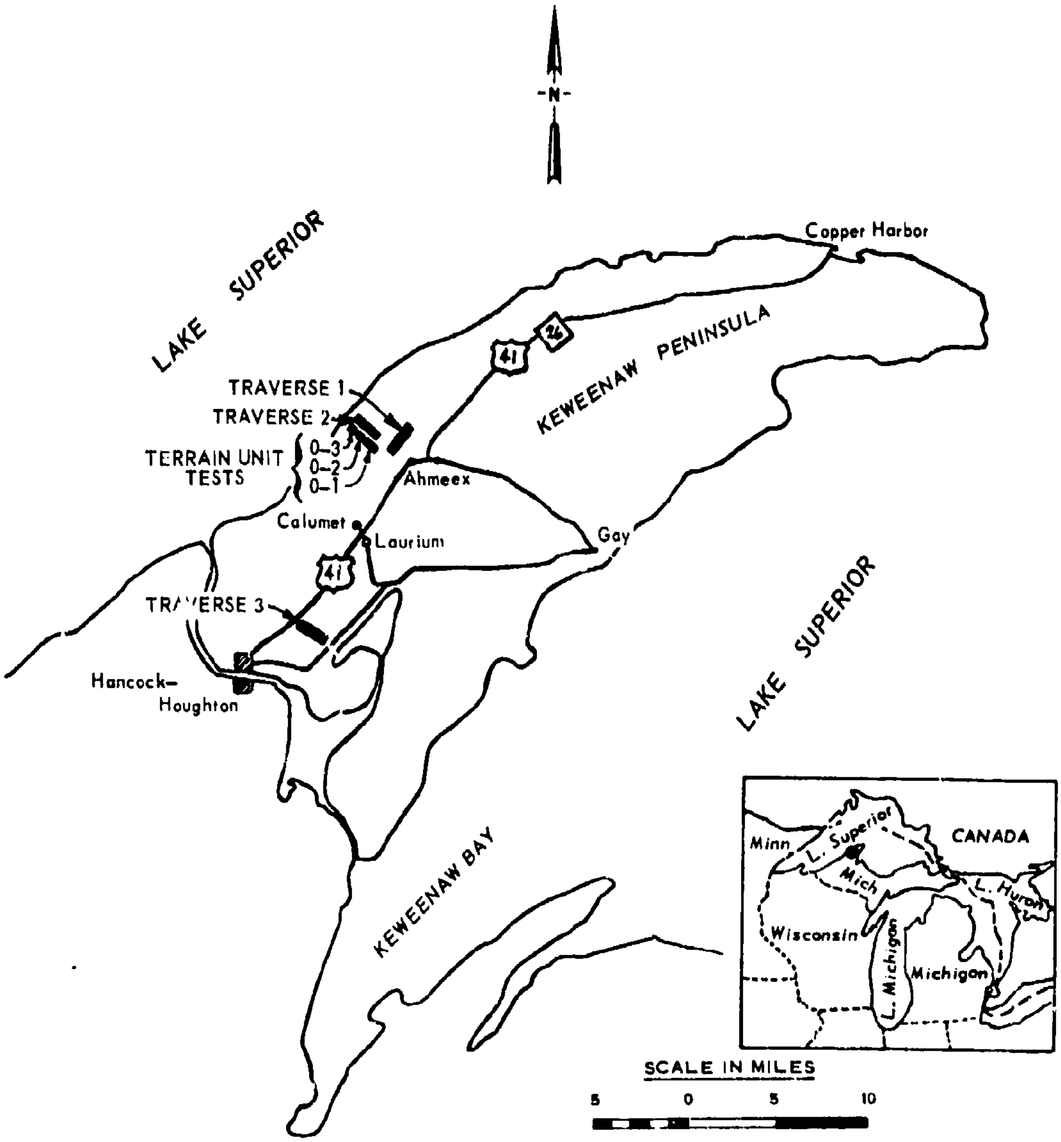


Figure 8. Location of test site in upper peninsula of Michigan

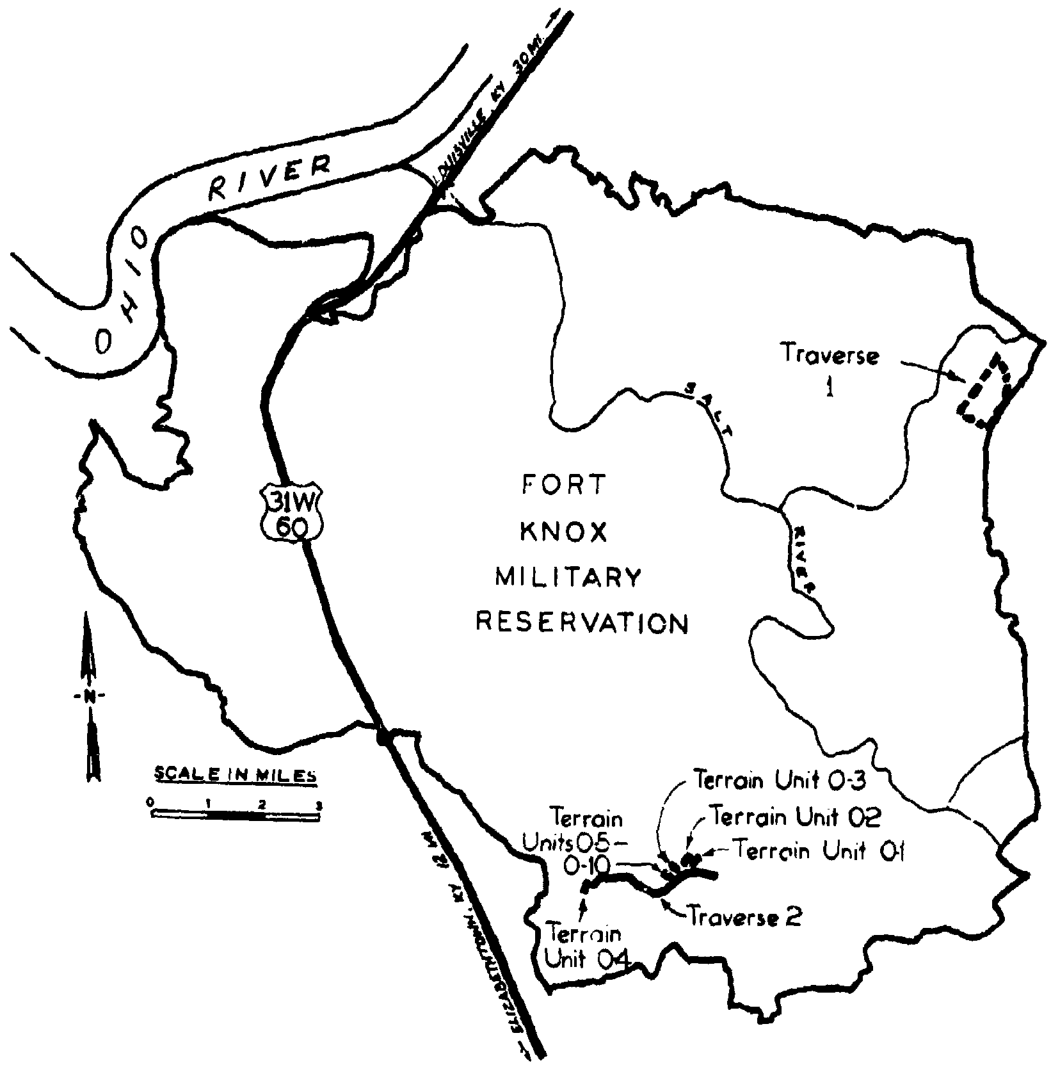


Figure 9. Location of test sites at Fort Knox, Kentucky

in straight-line segments, with directional changes coincidental with terrain unit boundaries where possible. Each terrain unit was then described in terms of the magnitudes of the terrain factors that would be encountered in each. Drainageways and roads were crossed at preselected points, and special terrain features that might cause injury to the vehicle occupants or damage to the vehicle if encountered were clearly marked.

23. Before each test run, the driver and navigator were briefed as though a mission were being performed from one point to another along a specific course. The vehicle occupants were not permitted to become familiar with the test course by driving over it before testing. They were instructed as to the location of the test course, including location of flags marking the beginning and end, terrain unit boundaries, and obstacles to be avoided. The driver was instructed to operate the vehicle over the test course at the maximum safe speed at which the occupants would not be injured nor the vehicle become inoperative because of damage. The occupants wore protective headgear and were restrained by seat belts during a test.

24. Each vehicle was driven over each traverse, usually one time in one direction, at a speed considered by the driver to be the maximum safe speed for the vehicle based on the limitations imposed by the terrain conditions encountered. The vehicles were timed through each unit on the traverse. These times were used to calculate speed for each vehicle in each areal terrain unit of the traverse over the measured distances as well as to calculate an overall speed for each vehicle over the entire traverse. In these tests, since significant streams were not encountered, all drainageways and roads crossing the traverse were described as linear obstacles within the areal terrain classification.

25. <u>Drawbar-pull tests.</u> Straight-line test lanes (usually 100 ft long) were selected such that each had a uniform soil strength. Before-traffic soil and related data were taken. A load vehicle was then positioned behind the test vehicle and attached to it with a cable, and instrumentation was connected. The measurement system was checked and calibrated. The test vehicle proceeded into the test lane in lowest

gear and optimum engine rpm. Once the test and load vehicles reached a constant speed, the load-vehicle driver applied the brakes in increments until the load became great enough to prevent any forward motion of the test vehicle. Drawbar pull, distance traveled by the wheels or tracks, distance traveled by the vehicle, and time were continuously recorded on an oscillograph during each test.

26. Motion-resistance tests. A motion-resistance test was conducted in the same test lane after a drawbar-pull test was concluded. After the necessary calibrations were made, the test vehicle was towed through the test lane in such a manner that it did not travel in ruts previously made. The test vehicle was towed at a speed of approximately 2 mph with the engine running and the transmission disengaged.

27. Slope (go-no go) tests. Slope-climbing tests were conducted in those terrain units in which slope appeared to be critical for vehicle go or no-go. The vehicle approached the slope course, and the driver attempted to maintain optimum engine speed through the course.

28. Obstacle-deformation tests. Tests were conducted in selected terrains where natural erosional processes had created stepped stream banks, which were relatively firm and unvegetated and were obstacles to vehicle movement. Obstacle step heights and shapes were selected to create a range of go-no go conditions. An obstacle profile was taken prior to each test; the vehicle attempted to negotiate the obstacle, and the obstacle's deformed profile was taken after each test.

29. Tests to determine area denied to vehicle passage by obstacles. Terrain units were selected for these tests in terrain with little or no significant surface roughness or vegetation other than relatively large, uniformly spaced trees and stumps that acted as obstacles to vehicle movement. Any underbrush present was cleared. A rectangular test section was marked off in each terrain unit, with ample acceleration and deceleration areas at the ends of the section. All lateral obstacles (logs, etc.) and longitudinal obstacles (trees and stumps) were counted, with measurements made of each for determining size, height, type, etc., for computation of obstacle mean spacing and percentage of total test

area denied to vehicle passage by the obstacles. The driver was instructed to override no obstacles in these tests but rather to achieve the maximum safe vehicle speed in the terrain conditions imposed by maneuvering, i.e., operating in the area undenied by obstacles.

30. Tree-override tests. Tree-override tests were conducted with the wheeled vehicles (M151 and M35A2) and the M113A1 (tracked vehicle). A wheeled vehicle was connected to the M113A1 with a cable attached to a load cell. The M113A1 towed the wheeled vehicle (in neutral gear) over an area of soil surrounding the upright tree selected for the test to measure the average motion resistance of the vehicle in the test area (paragraph 26). The wheeled vehicle was then pulled across the remaining area until the vehicle pushbar encountered the tree to be overridden. To complete the test, the M113A1 pulled the wheeled vehicle over the designated tree at 2 mph until the towed vehicle had completely overridden the tree and its branches at ground level. A continuous oscillogram was obtained for each tree overridden in this manner to obtain a record of distance and pull. To test the M113A1, a cable and load cell were attached to the trunk of the tree at the height of the M113A1 pushbar. The tree was then pulled over by the vehicle. The motion resistance of the M113A1 over the test area was obtained by towing it with the M35A2 as described in paragraph 26.

Tests conducted and data collected

31. The numbers and types of tests conducted with each vehicle at each test location are presented in Table 3. Results of the various types of tests are contained in tables as listed below, except for the obstacle-deformation and area-denied tests. Results from these latter types of tests are presented in tabulations in paragraphs 79 and 81, and 89, respectively.

a. Single-terrain-unit tests - Tables 4 and 5.

b. Traverse tests - Tables 6-11.

c. Drawbar-pull tests - Table 12.

d. Motion-resistance tests - Table 13.

e. Slope (go-no go) tests - Table 14.

f. Tree-override tests - Table 15.

Scale-Model Vehicle Tests

32. A series of scale-model vehicle tests was conducted in the laboratory at WES to study the possible use of scale models in analysis of obstacle-vehicle interference. The results of that program will be published in another report; however, certain data were extracted for analysis in connection with the study reported herein. Two vehicles, a 1:20-scale M60 tank and a 1:15-scale M35A2 truck, were selected to represent tracked and wheeled vehicles. Both vehicles were used in tests on a 4-ft-wide by 16-ft-long table on which various sizes and shapes of rigid obstacles were anchored. All the obstacles tested were wider than the vehicles tested. The obstacles and table were coated with various types of surface material to obtain three different tractive coefficients (drawbar pull divided by vehicle weight) for each vehicle as a check of the traction subroutine used in the obstacle submodel in AMC-71. A check was also made of the slope relations in AMC-71 by conducting tests with the scale models on single scaled slopes, each at least twice the length of the scaled vehicle being tested.

Obstacle-crossing tests

33. The obstacle-crossing tests (66 with the M60 and 133 with the M35A2) were conducted at slow speeds (equivalent to approximately 2-mph prototype vehicle speed) to minimize the effects of vehicle kinetic energy. The vehicle proceeded down the test lane, crossing at right angles obstacles of increasing size until the vehicle reached the maximum obstacle size negotiable for a given flank angle, configuration, and surface traction condition. This procedure was used for crossing mound- and trench-shaped obstacles of triangular shape. Following completion of these tests, either the top or bottom widths of the obstacles were varied to form trapezoidal shapes for testing. This procedure was used for all tests in which the vehicle encountered an interference other than traction. If traction was insufficient to negotiate a triangular shape, increasing the width to form a trapezoidal mound or trench had no effect on test results.

Traction tests

34. In the traction tests (three with each vehicle), the maximum vehicle drawbar pull was measured by a small load cell monitored by an oscillograph. To determine the tractive coefficient relative to each surface material, the load cell was attached with a 2-1/2-ft-long wire to the rear of the test vehicle. A remote power supply was held at a predetermined level to produce a scaled speed equivalent to a 2-mph prototype vehicle speed. The scale-model vehicle proceeded down the test lane while the pull on the vehicle was gradually increased by manually restraining the load cell and wire until a series of high pull-high slip conditions produced sufficiently repetitive values to obtain an average maximum drawbar pull for each vehicle on each surface condition. These values were then converted to tractive coefficients for each vehicle.

Slope tests

35. The vehicles attempted to negotiate single fixed slopes coated with a material that produced a known tractive coefficient. The slope was fixed such that the tangent of the slope angle was equal to the tractive coefficient. The vehicle proceeded down the test lane at a slow speed (equivalent to 2-mph prototype vehicle speed); as the slope was encountered, the vehicle attempted to negotiate it. The slopes were either increased or decreased until the maximum slope negotiable for a given tractive coefficient was determined.

PART III: ANALYSIS TO VALIDATE AREAL TERRAIN MODULE SUBMODELS

36. Data collected in single-terrain tests or tests on specially selected test courses were used to validate the areal terrain module submodels. Five numerical evaluation parameters were selected to obtain deviations of measured performances from performances predicted with AMC-71. These parameters (definitions given in paragraph 16) are:

a. Range of deviation.

b. Mean algebraic deviation.

c. Mean absolute deviation.

d. Relative deviation.

e. rms deviation.

These five parameters provided a spectrum of statistical variables for performance evaluation. No one of these parameters was found to be completely adequate under all circumstances without biasing the analyses of data, although relative deviation was considered the most meaningful overall parameter relative to the data presented herein. A relative deviation of 20 percent will be considered acceptable in this analysis.

37. The submodels listed in paragraph 8, except for acceleration-deceleration, were considered for detailed validation or evaluation for deficiencies. The vehicle (ride) dynamics module was also examined.

38. Some comments concerning certain submodels and their relations are appropriate. From the outset of the validation program, weaknesses were known to exist in some areas of the model, namely in the ride dynamics module and the acceleration-deceleration submodel. However, ride dynamics is an on-going major research effort designed to obtain a sufficient data base for revisions or restructure of vehicle speed relations as controlled by surface roughness and obstacle heights. Methodology used in formulating AMC-71 did not consider acceleration-deceleration capabilities of vehicles with regard to speed adjustments at the terrain unit boundaries. Only in those terrain units containing significant obstacles does AMC-71 consider these capabilities of a

vehicle. In these cases only, a portion of the obstacle submodel (to be discussed later in this part of the report), which contains an acceleration-deceleration subroutine, will alternately permit acceleration to a point between obstacles (based on the soil strength) then deceleration to contact with the next obstacle. The need for an accurate acceleration-deceleration subroutine to account for terrain unit edge effects became apparent as a result of the traverse testing in this program. Furthermore, certain coupling actions that take place within the model are simply not field testable on an individual basis. For example, measurement of all resisting forces acting on a vehicle at a particular instant of time during a cross-country test is a near impossibility. Consequently, no testing was directed toward measurement of the "combination of resisting forces" (paragraph 10b(9). Instead, action was directed toward validating or analyzing each force that creates resistance with the understanding that proper modeling of these forces should produce an acceptable summation of the total resistance acting on the vehicle at any increment of time during cross-country operation.

Power Train Submodel

39. The power train submodel is designed to accept basic vehicle data input and produce a theoretical tractive force-speed curve for the vehicle. This curve is assumed to represent the best possible performance of the vehicle at zero wheel or track slip and is later adjusted in AMC-71 according to a desired soil strength. If all power losses within the drive train are correctly appraised, the theoretical curve should match the curve developed from tests on hard surfaces. Also, an option is available in AMC-71 to bypass the power train submodel if pavement drawbar pull-speed curves and motion resistance-speed curves are available from reliable tests; these curves can be summed to obtain the tractive force-speed curve.

40. To exercise the power train submodel in this study, the following data were used as input for computation of the theoretical tractive force-speed curves for the five test vehicles:

a. Vehicle characteristics

(1) Tire rolling radius or drive sprocket radius.

(2) Transmission type.

(3) Number of gears and gear ratios.

(4) Transmission efficiency.

(5) Final drive ratio and efficiency.

b. Performance data

(1) Engine speed-torque curve.

(2) Transmission, torque converter, or fluid coupler speed-torque curves, input-torque values, and torque-multipler values.

41. Plates 1-5 show that the theoretical curves (predicted) derived from the power train submodel are nearly the same as the curves derived from pavement (measured) at Aberdeen Proving Ground. With a 0.90 transmission and final drive efficiency factor for the wheeled vehicles and a 0.95 transmission and final drive efficiency factor for the tracked vehicles, the output of the power train submodel is considered generally acceptable. More precise agreement could be obtained if all frictional power losses were modeled for each vehicle; however, losses at all points in the power train are seldom measured or published and, consequently, modeling of these losses for a particular vehicle would be difficult. Therefore, generalizations of available data indicate the present method of development of the power train curve is acceptable.

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* Aberdeen Proving Ground, "Tracked Vehicle Performance Data Consolidation," Report No. DPS-1846, Dec 1965, Aberdeen Proving Ground, Md.; and R. F. Depkin, "Wheeled Vehicle Performance Data Consolidation," eport No. DPS-2410, Jun 1967, Aberdeen Proving Ground, Md.

Soil and Slope Submodels

42. The predicted performances for drawbar-pull, motion-resistance, and slope-climbing tests (paragraphs 25-27) are based on the tractive force relations of the AMC-71 soil and slope submodels.

Drawbar-pull tests

43. Twenty-eight drawbar-pull tests were conducted on fine-grained soil at Fort Sill, 14 tests on coarse-grained soil at Yuma, and 7 on coarse-grained soil at Eglin (Table 3). All of the tests at Yuma and Eglin and the tests on terrain units 0-7 and 0-8 at Fort Sill (Table 12) were on level surfaces. Drawbar pull in pounds divided by vehicle weight in pounds (drawbar-pull coefficient, D/W) versus wheel or track slip for each test was plotted, and curves of best visual fit were drawn through the data points. Results of previous studies have indicated that the optimum drawbar pull for most vehicles consistently occurs at about 20 percent wheel or track slip (40 percent slip for tracked vehicles on coarse-grained soil), as indicated in Plate 6. Therefore, the optimum drawbar-pull coefficient at 20 percent slip for wheeled and tracked vehicles (fine-grained soils) and at 40 percent slip for tracked (coarse-grained soils), which can be predicted with the AMC-71 soil submodel, has been found to be a meaningful parameter for comparing vehicle performance.

44. A summary of the measured drawbar-pull coefficients from each test and the predicted drawbar-pull coefficients are presented in Table 12. The terrain data (Appendix D) show that most of the drawbar-pull tests at Fort Sill were on sloping surfaces. For these tests, the predicted vehicle performances from AMC-71 were derived from a combination of the soil and slope submodels as they were for the motion-resistance tests discussed later. Graphic comparisons of measured and predicted D/W for all tests are shown in Plate 7. Analysis of these tests, by vehicle, using the five evaluation parameters listed in paragraph 36 indicate the following:

No. of Tests	Vehicle	Range of Deviation D/W	Mean Algebraic Deviation D/W	Mean Absolute Deviation D/W	Relative Deviation %	rms Deviation D/W
		Numerical Evaluation Parameters				
		Fine-Grained Soil, FS				
7	M151	-0.04 to 0.11	0.02	0.04	11	0.05
6	M35A2	0 to 0.08	0.03	0.03	7	0.04
8	M113A1	-0.12 to 0.01	-0.02	0.02	4	0.04
7	M48	-0.04 to 0.05	0.01	0.03	6	0.03
		Coarse-Grained Soil, YPG and EAFB				
4	M151	-0.03 to 0.07	0.02	0.05	13	0.05
7	M35A2	-0.16 to 0.09	-0.04	0.09	25	0.10
8	M113A1	-0.09 to 0.15	0.03	0.08	16	0.09
2	M60	-0.10 to -0.01	-0.06	0.06	10	0.07

45. The weighted average* relative deviation for all vehicles in the fine-grained soil tests was 7 percent, or 13 percent less than the 20 percent limit, indicating acceptable prediction accuracy. Consequently, although the number of tests is limited, the drawbar-pull data indicate good prediction accuracy for fine-grained soil. The weighted average relative deviation for all vehicles in the coarse-grained soil tests was 17.9 percent, indicating acceptable prediction accuracy. The greatest relative deviation for the test vehicles occurred in tests

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* Weighted average of deviations $= \frac{\sum \text{(No. of Tests x Relative Absolute Deviation)}}{\text{Total No. of Tests}}$

with the M35A2, which was 5 percent above the acceptable 20 percent prediction error. The coarse-grained soil relations in AMC-71 were primarily developed from tests on clean sands (SP); whereas, most of the validation tests, although on coarse-grained soil, were on silty sands (SM). The difference in the two soils, both coarse-grained, undoubtedly affected the predictions to some extent. For this reason, greater deviations are to be expected in coarse-grained soil results than in the fine-grained soil results. These data indicate that some refinement is needed in the coarse-grained soil relations to account for different types of coarse-grained soils.

Motion-resistance tests

46. Motion resistance of each vehicle was measured in each terrain unit in conjunction with the drawbar-pull tests. In addition, six tests were conducted in a vegetation override area at Eglin (Table 3). Motion-resistance coefficients (motion resistance divided by vehicle weight, MR/W) were computed. A summary of the measured and predicted MR/W at all sites is presented in Table 13. Terrain data for the motion-resistance tests are presented in Appendix D. Graphic comparisons of all tests are shown in Plate 8. Analyses of these tests, by vehicle, using the five evaluation parameters, show the following:

No. of Tests	Vehicle	Range of Deviation MR/W	Mean Algebraic Deviation MR/W	Mean Absolute Deviation MR/W	Relative Deviation %	rms Deviation MR/W
		Numerical Evaluation Parameters				
			Fine-Grained Soil, FS			
7	M151	-0.05 to 0	-0.01	0.01	7	0.02
6	M35A2	-0.01 to 0	-0.003	0.003	0.3	0
8	M113	-0.02 to 0.01	-0.004	0.009	5	0.01
7	M48	-0.05 to 0.01	-0.007	0.01	5	0.02
			Coarse-Grained Soil, YPG and EAFB			
9	M151	-0.03 to 0.04	0	0.02	26	0.03
8	M35A2	-0.02 to 0.03	0.008	0.13	18	0.02
8	M113A1	0 to 0.04	0.02	0.02	30	0.03
2	M60	0.03 to 0.04	0.04	0.04	54	0.04

47. The weighted average relative deviation for all vehicles in the fine-grained soil tests was 4 percent. Although, the number of tests is limited, the MR/W data indicate good correlation between measured and predicted values for fine-grained soil. The weighted average relative deviation for all vehicles in the coarse-grained soil tests was 32 percent, or 12 percent over the acceptable prediction error. A greater deviation is to be expected in coarse-grained soil results than in the fine-grained soil results for reasons discussed in paragraph 45. Results indicate refinement is needed in the coarse-grained soil relations.

Slope tests (go or no-go)

48. Slope-climbing tests in terms of go or no-go were conducted at Yuma and Houghton on coarse-grained soil. A summary of the terrain data and measured and predicted vehicle performance data for each test is presented in Table 14. The results of these tests are discussed in the following paragraphs.

49. M151. Thirty tests were conducted on gravel and sand slopes with the M151 with average tire inflation pressures of 7.5, 15, 30, and 40 psi. The slopes ranged between 8.5 and 43.0 percent, with a cone index range between 17 and 527. Plates 9-12 show plots of cone index versus slope in percent for the M151 at each tire pressure tested. Data points lying above the predicted maximum slope curve would predict no-go and points on or below the curve would predict go. The plots show that all no-go vehicle performances were predicted correctly; however, four of the measured go tests were predicted no-go. As indicated in the plots, these four tests are relatively close to the curves, which indicates that predictions of maximum slope negotiable by the M151 are slightly conservative.

50. M35A2. Twenty-eight tests were conducted on gravel and sand slopes with the M35A2 with average tire inflation pressures of 10, 15, and 30 psi. The slopes ranged between 8.5 and 43.0 percent, with a cone index range between 17 and 461. Plates 13-15 show plots of cone index versus slope in percent for the M35A2 at each tire pressure tested. The plots show that 5 of the 17 no-go tests are below the predicted maximum slope curves so that, for these 5 tests, performance was predicted incorrectly as go. The M35A2 was able to negotiate 11 slopes, 2 of which were predicted incorrectly as no-go. The plots show that although vehicle performance on seven tests are not in agreement with predicted vehicle performance, they are relatively close to the curve. In summary, these data indicate that predicted vehicle performance on soil with a cone index below 100 is conservative and with a cone index above 100, is slightly optimistic.

51. M113A1 and M60. In AMC-71 the coarse-grained soil relations for tracked vehicles were developed from test results on sand (SP)

available at the time. From these results, characteristics of the vehicle and the ground slope were determined to be the only parameters needed to predict vehicle performance. Furthermore, AMC-71 does not differentiate between types of coarse-grained soil. However, the data measured in the slope tests indicate that tracked vehicle performances tend to separate according to whether the tests were conducted on gravel or sand (both coarse-grained soils), as shown in Plate 16. Therefore, test results for the M113A1 and M60 on gravel and sand will be analyzed separately.

52. Seven gravel slopes tested with the M113A1 ranged from 40.9 to 61.8 percent, with a cone index range between 278 and 417. The predicted maximum slope negotiable for the M113A1 (Plate 16) was 69 percent; whereas, the measured data indicate that the maximum slope negotiable was approximately 58 percent, giving a 19 percent deviation. Nineteen sand slopes tested ranged from 12.1 to 49.7 percent, with a cone index range between 12 and 110. The maximum slope negotiable was predicted to be 69 percent; the measured data indicate a maximum negotiable slope of 40 percent, producing a 73 percent deviation.

53. Four gravel slopes tested with the M60 ranged from 46.1 to 52.8 percent, with a cone index range between 308 and 532. The data show that maximum slope negotiable was predicted at 69 percent; the measured was 47 percent, producing a 47 percent deviation. Only two sand slopes were tested--a go test on a slope of 32.3 percent (83 cone index), and a no-go test on a slope of 33.5 percent (98 cone index). The maximum slope negotiable was predicted at 69 percent; the measured was 33 percent, producing a 109 percent deviation.

54. Summary of slope tests. The results on coarse-grained soil indicate generally good agreement between predicted and measured go-no go performance for the wheeled vehicles except for the M35A2 predictions, which appear slightly optimistic on slopes where cone index was above 100. For the tracked vehicles, the results indicate poor correlations between predicted and measured slope-climbing results. The correlations probably would be improved by including a prediction

parameter to better account for strength differences in coarse-grained soil in the tracked vehicle relations of AMC-71. Therefore, study and revision of the relations are needed.

Visibility Submodel

55. In AMC-71 the visibility submodel considers the effect on the driver of obscuration by vegetation and, consequently, the effect on vehicle speed. The submodel is currently based on the premise that in any terrain situation there is a practical limit imposed upon the speed a vehicle may safely achieve, i.e., the vehicle should at no time exceed that speed at which the driver can recognize a menacing obstacle, and he should stop his vehicle in time to avoid hitting it.

56. The factors considered in this submodel are velocity, driver reaction time, braking coefficient, stopping distance, and recognition distance. The values for driver reaction time and braking coefficient were measured in preliminary validation tests and were found to be essentially the same as the values developed for use in AMC-71. Because of the nature of the relations in the visibility submodel, the primary factor that affects changes in predicted vehicle speed for a given vehicle is the recognition distance imposed by the terrain conditions. Predicted vehicle speed relies heavily upon and, for the most part, is limited by recognition distance.

57. The recognition distance (current criterion for AMC-71) measured in the terrain is based on the maximum distance that 1-ft-square targets can be recognized when the center of the target is 1 ft above the ground surface. This then means that, in the predictions, the driver travels at a speed that allows him to stop his vehicle before hitting only those recognizable obstacles with minimum height above the ground of 1.5 ft. With this criterion, the visibility submodel predicts the maximum speed a driver and vehicle should be able to make. What speed the vehicle actually makes in the field, however, is purely a driver's decision; and man, being what he is, will seldom drive the exact speed as predicted when visibility controls.

58. In the analysis of the test data, terrain units examined were limited to those long enough (longer than 400 ft) to allow a representative speed to be reached (paragraph 115 and Table 4). The measured speeds for each vehicle were plotted against the measured recognition distance for each terrain unit considered. The plots are shown in Plates 17-25; the curves on these plots indicate the maximum safe speed predicted with AMC-71 for any given recognition distance.

59. The plates show that in 33 of the 487 terrain unit tests considered, or 7 percent of the total, the test driver exceeded the maximum speed predicted by the visibility submodel. However, in these 33 tests measured speed was generally low (less than 20 mph in 22 of the 33), and all speeds were within 5 mph of predicted speeds, except for one test. Further, the driver did not hit any dangerous obstacles in these tests, but, if he had, theoretically he should have been able to slow the vehicle to at least 5 mph before it hit; at this speed the driver probably would not have been injured nor would the vehicle have been damaged to the point of immobilization.

60. In summary, again considering that measured vehicle speed controlled by visibility is purely a driver's decision, these test data indicate that in AMC-71 the methods used to determine recognition distance for the terrain and the visibility relation predict a practical maximum speed that compares reasonably well with the maximum speed an expert cross-country driver wearing a safety helmet and restrained by a seat belt would actually be willing to travel.

61. A further consideration was those tests in which visibility controlled the predictions, indicated in Plates 17-25 by closed symbols. The results of these tests (Table 5 under factor 7) show that, for the two wheeled vehicles, the relative deviations are higher than the 20 percent acceptable deviation in this analysis. Relative deviations for the tracked vehicle tests are all within the 20 percent acceptable deviation. The weighted average relative deviation for all the tests where visibility controlled predicted speed was 26.7 percent, or 6.7 percent higher than the acceptable deviation. Some of the closed-symbol tests in the plates are considerably below the line representing

the predicted maximum safe speed, indicating predicted speed is much higher than measured speeds on these individual tests. A contributor to these large differences is the failure by one of the other submodels, especially the vegetation submodel (paragraphs 93-102), to limit predicted speeds. As the poorer submodels are improved, predictions from the visibility submodel should be better. Nevertheless, the visibility submodel and the system for determining recognition distance or both may require some refinement. For example, one refinement feature that probably should be added to the visibility submodel is a simple trigonometric calculation to adjust the measured terrain recognition distance to account for the location of the eye level of the driver in any given vehicle.

62. Experience in the validation tests, as well as other cross-country vehicle testing, indicated that, in general, linear-type depressions associated with natural drainage patterns such as streams or dry gaps could be recognized well in advance of a vehicle encounter. Topography of the terrain in which drainageways are present is usually evident, and recognizable vegetation changes usually occur along the edges of such features. Consequently, the vehicle driver is able to adjust readily to a maximum safe speed before vehicle contact; thus, this is not a problem from a safety standpoint.

63. Although linear-type depressions generally are not a visibility problem, pothole-type depressions can pose a serious problem; for the most part, they are not easily detected from even short distances. Fortunately, potholes large and deep enough to immobilize a vehicle or to injure the driver if they are hit are not often present in terrains unless man puts them there. However, when they do occur in the terrain, experience shows that unless the vehicle driver actually knows they are present and where they are, he probably will be driving too fast to avoid such holes when and if encountered. Observations from cross-country operations indicate that if menacing potholes are present in a terrain, for safety, vehicle speed generally should be kept to the speed of a man walking (about 2 mph).

64. In the visibility submodel of AMC-71, the recognition distance does not account for dangerous potholes in the terrain; however, natural terrain features of this type seldom occur. In those terrains where menacing potholes are known to exist, predicted and actual vehicle speed limits should be kept to a walking speed of 2 mph.

Obstacle Submodels

65. In AMC-71 the obstacle and vegetation submodels are coupled together. Forces, speeds, and other pertinent data are calculated in each submodel, but they are stored for use as required by the coupling program, which examines the various obstacle-vegetation-slope combinations possible for a given terrain input.

66. The obstacle geometry submodel checks the geometry of the characteristic obstacle occurring in a specific terrain against the configuration of the vehicle in a number of critical positions during obstacle crossing to determine whether or not the vehicle can cross the obstacle without a hang-up or nose-in immobilization. If either type of immobilization is indicated, a no-go is predicted in the terrain. The various configurations that are checked for no-go possibility are detailed in the report* that describes AMC-71. If no hang-ups or nose-ins are indicated, the obstacle traction submodel is exercised.

67. In the obstacle traction submodel, the average force required to negotiate a single obstacle is calculated as a function of geometric configuration and dimensions of the obstacle. The submodel also checks the obstacle face length to determine whether the obstacle will affect vehicle performance as a slope or as a cross-over and computes the required traction values for the appropriate situation.

68. For future use in the routine that couples vegetation influences (paragraphs 93-102) with soil-slope and obstacle influences to predict a speed governed by these terrain factors, the obstacle submodel

* U. S. Army Tank-Automotive Command, op. cit., page 5.

accepts input values of obstacle dimensions and spacing, combined with the curve of obstacle height and speed over obstacles at 2.5-g vertical acceleration. It used these values to compute percentage of area denied by obstacles, average force required to override obstacles, and peak traction demands while the vehicle is overriding obstacles.

69. To validate the obstacle relations individually, without considering the coupling mechanisms used in AMC-71 or vegetation influences, several procedures were developed to test some of the individual relations pertinent to the obstacle submodels only. Tests were conducted to validate hang-up and nose-in predictions, traction computations, and obstacle go-no go performance. The speed over obstacles at 2.5 g's was obtained from results of tests for the ride dynamics model (paragraphs 106-114), which is being studied separately from the validation program. Computation of the percentage of area denied to vehicle passage by obstacles was checked using selected terrains that contained a quantity of obstacles, such as trees and deadfall, without significant other vegetation or soil influences.

70. The obstacle-vehicle geometry interaction subroutine was developed using the obstacle-vehicle interaction relations obtained from WES and TACOM obstacle-vehicle geometry submodels. Most surface obstacles have natural geometric features that can be measured and correlated with geometric features of vehicles to estimate vehicle performance. This is basically the purpose of the interaction subroutine.

71. In the interaction subroutine it is assumed that the vehicle approaches the obstacle at 90 deg, the obstacles are either trench- or mound-shaped, the approach and departure angles of the vehicle are equal, and the ground surfaces on either side of the obstacle are on the same horizontal plane. It is also assumed in the submodel relation that all obstacles are rigid. Immobilization is predicted if there is any interference at any time during the complete passage of the vehicle over an obstacle.

72. The normal output of this interaction subroutine is either an interference, caused by obstacle-vehicle interaction or insufficient

traction, or a speed at which the vehicle can cross the obstacle. If interference occurs, vehicle speed is set equal to zero and a no-go situation is predicted. In the scale-model testing (paragraph 33), the same assumptions as above were used, but the subroutine was modified to predict go-no go performance with speed as an input. This permitted analysis of only go-no go performance by minimizing the effects of speed (kinetic energy).

Scale-model vehicle tests over rigid obstacles

73. Comparisons of measured and predicted results for the M60 and M35A2 on trench- and mound-shaped triangular and trapezoidal obstacles are shown in Tables 16-20. Results of scale-model obstacle tests with the M60 indicate very little effect of obstacle geometry on vehicle performance. No hang-ups occurred while the vehicle was crossing trench- and mound-shaped obstacles of both triangular and trapezoidal shapes. All no-go conditions, predicted and measured, were caused by insufficient traction. Based on the large number of obstacle configurations used in these tests, it would appear from the results that the problem of obstacle interference for tracked vehicles is negligible on trench- and mound-shaped obstacles with flank angles less than 70 percent. Differences in measured and predicted results on a percent-flank-angle basis for all obstacles are in most cases less than 5 percent. On an obstacle-height (trench depth or mound height) basis, the predicted values are very conservative when compared with measured results.

74. Analysis of test results with the M35A2 indicate that geometric configuration and shape, along with traction, are important in determining go-no go performance with wheeled vehicles on obstacles with flank angles of less than 70 percent. Geometric configuration and shape had little or no effect on results of tests in which the tractive coefficient was low. All predicted and measured no-go's occurred because of insufficient traction rather than obstacle hang-up when the tractive coefficient was 0.12. However, differences in performance were apparent for tests on obstacles in which the tractive coefficients were

0.27 and 0.45. As expected, hang-ups occurred on triangular mound-shaped obstacles whose height exceeded vehicle clearance. Only traction failures occurred on the same obstacles in the inverted position (trench), caused by bridging of the tires over obstacle interference points. Increasing the top width from a near-triangular configuration to trapezoidal shape produced similar results until the top width reached 3 in. (equivalent to 45 in. for the prototype vehicles), at which point predicted and measured no-go's were controlled by traction only. Beyond 3 in., varying the top width produced the same result regardless of the tractive coefficient. Results of tests with trapezoidal trench obstacles were the same as those obtained with triangular trench obstacles, i.e., traction only controlled the predicted and measured results. Differences in measured and predicted results on a percent-flank-angle basis for all obstacles tested with the wheeled vehicle are, in most cases, less than 10 percent. On an obstacle-height (trench depth or mound height) basis, the obstacle subroutine failed to predict measured immobilization due to traction for most obstacles. This failure in prediction indicates that more traction checks should be added to the obstacle-crossing routine for wheeled vehicles.

75. Scale-model testing with the tracked and wheeled vehicles indicates that the obstacle submodel generally produces acceptable results for rigid obstacles over the range of obstacles used in these tests. However, in AMC-71 relations, additional traction checks appear necessary for adequate prediction of wheeled vehicle obstacle crossings, based on the results of these tests over obstacles with flank angles less than 70 percent.

76. In the results of long-slope tests (Table 21), measured and predicted results on a percent-slope basis indicate differences of less than 3 percent for a range of tractive coefficients. For tracked vehicles, the 3 percent deviation occurred at the lowest tractive coefficient; for wheeled vehicles, the 3 percent deviation was generally constant. In tests on tractive coefficients of <0.35, the predicted slopes were equal to or less than the measured slopes negotiated by both the tracked and wheeled vehicles. Only on the higher tractive

coefficients (>0.45) did measured slope results exceed predicted for both vehicles.

77. Results of the limited scale-model slope tests indicate that the model vehicles were capable of negotiating slopes within 3 percent of predicted when the surface tractive coefficients were known.

Field obstacle tests,
deformable obstacles

78. Obstacle-crossing tests were conducted at Yuma and Fort Knox in terrain where natural erosional processes had created dry stream beds with banks that had different step heights. The steps were usually firm with little significant vegetation. Eleven tests were conducted at Yuma with the M151 and six at Fort Knox with the M113A1 to obtain data on trench obstacles in which the vehicles deformed the sides of the obstacles during the crossings. Obstacle profiles were taken before each test to determine obstacle geometric characteristics. In some cases profiles were taken after a test to obtain the deformed profile created by the vehicle in completing a test. Obstacle profiles for the M151 and M113A1 tests are shown in Plates 26 and 27, respectively.

79. Tests with the M151 at Yuma. Results predicted with AMC-71 and measured results of obstacle tests at Yuma with the M151 (Plate 26) are:

Terrain Unit Number	Go-No Go Performance		Reason for Immobilization	
	Predicted	Measured	Predicted	Measured
0-54	No-go	Go	Hang-up	None
0-55	No-go	No-go	Hang-up	Hang-up
0-56	No-go	No-go	Hang-up	Hang-up
0-57	No-go	No-go	Hang-up	Hang-up
0-58	No-go	Go	Hang-up	None
0-59	Go	Go	None	None
0-60	No-go	Difficult go	Hang-up	None
0-61	No-go	No-go	Hang-up	Hang-up
0-62	No-go	Go	Hang-up	None
0-63	No-go	No-go	Hang-up	Hang-up
0-64	No-go	Difficult go	Hang-up	None

80. As indicated by these results, AMC-71 failed to predict vehicle performance properly in 5 of the 11 tests. The obstacle-crossing subroutine of the obstacle submodel allows the M151 to negotiate a 13-in. (magnitude), perpendicular-faced, rigid obstacle, either mound or trench, but predicts a hang-up on a 14-in. obstacle. This coincides with the measured step height of terrain unit 0-64, which was a difficult go for the M151 on a 14-in. deformable mound. However, the prediction is poor when compared with test 0-62 on a 21-in. trench, which was a relatively easy go with deformation of the obstacle. As the front wheels rolled over the edge of the trench, some 6 in. of material were knocked off, producing a much less abrupt obstacle than the original 21-in. obstacle. In this test and the other tests that produced measured go results but no-go was predicted, go results were generally the result of deformation of the obstacle. Since obstacle deformation is not considered in AMC-71, the disagreement between measured and predicted results in these tests is to be expected.

81. Tests with the M113A1 at Fort Knox. Several obstacle-crossing tests were conducted with the M113A1 across a dry wash area in fine-grained soil at Fort Knox (Plate 27). The results of these tests are:

Terrain Unit Number	Go-No Go Performance		Reason for Immobilization	
	Predicted	Measured	Predicted	Measured
0-5	Go	Go	None	None
0-6	No-go	Go	Hang-up	None
0-7	No-go	Go	Hang-up	None
0-8	No-go	Go	Hang-up	None
0-9	No-go	Difficult go	Hang-up	None
0-10	No-go	No-go	Hang-up	Hang-up

All six obstacles used for these tests were trapezoidal trench obstacles with little or no significant vegetation. The M113A1 had no difficulty in crossing the first four obstacles in the field tests. Test 0-9 was a near immobilization by hang-up, and test 0-10 was a no-go caused by the vehicle falling into the obstacle and nosing into the opposite bank. Measured and predicted results were the same for test 0-5; for tests

0-6 through 0-10, all no-go's were predicted by reason of hang-up. However, as indicated by the scale-model tests with tracked vehicles, the obstacle submodel is very conservative in predicting results for trapezoidal obstacles and predicts hang-ups that generally either do not occur in deformable-obstacle tests or are actually traction deficiencies rather than obstacle-vehicle interferences.

82. Tests with tracked vehicles at Fort Sill and Yuma. Nine predicted no-go's which were measured go's also occurred in traverse terrain units at Fort Sill and Yuma with tracked vehicles (paragraph 137). These no-go's again point to the conservatism of the obstacle submodel predictions for tracked vehicles. Plate 28 shows that the obstacles in the nine terrain units, in which AMC-71 predicted no-go's for tracked vehicles, were not abrupt obstacles but were depressions in the terrain that were of sufficient geometric size and shape to be considered in one of the interference subroutines. The heavy tracked vehicles easily deformed the obstacles as they were crossed during the tests with no danger of hang-up.

83. Summary of obstacle-crossing tests. Results of tests with tracked vehicles crossing rigid and deformable obstacles indicate that the submodel fails to model most obstacle-tracked vehicle interactions adequately. It overstates the interference problem, predicting hang-ups that normally do not occur because of obstacle deformation or changes in vehicle position by deflection of suspension components. Analyses of obstacle tests indicate that vehicle traction generally governs go-no go performance of tracked vehicles, except over those obstacles with very steep approach and departure angles that cause immobilizations by hang-up. Combinations of relatively steep approach angles, large obstacle magnitudes, and wide base widths of trench obstacles increase the possibility of immobilization by hang-up by allowing the vehicle to literally fall into the obstacle, thereby reducing the possibility of obstacle crossing. In addition, scale-model tests indicate that predicting performance solely on the basis of obstacle heights is generally very conservative, increasing the possibility of go-no go prediction error.

84. In obstacle tests with wheeled vehicles, predicted and measured results show good correlation when the tractive coefficent is low (0.12). Obstacle geometry does not appear to affect results appreciably when the tractive coefficient is low, except for the most abrupt obstacles. When the tractive coefficient increases, however, the chance of prediction error from the obstacle submodel increases. Consequently, go-no go performance correlation (measured versus predicted) is rather poor for the higher tractive coefficients, with the vehicles generally capable of negotiating steeper, more abrupt obstacles than those predicted. Further testing appears necessary to define sufficiently the go-no go problem for wheeled vehicles on obstacles with medium-to-high tractive coefficients so that adjustments can be made to the prediction subroutine. The influence of various obstacle size and shape combinations on wheeled performance, along with obstacle deformation not considered in AMC-71, is apparent from the test data, indicating study and revision could improve the accuracy of the obstacle-vehicle relations.

85. In summary, the obstacle geometry submodel generally overstates the hang-up problem relative to tracked vehicles negotiating deformable obstacles. More traction checks appear necessary for adequate prediction of wheeled vehicle performance, and more tests are required to develop and improve the interference relations in the obstacle submodel.

Area denied by obstacles
in terrain units

86. Three individual terrain units (paragraph 29) were selected for tests at Eglin AFB and Houghton. Some trees or underbrush were removed where necessary in an attempt to obtain a terrain in which mean obstacle spacing and percentage of area denied to vehicle passage were the only terrain factors affecting vehicle speed. These two factors are essential elements of the relations in the obstacle submodel used to compute the maximum speed achievable in circumventing obstacles in a terrain unit. Accordingly, efforts were made to analyze the true effect of these factors on vehicle performance to determine the validity

of the relations in the obstacle submodel relating area denied to vehicle performance.

87. Two homogeneous terrain units were selected at Eglin, 0-12 and 0-14, and one at Houghton, 0-1, which are described in Appendix B. The two Eglin units were essentially bare, although the ground surface was covered with 1 to 2 in. of pine straw. The large pines and stumps in terrain unit 0-12 were spaced 13.7 ft apart (mean spacing), and those in terrain unit 0-14 were spaced 15.2 ft apart. The mean spacing of the medium-sized maples and stumps in Houghton terrain unit 0-1 was 8.8 ft. The ground surface in this latter unit was essentially bare.

88. Terrain units 0-8, 0-9, and 0-10 at Eglin, were not quite as homogeneous and uniform as the other areas but potentially represented useful obstacle-avoidance test areas. The underbrush was cleared from these units (as in the other tests), leaving only various-sized trees and stumps as obstacles. When the data collected were reduced, it became apparent that Eglin units 0-9 and 0-10 would be no-go for all vehicles because of the close spacing of the obstacles, which produced 3.5- and a 7.3-ft mean obstacle spacings, respectively. Consequently, these units were used as individual vegetation override tests (to be discussed later), but the measured obstacle data were also considered pertinent to this analysis.

89. Tests were conducted with the M151, the M35A2, and the M113A1 vehicles. Results of these tests are:

Terrain Unit No.	Mean Obstacle Spacing ft	Area Denied, %			Measured Speed, mph		
		M151	M35A2	M113A1	M151	M35A2	M113A1
Eglin 0-8	9.9	12.8	19.9	23.4	5.1	4.6	5.9
Eglin 0-9	3.5	100.0	100.0	100.0	No-go	No-go	No-go
Eglin 0-10	7.3	60.6	100.0	100.0	No-go	No-go	No-go
Eglin 0-12	13.7	19.1	41.4	48.3	19.2	8.0	9.8
Eglin 0-14	15.2	15.6	33.7	39.7	*	12.4	16.8
Houghton 0-1	8.8	41.3	92.9	100.0	2.3 No-go**	No-go	No-go

* M151 was unavailable for testing due to mechanical failure.

** M151 completed initial run at 2.3 mph by constantly maneuvering or reversing direction. Three more attempts to complete a run using different paths were unsuccessful.

90. Relations contained in the obstacle submodel governing avoidance of obstacles by vehicles initially consider the width of the vehicles multiplied by a width factor (≈1.5) that accounts for the area denied to the vehicles by the obstacles. Using the widths of the vehicles (62 in. for M151, 96 in. for M35A2, and 105 in. for M113A1) and the above width factor, the widths required for the vehicles to circumvent all obstacles in a terrain unit were:

Vehicle	Width Required to Circumvent Obstacles ft
M151	7.78
M35A2	12.00
M113A1	13.13

Accordingly, homogeneous terrain units in which the mean obstacle spacing is less than the above values will have a no-go condition predicted. Based on the results of the specific tests shown above (Eglin 0-9 and 0-10 and Houghton 0-1), this representation of required width to circumvent obstacles seems well justified.

91. Also important to AMC-71 predictions is the percentage of area of a terrain denied to a vehicle by obstacles. The basic equations in AMC-71 were derived from tests which showed that percentages greater than 50 percent usually produced a no-go condition (more than half the area was not usable); whereas, percentages less than 10 seemed to have little or no effect on vehicle performance. The results of the six tests shown in paragraph 89 seem to bear out the 50 percent and 10 percent limits. For example, the M151 was unable to complete a test in Eglin 0-10 in which 60.6 percent of the area was denied, but it was able to just complete a test in Houghton 0-1 in which 41.3 percent of the area was denied, indicating that 50 percent area denied is near the no-go point. In Eglin 0-12, the M151 completed a test in an area denied of 19.1 percent at 19.2 mph, but it could not negotiate the terrain unit at 25 mph because this speed was too fast to allow maneuvering. These results tend to indicate that the same conditions in an area denied of less than 10 percent should not affect vehicle speed.

92. Consequently, although the data for this particular analysis are limited, results indicate that the present relations in AMC-71 should provide acceptable results for consideration of the effects of obstacle mean spacing and area denied on vehicle performance. Further analysis of these effects on vehicle performance will be discussed under the vegetation and maneuvering submodels, which follow.

Vegetation Submodel

93. The vegetation submodel contains many relations associated with optimization of forces or speeds from other submodels and, consequently, is difficult to analyze as a separate entity. Nevertheless, factors 8 and 9 in Table 5 have overall relative deviations of 88.8 and 54.0 percent, respectively, indicating poor submodel prediction accuracy.

Tree-override tests

94. Tests were conducted to validate significant relations of peak tree-override forces and quantity of work required to override single and multiple trees as well as the maximum single stem diameter each vehicle was capable of overriding. Tests were conducted only in vegetated areas at Eglin and Houghton with the M151, the M35A2, and the M113A1. From the oscillogram for each override test, the peak force to override the tree and the amount of work required to completely override the tree (the total area under the oscillogram excluding the motion resistance from the test) were measured. These data were used with the measured tree data to develop the following tabulation:

Vehicle	Location	Stem Diameter in.	Tree Type	Peak Force, lb Measured	Peak Force, lb Predicted	Work, ft-lb Measured	Work, ft-lb Predicted
M151	Eglin	2.95	Pine	1,347	783	8,425	2,574
		3.15	Pine	1,776	953	4,981	3,124
		3.15	Oak	2,421	953	4,771	3,124
		3.15	Oak	3,541	953	6,935	3,124
M35A2	Eglin	5.12	Pine	3,345	2,751	68,198	13,407
		5.31	Oak	2,371	3,069	5,258	15,014
		5.43	Oak	3,813	3,282	36,498	16,037
		5.91	Pine	4,671	4,232	40,461	20,600
		5.98	Pine	6,269	4,384	94,499	21,430
		6.30	Oak	6,503	5,126	75,484	24,995
		7.48	Pine	7,750	8,579	99,651	41,856
		7.48	Pine	8,374	8,579	145,271	41,856
		7.87	Oak	6,464	9,993	119,786	48,819
		10.35	Oak	9,963	22,729	105,670	111,011
		11.22	Oak	11,847	28,956	73,484	141,264
	Houghton	6.75	Poplar	7,263	7,031	39,580	30,755
		7.00	Poplar	6,511	6,305	82,046	34,300
M113A1	Eglin	6.14	Oak	2,657	5,787	6,175	23,147
		8.27	Oak	4,720	14,140	11,168	56,561
		0.84	Oak	11,148	23,819	183,111	95,276
		10.83	Oak	10,135	31,755	70,034	127,024

To obtain values of predicted peak force and total work required to override each tree, AMC-71 uses the following equations:

$$\text{Peak force, lb} = 40 - \frac{\text{Pushbar height, in.}}{2} (\text{Stem diameter})^3 \quad (1)$$

$$\text{Total work, ft-lb} = 100 \ (\text{Stem diameter})^3 \quad (2)$$

These two equations were developed from vegetation tests described in WES Technical Report 3-783.* Although the predicted and measured values shown for the single-tree tests establish no definite pattern

* C. A. Blackmon and D. D. Randolph, "An Analytical Model for Predicting Cross-Country Vehicle Performance, Longitudinal Obstacles," Technical Report 3-783, Appendix B, Vol II, Jul 1968, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

relative to each other when plotted on 1:1 plots as shown in Plate 29, the data scatter is no greater than the scatter of data used to develop the original relations. The original results and these data indicate that the growth of individual trees is a function of their environment and, consequently, individual trees of the same size and species at the same geographic location and in the same soil type do not necessarily exhibit the same test behavior. Nevertheless, the relations now used generally produce predictions that are considered adequate for all sizes and species of trees pertinent to vehicle operation. However, results of further tests and study may indicate refinement can be made to the tree-override relations to produce more accurate predictions.

95. Two tests were conducted at Houghton to obtain data on multiple tree-override forces. In these tests, an M113A1 pulled an unpowered M35A2 over clumps of sugar maple trees containing two to four trees of various diameters. Peak forces on the vehicle pushbar and the total work required to override the clumps were measured for the M35A2 in each test, along with vehicle motion resistance in the soil around the clump. The results of these tests are:

Tree Diameters in Clump, in.	Peak Forces, lb		Work, ft-lb	
	Measured	Predicted	Measured	Predicted
2-3/4, 3-1/4 2, 1	4,235	1,315	29,606	6,413
6-1/4, 4-1/2	11,637	6,873	153,613	33,527

The predicted values shown were obtained by summing the total work required to override each tree singly and using this value in Equation 2 to obtain an equivalent stem diameter for the total work required to override the clump of trees. This equivalent diameter was then used to calculate the peak force using Equation 1. Because of the large variation in test data obtained in multiple-tree-override tests prior to formulation of AMC-71, no specific relations were included in AMC-71 to analyze multiple-tree-override tests forces. As shown by the results above, the equivalent diameter method does not suffice for the tests shown in the tabulation, and further testing is suggested to improve prediction reliability in multiple-tree override.

96. Tests were also conducted at Eglin and Houghton to validate AMC-71 predictions of the maximum stem diameter each vehicle was capable of overriding. To determine this diameter, Equation 1 was set equal to the maximum pushbar force the vehicle was capable of withstanding. This maximum force was assumed to be the weight of the vehicle, based on the assumption that the leading edge would be designed by the manufacturer to withstand at least the vehicle weight. Using this procedure, the following values were obtained:

Vehicle	Weight, lb	Pushbar Height, in.	Maximum Stem Diameter in.
M151	3,180	19	4.71
M35A2	18,225	39	9.62
M113A1	23,410	30	9.78
M48	104,000	45	18.11
M60	93,620	45	17.49

97. To validate these values, uniform single trees were selected in forested areas in which other terrain factors, such as surface roughness, would not affect test results. Validation tests were conducted with only the M151, the M35A2, and the M113A1. Some difficulty was experienced with the M151 in locating areas wherein the maximum traction of the vehicle could be obtained for use in overriding the trees. Also, some variation in results occurred between Eglin and Houghton trees as a function of the tree species and environment. The sugar maple trees at Houghton were very durable as a result of climatic influences on growth and, in contrast to the Eglin trees, usually bent over, upturning root balls that increased the difficulty required to override the trees. Consequently, the same force required to break or bend trees at Eglin could only override smaller diameter trees at Houghton because of the increased override force required. Results of these tests are shown in Table 15.

98. The M35A2 and M113A1 results agree reasonably well with the predicted results in paragraph 96, although the M113A1 tests at Houghton indicate slightly lower values. The M151 tests at both locations indicate lower values than predicted. However, in most of these tests,

traction was insufficient because of soil strength, which allowed the vehicle to spin out rather than stall the engine. With sufficient traction the M151 would probably have overridden trees approximately the same as those predicted at Eglin but not at Houghton, based on M113A1 tests. The relation used, however, is considered to produce acceptable results when the qualifying assumptions for traction demands are fulfilled.

99. Vegetation tests to validate area-denied relations were used in the obstacle submodel for an analysis of area denied by obstacles (paragraphs 86-92) and will not be repeated here. The correlation between the two types of obstacles, lateral (horizontal surface obstacles) and longitudinal (upright obstacles, trees or stumps), is considered by AMC-71 as a subroutine relative to either the obstacle submodel or the vegetation submodel as required for prediction purposes.

100. As discussed in the maneuvering submodel analysis below (paragraphs 103-105), AMC-71 relations governing vegetation override and maneuvering assume that the vehicle driver will override trees up to the maximum stem diameter negotiable by the vehicle and maneuver around those trees larger than the maximum. To determine the validity of this assumption, all trees overridden in each terrain unit were recorded for each vehicle test. Although the quantity of trees overridden decreased as diameter increased, in none of these tests did the vehicle override a tree equal to the maximum diameter negotiable. In most tests, the driver usually maneuvered around trees larger than 5 to 6 in. in diameter with the larger vehicles and trees larger than 3 in. in diameter with the M151. As vehicle size increased, however, the larger the stem size overridden increased, probably because of the increased feeling of security experienced by the driver with the larger vehicles. However, the driver realized that, on most occasions, maneuvering had less effect on decreasing vehicle speed than did overriding large trees. Consequently, the driver gradually familiarized himself with the effect of override of the larger vegetation on the speed of each vehicle in each test and arbitrarily selected an approximate stem size that would be avoided if possible in order to obtain a maximum safe vehicle speed for

each test. This selection was based on anticipated vehicle damage, vehicle maneuvering rate, test condition, and driver and navigator safety. Accordingly, in most tests, even in similar terrain, the driver overrode various maximum diameters such that analysis of maximum stem size overridden based on terrain data produced little or no correlation. The important result derived from these tests, however, was that the assumption made in AMC-71 that the driver overrides up to the maximum diameter negotiable, then maneuvers, is invalid in cross-country operation. Further testing is in order, therefore, to allow correct modeling of vehicle-driver reaction in forested terrain.

Observation in forested terrain

101. An important aspect not considered in AMC-71 was observed during tests at some of the forested sites where trees were closely spaced. In both single- and multiple-tree-override tests in forested terrains, one of the main factors in determining the measured vehicle speed where override was necessary was the influence exerted on the falling trees by surrounding vegetation. If the trees fell to the ground encountering little or no resistance from other trees while falling, the vehicle usually was able to override them without incident, provided the trees were sufficiently small to be overridden by the particular vehicle. However, when the trees being overridden either fell into other vegetation or lodged among other trees, the vehicle would usually continue up onto the trees until override was completed or the traction elements no longer contacted the ground surface. The latter was experienced with the vehicles in terrain unit 0-9 at Eglin and in tests on traverses 2 and 3 at Houghton. In these tests, the trees overridden fell into other trees and lodged at 15- to 35-deg angles with the ground surface. The vehicles continued up onto the trees until the entire vehicle was resting on the vegetation, with no ground contact. Predictions with AMC-71 based on work required to override the trees singly predicted go conditions for the M35A2 and M113A1 even though all tests were measured no-go's. Modeling of multiple-tree override to include interference from other trees is needed. Accordingly, sufficient vegetation testing should be conducted

in the future to produce a data base for development of relations that will model interference from other trees in cross-country operation in forested terrains.

102. Another important aspect that surfaced during the testing was the amount of superficial damage sustained by the nonarmored wheeled vehicles in the forested terrain sites; except for scratched paint, the armored tracked vehicles were not damaged. In the validation tests, the driver drove at a maximum safe speed for the particular vehicle under the terrain conditions imposed, without injuring the vehicle occupants or sustaining sufficient vehicle damage to cause immobilization. Although tests were completed in forested terrains without major or immobilizing damage, some superficial damage usually occurred to the nonarmored vehicles, ranging from numerous minor dents and scratches to bent fenders and cracked windshields. This damage occurred primarily when the vehicles sideswiped tree limbs and overridden vegetation dragged against the underside of the vehicle. If no damage, either major or minor, is to be permitted in cross-country operations, predicted speeds for nonarmored vehicles would have to be adjusted downward to allow the driver sufficient operating time to ensure that no minor vehicle damage would occur. This observation, coupled with the speed results obtained from the actual tests, emphasizes the need for revision of the vegetation submodel for better prediction capability in forested terrain.

Maneuvering Submodel

103. Although it is used as a coupling routine in AMC-71, the maneuvering submodel is closely associated with parts of the obstacle and vegetation submodels. The maneuvering submodel itself considers only two variables (mean obstacle spacing and area denied) and merely adjusts the minimum of the speeds from soil, slope, ride dynamics, and visibility to account for vehicle maneuvering required to avoid vegetation or obstacles too large for the vehicle to override. The equation used to adjust the minimum speed is:

$$\text{Manuever speed} = \frac{\text{Minimum speed for soil, slope, ride, visibility}}{40} \text{ (50\% - area denied)} \quad (3)$$

Based on the predicted and measured speed results for terrain-unit tests in which maneuvering limited predicted speed (paragraph 119), the maneuvering submodel appears to be modeling vehicle speed poorly. Relative deviations for wheeled vehicles in maneuver areas are on the order of >100 percent; whereas, those for tracked vehicles are somewhat lower at >40 percent (Table 5, factor 8). Investigation of possible areas for error indicate that Equation 3, which predicts a maneuver speed for each vehicle, is perhaps most incorrect with regard to modeling vehicle performance. Using data obtained from the obstacle and vegetation submodels, the maneuvering submodel couples the total area denied by both obstacles and vegetation into a routine that optimizes four possible obstacle-vegetation interactions:

a. Case A. Vehicle overrides trees less than Class X, circumvents the trees in Class X and all trees greater than those in Class X, and circumvents all discrete surface irregularities.

b. Case B. Vehicle overrides the trees in Class X and all smaller trees, circumvents all trees greater than those in Class X, and circumvents all discrete surface irregularities.

c. Case C. Vehicle circumvents the trees in Class X and all trees greater but overrides all surface irregularities.

d. Case D. Vehicle circumvents all trees greater than those in Class X, overrides all trees equal to or less than those in Class X, and overrides all surface irregularities.

104. These four cases show that maneuvering is an important aspect of each interaction routine. Consequently, if Equations 1 and 2 (paragraph 94) produce adequate prediction results, the last equation used by AMC-71 to predict a final maneuver speed, Equation 3, must incorrectly adjust the minimum speed and obtain the gross errors that were obtained in override tests. Analysis of Equation 3 would indicate that the "40"

should perhaps be a variable dependent upon vehicle characteristics such as vehicle type, turning radius, and vehicle length rather than a constant value. Test data used to derive this equation produced plots for wheeled and tracked vehicles that were seemingly not related to each other. Because of the uncertainty in the original data, the equation was written such that manuevering in a terrain unit would occur only between the limits of 50 and 10 percent area denied. If the area denied was thus 10 percent, the factor (50 percent minus area denied) would equal 40 and cancel with the 40 in the divisor, leaving no speed adjustment to be made. However, no effort was apparently made to include in the divisor other factors believed to affect the maneuverability of a vehicle, such as turning radius, length, and articulation. Consequently, it appears that the factor works much better for tracked vehicles with skid steer (≈ 0 turning radius) than for wheeled vehicles that require some finite distance within which a complete 360-deg turn can be made. Another possibility for error occurs in the development of the four interaction cases above. In developing maneuver relations for AMC-71, it was assumed that a vehicle driver would override trees or obstacles up to the maximum size that the vehicle was capable of overriding, after which he would begin to maneuver. As discussed in the vegetation override, analysis for those tests in which obstacles were overridden (paragraph 100), the driver usually made much better speeds within terrain units by overriding only very small trees (≈ 3 to 4 in.) or obstacles (≈ 4 to 6 in.) and maneuvering around the larger obstacles. Consequently, the measured speeds are usually more representative of a maneuvering situation than that considered by AMC-71.

105. Therefore, the results of validation tests in maneuver areas, which show the relative deviation to be 88.8 percent, indicate that the maneuvering submodel is not accurate and that further testing should be conducted to revise this important cross-country mobility factor. More consideration should be given to the actual override being accomplished rather than the potentialities for override, and Equation 3 should be revised to include various vehicle attributes that affect maneuverability.

Ride (Vehicle) Dynamics Module

106. The ride dynamics module computes speeds at which a vehicle can traverse discrete obstacles or continuous surface roughness without exceeding specified limiting shock or vibration criteria. The surface roughness relation consists of speed values corresponding to the limit of driver tolerance to random vibrations, as a function of rms terrain profile elevation. This limiting condition is defined in terms of the rate at which power can reasonably be absorbed by the human body. The present criterion used in the dynamic module for the driver tolerance limit is 6 watts of absorbed power. However, it became quite evident during this program that drivers were generally willing to maintain speeds that produced absorbed power levels noticeable in excess of 6 watts (more in the neighborhood of about 9 or 10 watts).

107. The obstacle impact relation is a function of obstacle height and speeds at which a vertical acceleration of 2.5 g's is experienced at the driver's station when the vehicle encounters discrete obstacles. Two terrain parameters involved, rms elevation and obstacle height, are factors quantified in the terrain unit or traverse description. The simulation of vehicle dynamics is necessarily complex, requiring detailed vehicle data that were not available for AMC-71. Accordingly, in the interest of expediency, AMC-71 computer relations were initially programmed for the five validation vehicles only rather than for tracked and wheeled vehicles of general configuration. (Since the completion of AMC-71, however, generalized digital computer models have been established.)

108. The currently implemented ride dynamics module is a digital simulation that treats vehicle motions in the center-line plane only (two dimensions). It is a generalized model that will handle any rigid-frame vehicle on tracks or tires, with any type or mix of suspensions. Tires are modeled using a segmented wheel representation, and a variety of this is used to introduce first-order coupling of the road wheels on a tracked vehicle by the track. Preprocessing of the detailed

vehicle data in the ride dynamics module reduces the making of dynamics-based predictions in the unit and traverse modules to a simple, rapid table-lookup process.

109. The lack of experimental ride and shock relations rendered it necessary to conduct extensive field tests to develop the appropriate relations to serve as baselines for comparisons. The details of this study concerning the pertinent developments and refinements will be reported in the near future. In accordance with the scope of this study, the ride relations determined from the ride dynamics simulation were used in the comparisons of predicted and measured speeds, as described in the following paragraphs.

110. The computer-simulated ride relations for surface roughness (rms elevation versus speed) shown in Plate 30 were used in AMC-71 to predict speeds for all terrain-unit validation tests. Results are shown in Table 4.

111. Results of terrain-unit tests in which surface roughness relations in AMC-71 (speed-limiting factor number 5 - paragraph 10) controlled predicted vehicle speed are summarized in the following tabulation:

		Terrain-Unit Tests Based on Simulated Surface Roughness Relations				
No. of Tests	Vehicle	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Devia-ation mph
61	M151	-15.5 to 16.1	4.3	5.9	31.9	7.2
53	M35A2	- 3.7 to 19.3	6.7	6.8	46.0	7.9
41	M113A1	-10.9 to 14.1	-1.6	4.8	29.6	6.2

The relative deviations for the vehicles are somewhat greater than the acceptable limit (20 percent), indicating improvement is needed.

112. An rms elevation versus speed curve (Plate 31) was developed for each vehicle based on the measured speed results in 32 terrain units. These tests, designated by an asterisk in Table 4, are tests in which field observations during the test and driver and navigator comments indicated that measured vehicle speed was limited by the

surface roughness. Note in Table 4 that for these tests the factor controlling predicted vehicle speed is not always surface roughness (paragraph 116).

113. The relations based on field-measured data in Plate 31 were put into the vehicle characteristics file in place of the simulated relations, and new speed predictions were made for all validation tests using AMC-71. The new results for terrain-unit tests where surface roughness controlled predicted vehicle speed are shown in the following tabulation. When the field relations were used to predict speeds, the number of tests in which surface roughness controlled predicted speed increased, as shown by a comparison of the tabulation in paragraph 111 with the following are:

		Terrain-Unit Tests Based on Measured Surface Roughness Relations				
No. of Tests	Vehicle	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation mph
65	M151	-11.6 to 15.1	2.2	4.4	25.0	5.6
67	M35A2	- 6.1 to 15.3	1.6	3.0	20.1	4.2
43	M113A1	- 6.2 to 5.1	-0.8	2.1	11.7	2.6
10	M48	- 5.3 to 13.1	1.4	3.8	20.2	5.2
3	M60	- 1.3 to 1.1	-0.3	1.1	7.0	1.1

114. The above results, when compared with the simulated results, show marked improvement in AMC-71 prediction accuracy when measured speed versus rms elevation relations are used. The data show that the relative deviation for each vehicle is near or below 20 percent, indicating acceptable prediction accuracy.

PART IV: ANALYSIS OF RESULTS OF SINGLE-TERRAIN-UNIT SPEED TESTS

115. Results from terrain-unit speed tests in this study were analyzed for traverse terrain units longer than about 400 ft and for single terrain units outside the traverses. Results of tests conducted in contiguous terrain units on traverses indicated that short terrain units (less than about 400 ft) do not usually allow sufficient distance for vehicle and driver adjustments to obtain a representative terrain-unit speed. Single terrain units not on a traverse (designated by a "0", e.g. FSO) were selected in areas that allowed ample distance outside the terrain unit for accelerations and decelerations.

116. Determination in a field test, especially in traverse terrain units, of the one terrain factor that limits measured vehicle speed in every unit is difficult and not always clear (paragraph 10b). Therefore, results of the terrain-unit tests were analyzed according to the factors that controlled the predicted speed in each unit for each vehicle as shown in Table 4. There is a drawback to this approach. In the model, for a given terrain unit, the speed-limiting factor that produces the lowest predicted vehicle speed is designated as the speed limiter for that terrain unit. Consequently, for predicted speeds for a vehicle in a given terrain unit, a poor relation in a submodel might shift the control of predicting speed to another terrain factor; thus, the speed-limiting factor in some cases could be misleading. Nevertheless, the data presented for each vehicle (grouped by speed limiters) in Table 4 should give a general indication of the weak points in AMC-71. Graphic representation of test results by speed limiters are shown in Plates 32-36.

117. Predicted and measured results of terrain-unit tests, grouped by speed limiters as shown in Table 5, indicate that the factor that controlled predicted speed in most terrain units was surface roughness (factor 5). The relative deviations for the vehicles were somewhat greater than the acceptable limit (20 percent) as discussed in paragraphs 110-111. Surface roughness governed the predicted speed most

often for the wheeled vehicles--the M151 and M35A2. The tracked vehicle speeds were influenced more by visibility (factor 7), maneuvering (factor 8), and combinations of all resisting forces (factor 9). The data indicate relatively good modeling for all vehicles in terrains in which predicted vehicle speeds were limited by combined surface and slope resistances (factor 6). For factor 6, relative deviations for all vehicles except the M113A1 (25.0 percent) were less than the 20 percent deviation limit considered acceptable in this analysis. Results for the tracked vehicles were also acceptable for those terrains in which visibility in the terrain unit (factor 7) limited the predicted speeds. However, relative deviations for the wheeled vehicles in these units exceeded 32 percent.

118. The most glaring deficiency in the model is in the vegetation submodel (paragraphs 93-102). Predicted speeds generally were 1.5 to 2 times faster than measured speeds, especially in those terrain units in which maneuvering dictated the predicted vehicle speed. Maneuvering (factor 8 in Table 5) produced relative deviations much greater than 20 percent for all vehicles and as high as 118 percent for the M151. Consequently, assumptions and techniques used in formation of this submodel appear to need revision. The combination of all resisting forces (factor 9), which is directly related to the vegetation submodel, produced relative deviations greater than 20 percent (for four of the five vehicles). These five speed limiters and the submodels which influence them were discussed in more detail in Part III of this report.

119. The overall average deviations for all terrain-unit tests with the vehicles at all test locations are:

No. of Tests	Vehicle	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation mph
135	M151	-15.5 to 21.2	4.1	6.0	41.1	7.7
132	M35A2	- 5.9 to 19.8	5.2	5.9	49.6	7.1
133	M113A1	-10.9 to 14.1	0.8	4.2	28.4	5.3
52	M48	- 5.8 to 17.0	1.7	3.3	21.3	5.0
35	M60	-13.5 to 4.4	-1.6	3.2	18.8	4.3

120. As indicated by the results shown in the tabulation above, relative percent deviation for only one vehicle, the M60, was within the 20 percent limit considered acceptable in this analysis. However, this vehicle was not tested at either Eglin AFB or Fort Knox, where some of the largest deviations between predicted and measured speeds occurred for the other vehicles. The poorest prediction accuracy was obtained for the M35A2, followed by the M151, both exceeding 40 percent relative deviation. In most of the same terrain units, the relative deviation for the M113A1, the tracked vehicle with the poorest correlation, was 28.4 percent. The wheeled vehicle speed deviations were usually higher than the tracked vehicle speed deviations.

PART V: ANALYSIS OF RESULTS OF TRAVERSE TESTS

121. Two arrays of terrain data were used in analyzing the results of the traverse tests: (a) specific measured values, i.e. the actual values of the terrain descriptors measured at each test site, and (b) classed values, i.e. the terrain descriptor values assembled into terrain factor classes. Vehicle performances were predicted with AMC-71 using each array; the predicted performances were then compared with performances measured in the field. Predictions using the terrain values collected in this study should represent the best predictions possible, since all the data were actually measured, not estimated or interpreted from air photos and the like.

122. The same five numerical evaluation parameters (paragraph 36) that were used to validate the submodels and to analyze the results of the terrain-unit tests were used in the analysis of the results of the traverse tests. Both speed tests and immobilizations were analyzed.

Speed Tests

123. Measured speeds were compared with speeds predicted with specific terrain values and the midpoint values of the classed terrain data. To obtain these predictions, the areal terrain module performs an optimal speed analysis in each terrain unit and outputs the predicted speed for each unit along with one of the six speed-limiting factors (paragraph 10b) that controlled the speed. The time required to cross each of the contiguous terrain units of the traverse is calculated as a function of terrain-unit length and predicted terrain-unit speed. The times in all the units are then summed and divided into the total traverse distance to obtain the predicted speed-interms of speed-made-good.* Predicted and measured speeds for each terrain unit along each

* The term speed-made-good refers to terrain unit or traverse tests wherein the vehicle time required to complete the test is divided into the straight-line distance from the beginning to the end of the terrain unit or traverse. All of the tests reported herein were of this type and consequently "speed-made-good" will be referred to as "speed" for ease of discussion.

traverse and the appropriate factors limiting predicted speed in each unit are shown in Table 6 (predictions based on specific terrain values) and Table 7 (predictions based on classed terrain values).

Speed tests on traverses, specific terrain values

124. Predicted and measured traverse speeds for each vehicle at each test site based on terrain data measured at each site are shown in Table 8. Graphic representation of these data is shown in Plate 37. The data show that measured vehicle speeds ranged from 4.1 mph for the M35A2 on traverse 2 at Houghton to 25.2 mph for the M151 on traverse 2 at Yuma. Predicted vehicle speeds ranged from 5.2 mph for M113A1 on traverse 3 at Houghton to 29 mph for the M151 on traverse 2 at Yuma. Analyses of these tests by vehicle, using the aforementioned evaluation parameters, indicate the following:

		Numerical Evaluation Parameters				
No. of Tests	Vehicle	Range of Speed Deviation mph	Mean Algebraic Speed Deviation mph	Mean Absolute Speed Deviation mph	Relative Deviation %	rms Deviation mph
17	M151	-0.6 to 12.6	4.3	4.3	33.6	6.0
16	M35A2	0.5 to 0.4	5.2	5.2	47.7	5.7
17	M113A1	-5.1 to 7.7	0.7	2.9	21.0	3.7
7	M48	0.5 to 4.4	2.0	2.0	14.8	2.3
4	M60	-5.0 to 0.2	-1.6	1.8	10.3	2.6

125. As indicated by the evaluation parameters above, the overall relative deviation for the M151 was 33.6 percent, although relative deviations for the M151 were within acceptable limits (20 percent) for traverse tests at Fort Sill, Yuma, and Houghton (Table 9). The greatest overall relative deviation was obtained for the M35A2 (47.7 percent) with deviations for tests at all five locations with the M35A2 greater than the 20 percent acceptable limit. In the field tests, the M35A2 was slow to accelerate; unless the unit was of sufficient length to allow the vehicle to overcome its slow acceleration characteristics, it failed to achieve a maximum speed representative of the terrain conditions. At present AMC-71 does not account for vehicle acceleration-deceleration at the edge of the terrain units as a vehicle moves from one unit to the

next. Therefore, a contributing factor to the large deviations in all traverses for the M35A2 was probably the lack of an acceleration-deceleration routine in the model.

126. In Table 9, test results for the tracked vehicles (M113A1, M48, and M60) show deviations are greater than the acceptable limit (20 percent) at forested sites (Eglin, Houghton, and Fort Knox). Nevertheless, the summary in paragraph 124, based on all traverses, shows that the relative deviation for the M113A1 is very close to the acceptable limit and those for the M48 and M60 are less than the limit.

127. The overall weighted average relative deviation from the results in paragraph 124 for all five vehicles was 30.1 percent or 10 percent greater than the maximum relative deviation of 20 percent considered acceptable for prediction accuracy with AMC-71. Additional analysis of the results of the traverse speeds indicate that if the measured surface roughness relations (paragraphs 113-114) are used for predictions, the weighted relative deviation for all five vehicles would be reduced to 27.7 percent.

128. Speeds predicted from the vegetation submodel are generally faster than those actually obtained in field tests (paragraph 116-118). Nevertheless, based on test observations and discussions with the driver and navigator during the test program, the field-measured speeds do reflect the maximum safe speed obtainable for the terrain conditions imposed on the vehicle; therefore, the error appears to be in the predictions. The large deviations between predicted and measured results usually occurred in traverse tests at all the test locations where forested terrain was encountered, with the largest occurring at Eglin where all terrain units had significant-to-dense vegetation. Analysis shows that, if the Eglin tests were deleted from the average, the weighted relative deviation would be reduced to 15 percent. Stated more simply, this would indicate that if simulated ride dynamics relations were corrected or measured relations were used and the maneuvering relation corrected, AMC-71 would, in fact, have an overall prediction error of about 15 percent for traverses.

129. Results show that one of the present weaknesses of AMC-71 appears to be the modeling of vehicle performance in forested terrain where maneuvering and vehicle override are significant factors (paragraphs 101 and 102). Therefore, modeling of vegetation and maneuvering appears to be the one major revision necessary for dramatic improvement in prediction accuracy with AMC-71 for traverse and terrain-unit operation.

Speed tests on traverse, classes terrain values

130. Predicted and measured traverse speeds for each vehicle based on classed terrain data at each site are shown in Table 10. Table 11 shows a summary evaluation of the vehicle speed data on traverses of each test location. Graphic representation of these data is shown in Plate 38. Analyses of these tests produced the following results:

No. of Tests	Vehicle	Range of Speed Deviation mph	Mean Algebraic Speed Deviation mph	Mean Absolute Speed Deviation mph	Relative Deviation %	rms Deviation %
17	M151	-2.7 to 11.6	4.5	4.9	38.6	5.8
16	M35A2	-0.7 to 8.7	5.1	5.1	46.8	5.6
17	M113A1	-4.8 to 6.8	0	2.7	19.3	3.4
7	M48	-0.4 to 4.8	2.2	2.2	16.3	2.7
4	M60	-5.3 to -0.3	-2.1	2.1	12.1	2.9

131. The data show that predicted vehicle speed ranged from 5.3 mph for the M35A2 on traverse 1 at Fort Knox and for the M113A1 on traverse 3 at Houghton to 30 mph for the M151 on traverse 2 at Yuma (paragraph 124).

132. The overall weighted average relative deviation for all five vehicles was 31.1 percent or 1.0 percent higher than the weighted deviation obtained for the specified terrain values (paragraph 125). As stated earlier, the classed data used in this analysis represented the

best data possible for a classed system because the data base was composed of field-measured data. The results obtained for the classed values, when compared with the summary in paragraph 124, were only slightly worse than those obtained with the specific terrain values.

Summary of traverse tests

133. Analysis of traverse test data, in which traverses were selected in fine-grained and coarse-grained soils and over terrains varying from smooth and open to rough and wooded, produced an overall deviation (30.1 relative deviation) that was 10.1 percent higher than the acceptable limit (20 percent relative deviation). The overall traverse results reveal that, in general, predicted speeds were faster than measured, as indicated by the overall mean algebraic speed deviation of +2.9 mph. Also, prediction accuracy was better for the tracked vehicles (relative deviation 17.9 percent) than for the wheeled vehicles (relative deviation 40.9 percent). Tests indicated problems in some modeling techniques, which will require further analysis and testing for refinement. Revisions or refinements to the AMC-71 areal terrain module, especially in the relation dealing with predictions in forested terrains, and an adequate acceleration-deceleration routine to account for terrain-unit edge effects would undoubtedly improve prediction accuracy on traverses.

134. Analyses of the predictions on traverses using classed terrain values indicate that, overall, only 1.0 percent relative deviation in prediction accuracy is lost in going from specific terrain value predictions to classed terrain value predictions.

135. Better prediction accuracy was attained for the traverse tests than for the terrain-unit tests. This is explained by the fact that, in predictions of speeds for terrain-unit tests, the model predicts a vehicle speed based on a single terrain unit. However, in traverse predictions, the time in each contiguous terrain unit is computed from the length of each unit and predicted speed in the unit. The total traverse length divided into the total of the predicted times produces the predicted speeds on traverses. Consequently, the reason for the

better accuracy of the traverse predictions is primarily due to the averaging process that takes place in computing traverse speeds.

Immobilization on Traverses

136. In the traverse tests, predicted vehicle performance in terms of go-no go agreed with measured performance in most of the 249 terrain units. However, in 10 terrain units in which specific terrain values were used for predictions and in 11 tests on 10 terrain units in which classed values were used for predictions, measured and predicted vehicle go-no go performance did not agree.

Specific values of terrain data

137. The following tabulation shows the location, traverse-terrain unit, and vehicle for which no-go performance was predicted. The complete terrain measurements are shown in Appendix D.

Location	Traverse-Terrain Unit	Predicted No-Go Performance
FS	1-16	M48
FS	3-6	M113A1
FS	3-15	M113A1
YPG	1-17	M60
YPG	1-38	M60
YPG	1-48	M113A1
YPG	3-6	M60
YPG	4-2	M60
YPG	4-3	M60
HTN	2-7	M35A2

In 9 (Fort Sill and Yuma tests) of these 10 terrain units, the size and shape of obstacles caused predicted no-go performance for the tracked vehicles, although in field tests the vehicles were able to negotiate these obstacles (paragraph 82). Obstacles that were present are described in the data for many of the other traverse terrain units tested; however, their size and shape were such that they did not cause predicted immobilizations. In the cases shown above where no-go performance was predicted, all obstacles in these terrain units were trench-shaped (linear depressions), and the model showed that no-go's were a

result of inadequate traction of the vehicles on obstacles. Since the physical dimensions of the obstacles are fixed field measurements and in the field tests the vehicles negotiated the obstacles, the obvious conclusion is that at least the technique for handling tracked vehicles in the obstacle submodel needs improvement. Recognizing that improvement in the submodel will require more study and is beyond the scope of the validation program, the decision was made to force the model vehicles over the obstacles and allow the model to predict positive vehicle speed for the 9 terrain units. Bypass of the no-go's in the 9 terrain units allowed all the vehicles to complete all the traverses on a predicted basis; therefore, predicted and measured traverse speeds could be compared and evaluated.

138. The other test in which predicted and measured vehicle performances did not agree was with the M35A2 at Houghton on traverse 2, terrain unit 7. AMC-71 predicted a go at 9.1 mph; however, in the field test the M35A2 was immobilized while trying to override two 6.5-in.-diam trees shortly after entering terrain unit 7. Two more attempts to negotiate the terrain unit with the vehicle failed; consequently, no-go for the M35A2 was considered representative of the terrain unit.

Classed values of terrain data

139. The following tabulation shows the location, traverse-terrain unit number, and vehicle for which no-go performance was predicted, although in field tests the vehicles were able to negotiate these units:

Location	Traverse-Terrain Unit	Predicted No-Go Performance
FS	1-16	M48
FS	3-6	M113A1
YPG	1-38	M60
YPG	4-2	M60
EAFB	2-9	M151
HTN	2-5	M151
HTN	2-5	M35A2
HTN	2-7	M35A2
FK	1-8	M35A2

In Fort Sill 1-16 and 3-6, Yuma 1-38, and Houghton 2-7, the reason for predicted no-go was the same as discussed in paragraph 137, and the predicted no-go's were again bypassed. The remaining no-go's shown in the tabulation were caused by placing the specific terrain data in the specified classes and using the midpoint of the classes for prediction. In Yuma 4-2, Eglin 2-9, and Fort Knox 1-8, tree size and spacing were the reasons for predicted no-go; in Houghton 2-5, slope was the reason for predicted no-go performance. For these no-go predictions, the spacing of the tree size causing the predicted no-go was increased by one class, and with these adjusted terrain data, go performance was predicted as indicated in Table 7.

PART VI: SUMMARY OF TEST RESULTS AND RECOMMENDATIONS

Summary of Test Results

140. Results of this study are summarized below.

a. Validation of submodels

(1) The power train analysis indicates that, although more precise agreement between measured and predicted results would be obtained if all frictional power losses could be modeled for each vehicle, the present method of producing the predicted power train curve is satisfactory at this time.

(2) Results from soil traction tests (soil submodel) indicate that some refinement is needed in the coarse-grained soil relations to account for silty sand soils; however, in general, the results for each vehicle indicate acceptable prediction accuracy for the soil submodel.

(3) The slope test data on a go-no go basis show good agreement between predicted and measured vehicle performance for the vehicles tested, except that study and revision are apparently needed for tracked vehicles on coarse-grained soil slopes.

(4) Analysis indicates that, although some refinement could be made, the visibility relation presently used in AMC-71 predicts a practical maximum speed that compares reasonably well with the maximum measured speed an expert cross-country driver would actually be willing to travel.

(5) Results of obstacle override tests indicate that this submodel overstates the interference problem, predicting hang-ups that do not occur. In obstacle override, the influence of various obstacle size and shape combinations on wheeled performance, along

with obstacle deformation not considered in AMC-71, is apparent, indicating that study and revision could improve the accuracy of the relations.

(6) Results indicate that obstacle mean spacing and area-denied relations presently used in AMC-71 should provide acceptable results for consideration of the effects on vehicle performance.

(7) Analysis of the vegetation override relations relative to single trees indicates generally acceptable accuracy or at least the data scatter is no greater than that used in the development of the original relations. However, improvement is needed in the technique used for multiple-tree override.

(8) Prediction accuracy for all vehicles in forested terrain is generally poor, with predictions of vehicle speed usually higher than measured speed.

(9) Results of terrain-unit tests involving the maneuvering and vegetation submodels generally show poor accuracy.

(10) Results show that, for the M151, the M35A2, and the M113A1, ride dynamics controlled predicted vehicle speed in more terrain units than any other factor.

(11) Predictions based on simulated surface roughness relations show that the relative deviations for the vehicles tested were somewhat greater than the acceptable limit of 20 percent, indicating improvement is needed in these relations.

(12) Vehicle speed prediction in terrain units based on measured surface roughness relations show the relative deviation for each vehicle is near or below 20 percent, indicating acceptable prediction accuracy.

b. Speed in single terrain units. Analysis of terrain-unit tests show that the M35A2 had the poorest prediction accuracy (relative deviation of 49.6 percent) and the M60 had the best prediction accuracy (relative deviation of 18.8 percent).

c. Speed in traverses

(1) Analysis of the traverse test data shows an overall relative deviation or prediction error of 30.1 percent. Therefore, study and revision are needed in some areas of AMC-71 to improve prediction accuracy. Results also show that prediction accuracy was better for the tracked vehicles (relative deviation 17.9 percent) than for the wheeled vehicles (relative deviation 40.4 percent).

(2) Results of traverse tests reveal that, in general, predicted speeds were higher than measured speeds as indicated by the overall mean algebraic deviation of +2.6 mph.

(3) Analysis of classed terrain value predictions on traverses indicates that, overall, only very little prediction accuracy is lost in going from specific terrain value predictions to classed terrain value predictions using measured terrain data.

(4) Analyses show that, if the simulated surface roughness relations used thoughout this study were replaced by the measured relations and the maneuver relations were corrected, AMC-71 would have an overall speed prediction error of less than 15 percent for the traverse conditions tested.

Recommendations

141. It is recommended that:

a. The AMC mobility model be used in all vehicle mobility studies by and for the U. S. Military.

b. Tests be conducted and results used to refine or revise the vegetation override and maneuver relations for improved prediction accuracy in forested terrain.

c. An acceleration-deceleration subroutine be developed for the mobility model to account for vehicle acceleration-deceleration within terrain units and at the edge of terrain units on traverses as a vehicle moves from one unit to the next.

d. When possible, measured surface roughness-speed relations be used in the AMC-71 in lieu of simulated relations.

e. The vehicle dynamics research program be continued to develop and improve relations for more accurate simulations of vehicle performance when field tests are not feasible.

f. A test program be initiated to refine the coarse-grained soil relations, especially for tracked vehicles, to improve prediction accuracy.

g. Refinement be made to the visibility submodel to account for differences in location of the eye level of a vehicle driver.

h. A program be conducted to develop obstacle relations, that would account for obstacle deformation to improve prediction accuracy.

Table 1

Terrain, Vehicle, Driver Attributes Used in

Off- and On-Road Performance Prediction Models

Terrain or Road	Vehicle	Driver
	Off Road	
Surface material	Geometric	Reaction time
Type	Mechanical	Recognition distance
Strength	Inertial	V-ride limit
Surface geometry		Vertical acceleration limit
Slope		
Discrete obstacles		Horizontal acceleration limit
Roughness		
Vegetation		
Stem size and spacing		
Visibility		
Hydrologic geometry		
Stream cross section		
Water velocity and depth		
	On Road	
Surface material	Mechanical	V-ride limit
Type	Inertial	
Strength		
Surface geometry		
Slope		
Roughness		
Curvature		

Table 2

Terrain or Road Factors Used in Performance Prediction Model

Areal Terrain Units		Linear Terrain Units		Road Units	
Terrain Factor	Measurement Unit	Terrain Factor	Measurement Unit	Road Factor	Measurement Unit
Surface		Surface		Surface	
1. Type	NA*	1. Type	NA	1. Type	NA
2. Strength	Cone index or rating cone index	2. Strength	Cone index or rating cone index	2. Strength	Cone index or CBR
3. Slope	Percent			3. Slope	Degree
4. Surface roughness	Root mean square elevation, in.	Cross Section		4. Curvature	Degree
		3. Left approach angle	Degree	5. Roughness	Root mean square elevation, in.
Obstacle		4. Differential bank height or differential vertical magnitude	Metre		
5. Approach angle	Degree				
6. Height	Centimetre				
7. Base width	Centimetre				
8. Length	Metre				
9. Spacing	Metre	5. Right approach angle	Degree		
10. Type	NA				
Vegetation		6. Low bank height or least vertical magnitude	Metre		
11. Stem diameter	Centimetre				
12. Stem spacing	Metre				
13. Visibility	Metre	7. Base width or top width	Metre		
		Water			
		8. Depth	Metre		
		9. Velocity	Metres/second		

* Not applicable.

Table 3

Field Tests Conducted

Vehicle	Fort Sill	Yuma Proving Ground	Eglin AFB	Houghton	Fort Knox	Total
		Speed Tests in Single Terrain Units				
M151	37	41	18*	15*	26	137
M35A2	36	41	19*	10*	26	132
M113A1	37	40	21*	13*	24	135
M48	38	-	-	14	-	52
M60	-	35	-	-	-	35
				Total		491
		Speed Tests in Traverses				
M151	4	5	3	3	2	17
M35A2	4	5	3	2	2	16
M113A1	4	5	3	3	2	17
M48	4	-	-	3	-	7
M60	-	4	-	-	-	4
				Total		61

(Continued)

* One Test in group was a no-go test.

(Sheet 1 of 3)

Table 3 (Continued)

Vehicle	Fort Sill	Yuma Proving Ground	Eglin AFB	Houghton	Fort Knox	Total
		Drawbar-Pull Tests				
M151	7	4	-	-	-	11
M35A2	6	4	3	-	-	13
M113A1	8	4	4	-	-	16
M48	7	-	-	-	-	7
M60	-	2	-	-	-	2
				Total		49
		Motion-Resistance Tests				
M151	7	4	5	-	-	16
M35A2	6	4	4	-	-	14
M113A1	8	4	4	-	-	16
M48	7	-	-	-	-	7
M60	-	2	-	-	-	2
				Total		55
		Slope-Climbing Tests				
M151	-	29	-	1	-	30
M35A2	-	27	-	1	-	28
M113A1	-	25	-	1	-	26
M48	-	-	-	-	-	-
M60	-	6	-	-	-	6
				Total		90

(Continued)

(Sheet 2 of 3)

Table 3 (Concluded)

Vehicle	Fort Sill	Yuma Proving Ground	Eglin AFB	Houghton	Fort Knox	Total
			Obstacle-Deformation Tests			
M151	-	11	-	-	-	11
M113A1	-	-	-	-	6	6
					Total	17
			Area-Denied Tests			
M151	-	-	5	1	-	6
M35A2	-	-	5	1	-	6
M113A1	-	-	5	1	-	6
					Total	18
			Tree-Override Tests			
M151	-	-	10	6	-	16
M35A2	-	-	2	-	-	2
M113A1	-	-	5	3	-	8
					Total	26

Table 4

Vehicle Speed Data, Terrain-Unit Tests

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed**	Reason for Immobilization
				M151			
FS1	11	821	15.6	15.3	0.3	5	
FS2	3	941	23.8	24.0	-0.2	5	
FS2	5	413	13.3	16.6	-3.3	5	
FS2	9*	504	30.0	28.9	1.1	5	
FS3	7	462	27.8	11.7	16.1	5	
FS3	16	500	24.8	14.3	10.5	5	
FS4	2	400	30.0	20.7	9.3	5	
FS4	3	400	30.0	21.3	8.7	5	
FS4	4*	600	30.0	20.3	9.7	5	
FS4	5*	600	30.0	27.6	2.4	5	
FS4	9*	891	30.0	27.6	2.4	5	
FS4	10	406	16.0	17.8	-1.8	5	
FS0	1A	2500	30.0	45.5	-15.5	5	
FS0	9	800	22.9	13.6	9.3	5	
YPG1	3	508	30.0	21.8	8.2	5	
YPG1	16	763	30.0	22.6	7.4	5	
YPG1	26	680	19.2	12.7	6.5	5	
YPG1	27*	518	14.8	12.1	2.7	5	
YPG1	31*	428	11.6	9.9	1.7	5	

(Continued)

* Tests in which measured speed was considered to be limited by surface roughness.

** The factor controlling predicted speed refers to the 6 speed-limiting factors (5-10) listed in paragraph 10 of this report.

(Sheet 1 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M151 (Continued)				
YPG1	32	987	18.2	11.7	6.5	5	
YPG1	33	1739	21.8	12.3	9.5	5	
YPG1	34	538	18.9	10.2	8.7	5	
YPG1	35*	1008	7.5	9.0	-1.5	5	
YPG1	39	1297	20.6	11.2	9.4	5	
YPG1	41	497	21.9	9.8	12.1	5	
YPG1	42*	518	15.8	12.3	3.5	5	
YPG1	47	500	21.3	11.5	9.8	5	
YPG1	48	669	12.1	11.5	0.6	5	
YPG1	49	573	12.0	14.4	-2.4	5	
YPG1	50	524	8.0	13.4	-5.4	5	
YPG1	51*	1235	16.7	17.5	-0.8	5	
YPG2	1*	1635	30.0	27.2	2.8	5	
YPG2	2*	1267	28.2	23.2	5.0	5	
YPG3	2	498	30.0	21.4	8.6	5	
YPG3	7	1177	30.0	22.2	7.8	5	
YPG3	14	410	30.0	22.9	7.1	5	
YPG3	19	1083	30.0	21.5	8.5	5	
YPG3	22	520	39.0	27.5	11.5	5	
YPG3	23*	1000	39.0	44.6	-5.6	5	
YPG4	1	1575	26.3	15.9	10.4	5	
YPG4	2*	1800	19.7	17.0	2.7	5	

(Continued)

(Sheet 2 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M151 (Continued)			
YPG4	4*	610	26.1	21.4	4.7	5	
YPG4	5*	1715	28.6	18.3	10.3	5	
YPG5	1*	954	21.5	13.9	7.6	5	
YPG5	5*	1149	17.1	15.6	1.5	5	
YPG5	6*	655	18.4	17.1	1.3	5	
YPG5	7	522	16.0	14.4	1.6	5	
YPG5	8	1489	15.7	13.0	2.7	5	
YPG0	47*	800	28.6	18.6	10.0	5	
EAFB3	10	488	22.5	8.7	13.8	5	
EAFB0	11*	1000	30.0	38.3	-8.3	5	
HTN1	5	535	29.6	19.2	10.4	5	
FK1	5	650	18.0	13.1	4.9	5	
FK1	9	1972	20.8	21.6	-0.8	5	
FK2	1	1995	11.7	10.7	1.0	5	
FK2	3*	833	18.8	15.2	3.6	5	
FK2	7	860	13.6	8.5	5.1	5	
FK2	8	995	26.6	18.6	8.0	5	
FK0	1*	750	19.2	19.2	0.0	5	
FK0	2*	550	30.0	27.6	2.4	5	
FK0	4*	400	16.5	20.5	-4.0	5	

(Continued)

(Sheet 3 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M151 (Continued)			
FS0	4A	125	18.2	16.2	2.0	6	
FS0	5A	125	12.8	14.2	-1.4	6	
FS0	6A	100	23.9	24.5	-0.6	6	
YPG0	5	44	14.1	6.8	7.3	6	
FS1	3	1461	20.7	19.8	0.9	7	
FS1	4	525	16.4	20.5	-4.1	7	
FS1	5	557	16.2	21.3	-5.1	7	
FS1	6	1133	22.7	20.0	2.7	7	
FS1	8	590	15.9	16.4	-0.5	7	
FS1	10	569	15.6	14.8	0.8	7	
FS1	19	720	20.2	13.9	6.3	7	
FS1	20	1152	11.5	9.4	2.1	7	
FS1	21	712	26.0	11.0	15.0	7	
FS1	23	407	20.0	7.5	12.5	7	
FS2	1*	485	22.5	19.7	2.8	7	
FS2	2*	2463	22.9	19.1	3.8	7	
FS2	13	2050	22.9	27.8	-4.9	7	
FS3	10	1172	12.5	10.8	1.7	7	
FS3	13	750	17.2	12.0	5.2	7	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M151 (Continued)				
FS3	19	660	16.1	16.0	0.1	7	
FS3	21	480	16.1	16.0	0.1	7	
YPGO	48	646	12.4	9.3	3.1	7	
EAFB1	1	693	21.4	7.6	13.8	7	
EAFB2	1	553	18.1	7.2	10.9	7	
EAFB2	12	550	29.6	8.4	21.2	7	
EAFB2	13	633	25.1	8.8	16.3	7	
EAFB2	14	584	18.9	8.1	10.8	7	
HNT1	1*	550	19.6	24.0	-4.4	7	
HNT1	2	750	15.5	16.0	-0.5	7	
HNT1	3*	1046	17.7	16.2	1.5	7	
HNT1	4	634	6.3	6.7	-0.4	7	
HNT3	6	508	7.9	12.6	-4.7	7	
FK1	5A	1550	16.6	14.9	1.7	7	
FK1	6	1825	19.4	15.8	3.6	7	
FK1	8	950	25.2	17.0	8.2	7	
EAFB1	2	611	14.0	6.4	7.6	8	
EAFB1	9	559	22.1	12.3	9.8	8	
EAFB1	10	398	20.4	9.0	11.4	8	
EAFB1	11	423	26.0	11.1	14.9	8	
EAFB2	6	741	19.3	9.0	10.3	8	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M151 (Continued)			
EAFB3	2	628	24.5	7.5	17.0	8	
EAFB3	5	408	17.6	8.8	8.8	8	
EAFBO	8	354	5.9	5.1	0.8	8	
EAFBO	10	210	16.1	4.9	11.2	8	
EAFBO	12	450	24.5	19.2	5.3	8	
HNT2	7	500	2.2	3.9	-1.7	8	
HNT2	10	550	13.0	6.2	6.8	8	
HNT3	1	665	10.3	5.2	5.1	8	
HNT3	4	735	6.5	4.0	2.5	8	
FK1	1	1925	20.3	8.3	12.0	8	
FK1	3	2860	28.9	8.5	20.4	8	
FK1	4	900	27.1	8.7	18.4	8	
FK2	6	785	17.4	6.7	10.7	8	
FK2	9	402	17.4	8.9	8.5	8	
FK2	11	1292	12.8	6.7	6.1	8	
FK2	13	433	15.1	7.4	7.7	8	
FS0	3A	200	25.9	29.4	-3.5	9	
FS3	1	550	12.8	11.2	1.6	9	
FS3	2	546	12.8	11.4	1.4	9	
YPG1	25	1062	4.5	12.8	-8.3	10	
YPG1	28	442	4.5	14.0	-9.5	10	

(Continued)

(Sheet 6 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M151 (Continued)			
YPG1	30	512	4.5	12.1	-7.6	10	
YPG5	2*	954	9.4	12.1	-2.7	10	
HTN1	8	517	8.1	7.8	0.3	10	
HTN2	2	420	9.1	5.4	3.7	10	
HTN2	6	670	5.7	5.0	0.7	10	
HTN2	9	900	9.6	5.4	4.2	10	
FK1	2	845	15.6	8.0	7.6	10	
FK1	7	675	8.3	5.6	2.7	10	
FK2	5	843	3.5	9.2	-5.7	10	
FK2	10	508	10.3	7.1	3.2	10	
FK2	12	1828	5.6	7.4	-1.8	10	
FK2	14*	443	8.1	12.8	-4.7	10	
FK2	15*	819	8.8	16.9	-8.1	10	
				No-Go's			
EAFBO	9	200	0	0	-		4
HTNO	1	330	0	0	-		4

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M35A2			
FS1	11	821	15.9	11.7	4.2	5	
FS1	21	712	24.1	10.8	13.3	5	
FS2	1*	486	22.0	13.5	8.5	5	
FS2	5	413	14.2	12.1	2.1	5	
FS2	9*	504	31.0	23.4	7.6	5	
FS3	6	500	21.9	13.2	8.7	5	
FS4	4*	600	34.0	23.0	11.0	5	
FS4	5*	600	34.4	23.8	10.6	5	
FS4	9*	891	31.7	23.8	7.9	5	
FS4	10	406	16.1	16.1	0	5	
YPG1	3	508	33.4	16.4	17.0	5	
YPG1	16	763	26.7	16.7	10.0	5	
YPG1	26	680	18.6	9.5	9.1	5	
YPG1	27*	518	15.3	10.7	4.6	5	
YPG1	30	512	21.0	10.3	10.7	5	
YPG1	31*	428	12.8	8.0	4.8	5	
YPG1	32	987	17.8	13.6	4.2	5	
YPG1	33	1739	20.1	10.5	9.6	5	
YPG1	34	538	18.2	10.3	7.9	5	
YPG1	35*	1008	9.0	12.7	-3.7	5	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M35A2 (Continued)				
YPG1	39	1297	19.4	10.4	9.0	5	
YPG1	41	497	20.1	10.5	9.6	5	
YPG1	42*	518	16.1	11.3	4.8	5	
YPG1	47	500	19.8	9.9	9.9	5	
YPG1	48	669	13.2	9.1	4.1	5	
YPG1	49	573	13.0	9.8	3.2	5	
YPG1	50	524	9.5	5.6	3.9	5	
YPG1	51*	1235	16.7	12.4	4.3	5	
YPG2	1*	1635	27.6	19.0	8.6	5	
YPG2	2*	1267	23.9	18.5	5.4	5	
YPG3	2	498	28.0	23.6	4.4	5	
YPG3	7	1177	34.4	17.5	16.9	5	
YPG3	14	410	37.9	18.6	19.3	5	
YPG3	19	1083	32.9	19.0	13.9	5	
YPG4	1	1575	22.8	17.2	5.6	5	
YPG4	2*	1800	18.8	15.0	3.8	5	
YPG4	4*	610	22.7	18.2	4.5	5	
YPG4	5*	1715	24.2	18.7	5.5	5	
YPG5	1*	954	19.9	12.8	7.1	5	
YPG5	5*	1149	15.5	11.5	4.0	5	
YPG5	6*	655	17.9	14.4	3.5	5	
YPG5	7	522	16.1	12.8	3.3	5	

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M35A2 (Continued)			
YPGO	47*	800	24.2	18.6	5.6	5	
EAFBO	11*	1000	28.4	27.4	1.0	5	
HTN1	1*	550	19.8	19.0	0.8	5	
HTN1	3*	1046	18.4	13.4	5.0	5	
HTN1	5	535	24.8	17.1	7.7	5	
FK2	3*	833	18.2	11.1	7.1	5	
FK2	8	995	23.0	15.6	7.4	5	
FK2	14*	443	12.8	9.0	3.8	5	
FKO	1*	750	18.4	14.7	3.7	5	
FKO	2*	550	27.6	21.2	6.4	5	
FKO	4*	400	16.5	13.4	3.1	5	
FS2	3	941	16.7	15.3	1.4	6	
FS4	2	400	17.8	17.0	0.8	6	
FS4	3	400	25.2	18.0	7.2	6	
FSO	3B	200	9.8	11.8	-2.0	5	
FSO	4B	125	4.8	5.5	-0.7	6	
FSO	5B	125	4.8	4.2	0.6	6	
FSO	6B	100	9.2	10.5	-1.3	6	
YPGO	10	72	7.4	6.1	1.3	6	
FK1	5	650	4.5	7.0	-2.5	6	

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M35A2 (Continued)			
FK1	5A	1550	4.5	7.7	-3.2	6	
FK1	6	1825	4.5	6.4	-1.9	6	
FK1	8	950	7.3	10.2	-2.9	6	
FK2	7	860	9.8	4.8	5.0	6	
FS1	3	1461	20.7	16.9	3.8	7	
FS1	4	525	16.4	12.8	3.6	7	
FS1	5	557	16.2	13.1	3.1	7	
FS1	6	1133	22.7	15.5	7.2	7	
FS1	8	590	15.5	15.8	-0.3	7	
FS1	10	569	15.6	11.9	3.7	7	
FS1	19	720	20.2	12.9	7.3	7	
FS1	20	1152	11.5	10.6	0.9	7	
FS1	23	407	20.0	10.4	9.6	7	
FS2	2*	2463	22.9	17.3	5.6	7	
FS2	13*	2050	22.9	25.3	-2.4	7	
FS3	10	1172	12.5	10.5	2.0	7	
FS3	13	750	17.2	14.1	.3.1	7	
FS3	19	660	16.1	15.8	0.3	7	
FS3	21	480	16.1	15.8	0.3	7	
YPG1	25	1062	11.1	9.3	1.8	7	
YPG1	28	442	11.1	11.4	-0.3	7	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M35A2 (Continued)			
YPG3	22	520	42.0	22.2	19.8	7	
YPG3	23*	1000	42.4	29.6	12.8	7	
YPG0	48	646	12.8	9.3	3.5	7	
EAFB0	15	450	13.9	12.1	1.8	7	
HTN1	2	750	16.0	13.5	2.5	7	
HTN1	4	634	6.4	6.8	-0.4	7	
HTN1	8	517	10.6	5.4	5.2	7	
HTN2	6	670	13.0	3.6	9.4	7	
HTN2	10	550	15.4	12.2	3.2	7	
FS0	9	800	19.0	12.5	6.5	8	
EAFB1	11	423	14.2	6.6	7.6	8	
EAFB2	1	553	17.2	5.8	11.4	8	
EAFB2	6	746	11.6	4.9	6.7	8	
EAFB0	8	365	5.6	4.6	1.0	8	
EAFB0	12	450	5.5	8.0	-2.5	8	
EAFB0	14	450	8.0	12.4	-4.4	8	
FK1	1	1995	13.9	4.8	9.1	8	
FK1	2	845	9.9	4.7	5.2	8	
FK1	4	900	9.6	5.2	4.4	8	
FK1	7	675	1.5	5.1	-3.6	8	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M35A2 (Continued)				
FK2	1	1162	12.5	6.8	5.7	8	
FK2	6	785	15.6	4.4	11.2	8	
FK2	9	402	14.9	5.2	9.7	8	
FK2	10	508	13.4	3.9	9.5	8	
FK2	13	438	15.1	5.3	9.8	8	
FS3	1	550	13.2	8.2	5.0	9	
FS3	2	546	17.8	10.2	7.6	9	
FS3	7	462	17.8	5.9	11.9	9	
FSO	1B	2500	20.3	26.2	-5.9	9	
YPG5	8	1489	15.0	8.4	6.6	9	
EAFB1	1	693	17.3	8.8	8.5	9	
EAFB1	2	611	13.7	7.1	6.6	9	
EAFB1	9	559	17.3	8.8	8.5	9	
EAFB1	10	398	16.7	6.6	10.1	9	
EAFB2	12	550	17.2	6.9	10.3	9	
EAFB2	13	663	15.8	7.6	8.2	9	
EAFB2	14	584	19.7	6.5	13.2	9	
EAFB3	2	628	15.0	7.4	7.6	9	
EAFB3	5	408	14.5	7.9	6.6	9	
EAFB3	10	488	16.3	8.6	7.7	9	
EAFBO	13	388	13.2	8.0	5.2	9	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M35A2 (Continued)			
HTN2	2	420	13.9	3.2	10.7	9	
FK1	3	1046	9.6	4.5	5.1	9	
FK1	9	1972	15.6	13.2	2.4	9	
FK2	11	1292	14.2	6.3	7.9	9	
FK2	15*	819	15.5	12.6	2.9	9	
				No-Go			
HTN2	7	500	9.1	0	-		9
				Go			
YPG5	2*	1710	10.3	11.3	-1.0	10	
FK2	5	843	2.9	6.1	-3.2	10	
FK2	12	1828	5.8	6.5	-0.7	10	
				No-Go			
EAFBO	9	200	0	0	-		4
				M113A1			
FS1	11	821	9.7	15.7	-6.0	5	
FS2	5	431	6.9	17.8	-10.9	5	
FS2	9*	504	35.2	21.1	14.1	5	
FS3	16	500	23.4	18.3	5.1	5	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M113A1 (Continued)				
FS4	4*	600	36.8	23.8	13.0	5	
FS4	5*	600	37.0	28.8	8.2	5	
FS4	9*	891	35.6	28.8	6.8	5	
FS4	10	406	10.2	20.4	-10.2	5	
YPG1	27*	518	8.7	14.1	-5.4	5	
YPG1	31*	428	5.9	12.6	-6.7	5	
YPG1	32	987	13.2	14.2	-1.0	5	
YPG1	33	1739	18.5	16.7	1.8	5	
YPG1	34	538	14.1	14.9	-0.8	5	
YPG1	35*	1008	3.7	11.2	-7.5	5	
YPG1	39	1297	16.5	17.3	-0.8	5	
YPG1	41	497	18.6	18.4	0.2	5	
YPG1	42*	518	10.1	17.1	-7.0	5	
YPG1	47	500	17.6	18.7	-1.1	5	
YPG1	48	669	6.2	15.5	-9.3	5	
YPG1	49	573	6.1	15.4	-9.3	5	
YPG1	50	524	4.0	9.7	-5.7	5	
YPG1	51*	1235	11.2	19.0	-7.8	5	
YPG4	2*	1800	15.1	16.7	-1.6	5	
YPG5	1*	954	18.0	18.3	-0.3	5	
YPG5	5*	1149	11.8	14.2	-2.4	5	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M113A1 (Continued)				
YPG5	6*	655	13.5	17.8	-4.3	5	
YPG5	7	522	10.2	12.0	-1.8	5	
YPG5	8	1489	10.2	9.3	0.9	5	
HTN1	1*	550	17.6	18.9	-1.3	5	
HTN1	3*	1046	14.3	17.8	-3.5	5	
HTN2	9	900	7.9	7.3	0.6	5	
HTN2	10	550	14.0	11.1	2.9	5	
HTN3	4	735	6.9	5.8	1.1	5	
FK1	9	1972	16.8	19.5	-2.7	5	
FK2	3*	833	14.0	18.9	-4.9	5	
FK2	7	860	7.2	7.7	-0.5	5	
FK2	14*	443	5.9	13.4	-7.5	5	
FK2	15*	819	11.0	14.3	-3.3	5	
FKO	1*	750	14.5	15.1	-0.6	5	
FKO	2*	550	33.4	19.8	13.6	5	
FKO	4*	400	10.9	16.6	-5.7	5	
FS2	3	941	16.[illegible]	13.9	2.9	6	
FS4	2	400	20.8	18.2	2.6	6	
FS4	3	400	23.3	19.8	3.5	6	
FSO	1C	2500	18.3	21.0	-2.7	6	

(Continued)

(Sheet 16 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M113A1 (Continued)			
FSO	3C	200	10.8	8.2	2.6	6	
FSO	4C	125	5.8	5.2	0.6	6	
FSO	5C	125	5.3	3.8	1.5	6	
FSO	6C	100	10.3	10.0	0.3	6	
YPG1	3	508	21.9	17.5	4.4	6	
YPG1	16	763	21.7	19.5	2.2	6	
YPG2	1*	1635	21.3	19.2	2.1	6	
YPG2	2*	1267	21.3	19.2	2.1	6	
YPG3	2	498	21.3	22.9	-1.6	6	
YPG3	7	1177	21.3	20.5	0.8	6	
YPG3	14	410	21.9	15.0	6.9	6	
YPG3	19	1083	21.9	20.4	1.5	6	
YPG3	22	520	21.7	21.6	0.1	6	
YPG3	23*	1000	21.3	25.4	-4.1	6	
YPG4	1	1575	21.9	19.7	2.2	6	
YPG4	4*	610	21.9	19.0	2.9	6	
YPG4	5*	1715	21.9	19.7	2.2	6	
YPGO	47*	800	21.9	18.4	3.5	6	
EAFBO	11*	1000	22.9	24.3	-1.4	6	
FS1	3	1461	21.2	20.5	0.7	7	
FS1	4	525	16.7	18.6	-1.9	7	
FS1	5	557	16.5	20.0	-3.5	7	

(Continued)

(Sheet 17 of 25)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M113A1 (Continued)			
FS1	6	1133	23.2	21.7	1.5	7	
FS1	8	590	15.9	19.9	-4.0	7	
FS1	10	569	15.9	16.3	-0.4	7	
FS1	19	720	20.7	19.3	1.4	7	
FS1	20	1152	11.7	16.6	-4.9	7	
FS1	21	712	26.6	19.7	6.9	7	
FS1	23	467	20.5	18.6	1.9	7	
FS2	1*	486	23.1	22.1	1.0	7	
FS2	2*	2463	23.5	20.8	2.7	7	
FS2	13*	2050	23.4	20.8	2.6	7	
FS3	10	1172	12.7	14.6	-1.9	7	
FS3	13	750	17.7	20.9	-3.2	7	
FS3	19	660	16.4	20.7	-4.3	7	
FS3	21	480	16.4	20.7	-4.3	7	
EAFBO	15	365	18.2	16.8	1.4	7	
HTN1	4	634	7.7	10.9	-3.2	7	
FSO	9	800	17.4	11.7	5.7	8	
EAFB1	9	559	15.0	12.0	3.0	8	
EAFB1	11	423	15.2	9.7	5.5	8	
EAFB2	6	741	12.6	8.1	4.5	8	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M113A1 (Continued)				
EAFB3	2	628	16.8	11.3	5.5	8	
EAFBO	8	354	6.4	5.9	0.5	8	
EAFBO	12	450	2.3	9.8	-7.5	8	
EAFBO	14	450	7.0	16.8	-9.8	8	
HTN3	1	665	5.6	6.6	-1.0	8	
FK1	1	1995	17.8	9.0	8.8	8	
FK1	7	675	9.0	9.6	-0.6	8	
FK2	1	1162	5.8	12.4	-6.6	8	
FK2	6	785	11.5	10.3	1.2	8	
FK2	10	508	6.7	10.0	-3.3	8	
FK2	11	1292	10.4	8.7	1.7	8	
FK2	13	438	8.9	11.6	-2.7	8	
FKO	3	260	19.0	13.1	5.9	8	
FS3	1	550	13.8	10.6	3.2	9	
FS3	2	546	21.8	12.8	9.0	9	
FS3	7	462	19.3	8.1	11.2	9	
YPG1	25	1062	10.9	11.5	-0.6	9	
YPG1	26	680	14.4	13.4	1.0	9	
YPG1	28	442	11.4	12.4	-1.0	9	
YPG1	30	512	12.4	15.9	-3.5	9	

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M113A1 (Continued)				
YPGO	48	646	12.9	14.4	-1.5	9	
EAFB1	1	693	19.8	12.7	7.1	9	
EAFB1	2	611	14.8	10.3	4.5	9	
EAFB1	10	398	19.3	10.2	9.1	9	
EAFB2	1	553	21.9	9.5	12.4	9	
EAFB2	12	550	21.3	10.7	10.6	9	
EAFB2	13	633	19.8	10.9	8.9	9	
EAFB2	14	584	21.9	9.6	12.3	9	
EAFB3	5	408	17.0	11.6	5.4	9	
EAF33	10	488	19.0	12.3	6.7	9	
EAFBO	13	388	13.4	11.5	1.9	9	
EAFBO	16	450	20.8	14.9	5.9	9	
HTN1	5	535	21.3	16.6	4.7	9	
HTN1	8	517	13.1	9.5	3.6	9	
HTN2	2	420	11.5	5.4	6.1	9	
HTN2	6	670	12.7	7.2	5.5	9	
HTN2	7	500	10.3	8.4	1.9	9	
FK1	2	845	14.3	8.4	5.9	9	
FK1	3	2860	17.7	10.5	7.2	9	
FK1	4	900	18.2	10.4	7.8	9	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
				M113A1 (Continued)			
FK1	5	650	11.2	11.7	-0.5	9	
FK1	5A	1550	12.7	14.7	-2.0	9	
FK2	9	402	13.8	10.5	3.3	9	
				No-Go			
HTNO	3	300	0.3	0	-		9
				Go			
YPG5	2*	1710	9.7	15.1	-5.4	10	
FK2	5	343	2.5	10.0	-7.5	10	
FK2	12	1828	4.5	8.0	-3.5	10	
				No-Go			
EAFBO	9	200	8.1	0	0		4
				M48			
FS2	3	941	13.3	13.5	-0.2	6	
FS2	5	413	28.0	13.2	14.8	6	
FS2	9*	504	28.0	23.2	4.8	6	
FS3	2	546	28.0	11.0	17.0	6	
FS3	16	500	28.0	13.4	14.6	6	

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M48 (Continued)				
FS4	2	400	15.3	19.0	-3.7	6	
FS4	3	400	21.8	20.7	1.1	6	
FS4	4*	600	28.0	26.6	1.4	6	
FS4	5*	600	28.0	29.9	-1.9	6	
FS4	9*	891	28.0	29.9	-1.9	6	
FS4	10	406	28.0	19.5	8.5	6	
FSO	1A	2500	18.3	20.7	-2.4	6	
FSO	4A	125	5.3	5.5	-0.2	6	
FSO	6A	100	7.8	8.7	-0.9	6	
FSO	8A	2000	28.0	27.2	0.8	6	
HTN1	1*	550	15.9	15.4	0.5	6	
HTN1	2	750	13.0	14.6	-1.6	6	
HTN1	3*	1046	13.9	12.6	1.3	6	
HTN1	5	535	12.3	13.9	-1.6	6	
HTN1	8	517	11.0	9.7	1.3	6	
FS1	3	1461	21.2	23.4	-2.2	7	
FS1	4	525	16.7	20.8	-4.1	7	
FS1	5	557	16.5	21.3	-4.8	7	
FS1	6	1133	23.2	19.6	3.6	7	
FS1	8	590	15.9	18.6	-2.7	7	
FS1	10	569	15.9	15.9	0	7	
FS1	11	821	16.4	15.0	1.4	7	

(Continued)

Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M48 (Continued)				
FS1	19	720	20.7	17.2	3.5	7	
FS1	20	1152	11.7	17.5	-5.8	7	
FS1	21	712	26.6	19.4	7.2	7	
FS1	23	407	20.5	20.0	0.5	7	
FS2	1*	486	23.1	21.4	1.7	7	
FS2	2*	2463	23.5	22.5	1.0	7	
FS2	13*	2050	23.4	23.0	0.4	7	
FS3	10	1172	12.7	14.6	-1.9	7	
FS3	13	750	17.7	16.7	1.0	7	
FS3	19	660	16.4	18.8	-2.4	7	
FS3	21	480	16.4	18.8	-2.4	7	
HTN3	6	508	9.9	10.9	-1.0	7	
FSO	9	800	15.4	10.7	4.7	8	
HTN2	2	420	7.3	6.6	0.7	8	
HTN3	1	665	6.8	3.4	3.4	8	
HTN3	4	735	10.3	4.8	5.5	8	
FS3	1	550	22.8	10.1	12.7	9	
FS3	7	462	14.3	9.6	4.7	9	
FSO	3A	200	9.3	10.0	-0.7	9	
FSO	5A	125	4.3	4.2	0.1	9	

(Continued)

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Table 4 (Continued)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M48 (Continued)				
HTN1	4	634	12.4	11.0	1.4	9	
HTN2	6	670	10.1	7.9	2.2	9	
HTN2	7	500	9.9	7.9	2.0	9	
HTN2	9	900	10.4	8.3	2.1	9	
HTN2	10	550	12.4	9.6	2.8	9	
				M60			
YPG1	16	763	16.4	20.8	-4.4	6	
YPG1	25	1062	12.4	15.3	-2.9	6	
YPG1	27*	518	15.6	12.4	3.2	6	
YPG1	30	512	16.6	17.3	-0.7	6	
YPG1	33	1739	18.4	16.5	1.9	6	
YPG1	34	538	16.4	14.6	1.8	6	
YPG1	39	1297	17.4	16.4	1.0	6	
YPG1	41	497	18.4	18.8	-0.4	6	
YPG1	42*	518	16.3	16.4	-0.1	6	
YPG1	47	500	19.4	19.4	0	6	
YPG1	49	573	15.6	13.6	2.0	6	
YPG1	50	524	14.8	10.4	4.4	6	
YPG1	51*	1235	15.1	16.8	-1.7	6	
YPG2	1*	1636	14.9	19.9	-5.0	6	
YPG2	2*	1267	14.9	19.9	-5.0	6	

(Continued)

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Table 4 (Concluded)

Location and Traverse	Terrain Unit No.	Distance ft	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)	Factor Controlling Predicted Speed	Reason for Immobilization
			M60 (Continued)				
YPG3	2	498	14.9	13.6	1.3	6	
YPG3	7	1177	14.9	21.2	-6.3	6	
YPG3	14	410	15.9	22.9	-7.0	6	
YPG3	19	1083	15.4	21.8	-6.4	6	
YPG3	22	520	16.9	23.0	-6.1	6	
YPG3	23*	1000	14.9	28.4	-13.5	6	
YPG4	1	1575	18.9	19.5	-0.6	6	
YPG4	2*	1800	16.9	16.2	0.7	6	
YPG4	5*	1715	18.4	20.2	-1.8	6	
YPG0	2	43	1.5	3.7	-2.2	6	
YPG0	47*	800	18.4	21.3	-2.9	6	
YPG1	28	442	12.8	15.6	-2.8	7	
YPG1	3	508	13.0	18.5	-5.5	9	
YPG1	26	680	15.0	13.9	1.1	9	
YPG1	31*	428	14.5	11.0	3.5	9	
YPG1	32	987	15.6	12.7	2.9	9	
YPG1	35*	1008	14.2	11.3	2.9	9	
YPG1	48	725	15.2	14.2	1.0	9	
YPG4	4*	610	17.4	18.0	-0.6	9	
YPG0	48	646	10.4	19.0	-8.6	9	

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Table 5

Summary Evaluation of Vehicle Speed Data, Terrain-Unit Tests

Factor Controlling Speed*	Number of Tests	Vehicle	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation mph
5	61	M151	-15.5 to +16.1	4.4	5.9	31.9	7.2
	52	M35A2	- 3.7 to +19.3	6.8	6.8	46.0	7.9
	41	M113A1	-10.9 to +14.1	-1.5	4.8	29.6	6.2
6	4	M151	- 1.4 to + 7.3	1.8	2.8	18.2	3.9
	13	M35A2	- 3.2 to + 7.2	0.1	2.4	25.0	3.0
	23	M113A1	- 4.1 to + 6.9	1.5	2.4	13.7	2.8
	20	M48	- 3.7 to +17.0	2.6	4.0	23.0	6.5
	26	M60	-13.5 to + 4.4	-2.0	3.2	18.1	4.3
7	31	M151	- 5.1 to +21.2	3.9	5.5	37.9	7.7
	26	M35A2	- 2.4 to +19.8	4.1	4.4	32.4	6.2
	19	M113A1	- 4.9 to + 6.9	-0.6	2.7	14.3	3.2
	19	M48	- 5.8 to + 7.2	-0.4	2.5	13.4	3.1
	1	M60	-	-2.8	2.8	17.9	2.8
8	21	M151	- 1.7 to +20.4	9.2	9.4	118.8	10.7
	16	M35A2	- 4.4 to +11.4	5.5	6.8	107.9	7.4
	17	M113A1	- 9.8 to + 8.8	0.6	4.3	41.3	5.2
	4	M48	+ 0.7 to + 5.5	3.6	3.6	56.2	4.0
9	3	M151	- 3.5 to + 1.6	-0.2	2.2	12.7	2.4
					7.5		

(Continued)

* See Paragraph 10b.

Table 5

(Concluded)

Factor Controlling Speed*	Number of Tests	Vehicle	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation mph
9	22**	M35A2	- 5.9 to +13.2	7.0	7.5	86.2	8.0
(Continued)	31**	M113A1	- 3.5 to +12.4	4.9	5.4	49.1	6.5
	9	M48	- 0.7 to +12.7	3.0	3.2	36.8	4.8
	8	M60	- 8.6 to + 3.5	-0.4	3.3	22.3	4.1
10	15	M151	- 9.5 to + 7.6	-1.7	4.7	50.0	5.5
	3	M35A2	- 3.2 to - 0.7	-1.6	1.6	20.0	2.0
	3	M113A1	- 7.5 to - 3.5	-5.5	5.5	50.0	5.7

* See paragraph 10b.

** One test resulted in immobilization due to factor 9 (paragraph 10 of this report).

Table 6

Vehicle Speed (mph) in Terrain Units, Traverse Tests (Specific Terrain Values)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Fort Sill - Traverse 1								
1	18.7	19.0	5	10.3	18.3	5	18.1	14.1	5	15.9	28.0	6	-	-	-
2	19.0	29.4	5	10.5	24.6	5	20.1	24.8	6	20.8	22.8	6	-	-	-
3	19.8	20.7	7	16.9	20.7	7	20.5	21.2	7	23.4	21.2	7	-	-	-
4	20.5	16.4	7	12.8	16.4	7	18.6	16.7	7	20.8	16.7	7	-	-	-
5	21.3	16.2	7	13.1	16.2	7	20.0	16.5	7	21.3	16.5	7	-	-	-
6	20.0	22.7	7	15.5	22.7	7	21.7	23.2	7	19.6	23.2	7	-	-	-
7	11.4	12.3	5	12.3	13.3	5	15.8	6.3	5	10.6	15.9	7	-	-	-
8	16.4	15.9	7	15.8	15.5	7	19.9	15.9	7	18.6	15.9	7	-	-	-
9	[illegible].5	11.8	5	6.8	12.9	5	8.3	6.0	5	8.5	16.0	7	-	-	-
10	14.8	15.6	7	11.9	15.6	7	16.3	15.9	7	15.9	15.9	7	-	-	-
11	15.3	15.6	5	11.7	15.9	5	15.7	9.7	5	15.0	16.4	7	-	-	-
12	14.7	14.5	5	16.2	15.1	5	20.8	8.4	5	20.8	16.8	7	-	-	-
13	7.9	12.8	5	8.3	13.7	5	16.2	6.6	5	8.9	14.9	9	-	-	-
14	14.6	19.3	5	9.8	15.3	6	10.2	14.3	6	10.1	11.9	6	-	-	-
15	17.6	19.1	7	14.6	19.1	7	18.3	19.5	7	16.0	19.5	7	-	-	-
16	4.8	1.4	10	5.2	1.2	10	11.8	2.0	10	6.2	20.0	10	-	-	-
17	14.4	19.6	7	11.6	19.6	7	15.0	20.1	7	14.2	20.1	7	-	-	-
18	13.3	11.9	5	11.9	12.9	5	17.5	6.0	5	13.3	19.7	7	-	-	-
19	13.9	20.2	7	12.9	20.2	7	19.3	20.7	7	17.2	20.7	7	-	-	-
20	9.4	11.5	7	10.6	11.5	7	16.6	11.7	7	17.5	11.7	7	-	-	-
21	11.0	26.0	7	10.8	24.1	5	19.7	26.6	7	19.4	26.6	7	-	-	-
22	13.3	22.7	7	10.2	22.7	7	20.8	23.3	7	22.2	23.3	7	-	-	-
23	7.5	20.0	7	10.4	20.0	7	18.6	20.5	7	20.0	20.5	7	-	-	-
24	10.3	26.4	5	9.7	22.8	5	17.8	26.1	5	17.4	28.0	6	-	-	-

(Continued)

* Factor controlling predicted speed (paragraph 10b).

(Sheet 1 of 10)

Table 6 (Continued)

Terrain Unit No.	M151 Meas	M151 Pred	M151 FCS*	M35A2 Meas	M35A2 Pred	M35A2 FCS	M113A1 Meas	M113A1 Pred	M113A1 FCS	M48 Meas	M48 Pred	M48 FCS	M60 Meas	M60 Pred	M60 FCS
Fort Sill - Traverse 2															
1	19.7	22.5	7	13.5	22.0	5	22.1	23.1	7	21.4	23.1	7	-	-	-
2	19.1	22.9	7	17.3	22.9	7	20.8	23.5	7	22.5	23.5	7	-	-	-
3	24.0	23.8	5	15.3	16.7	6	13.9	16.8	6	13.5	13.3	6	-	-	-
4	18.4	13.9	5	11.0	14.7	5	12.7	7.5	5	15.4	24.0	7	-	-	-
5	16.6	13.3	5	12.1	14.2	5	17.8	6.9	5	13.2	28.0	6	-	-	-
6	18.2	24.8	5	13.7	17.8	6	17.3	21.3	9	14.7	15.8	9	-	-	-
7	27.6	28.9	5	21.5	24.3	5	20.3	30.2	5	21.5	28.0	6	-	-	-
8	24.7	24.8	5	18.7	21.9	5	18.5	23.4	5	22.4	28.0	6	-	-	-
9	28.9	30.0	5	23.4	31.0	5	21.1	35.2	5	23.2	28.0	6	-	-	-
10	14.5	20.5	5	13.0	17.7	5	14.6	15.4	5	16.9	17.5	7	-	-	-
11	22.0	19.8	7	15.8	19.8	7	17.4	20.2	7	18.9	20.2	7	-	-	-
12	21.4	20.1	7	18.1	20.1	7	20.0	20.5	7	18.8	18.3	6	-	-	-
13	27.8	22.9	7	25.3	22.9	7	20.8	23.4	7	23.0	23.4	7	-	-	-
Fort Sill - Traverse 3															
1	11.2	12.8	9	8.2	13.2	9	10.6	13.8	9	10.1	22.8	9	-	-	-
2	11.4	12.8	9	10.2	17.8	9	12.8	21.8	9	11.0	28.0	6	-	-	-
3	13.1	12.3	9	9.6	11.9	9	13.4	7.3	5	10.3	17.2	9	-	-	-
4	9.4	12.8	9	9.1	9.8	9	11.2	11.8	9	8.6	17.8	9	-	-	-
5	9.2	12.8	9	6.2	17.8	9	9.8	14.1	5	8.3	28.0	6	-	-	-
6	3.6	2.9	10	3.9	11.9	9	8.3	6.0	5	7.4	6.9	10	-	-	-
7	11.7	27.8	5	5.9	17.8	9	8.1	19.3	9	9.6	14.3	9	-	-	-
8	14.3	21.8	7	9.4	21.8	7	13.4	22.3	7	12.0	22.3	7	-	-	-
9	10.7	10.1	7	8.3	10.1	7	12.7	10.3	7	9.1	10.3	7	-	-	-
10	10.8	12.5	7	10.5	12.5	7	14.6	12.7	7	14.6	12.7	7	-	-	-
11	12.9	18.4	7	12.2	18.4	7	18.7	18.8	7	14.2	18.8	7	-	-	-
12	10.1	16.1	5	9.7	16.2	5	16.0	10.4	5	9.4	17.9	9	-	-	-
13	12.0	17.2	7	14.1	17.2	7	20.9	17.7	7	16.7	17.7	7	-	-	-

(Continued)

(Sheet 2 of 10)

Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
	Fort Sill - Traverse 3 (Continued)														
14	8.2	13.1	5	8.5	14.1	5	14.2	6.8	5	8.8	17.0	7	-	-	-
15	4.9	3.7	10	5.3	7.9	5	10.1	3.2	5	6.9	7.2	10	-	-	-
16	14.3	24.8	5	13.2	21.9	5	18.3	23.4	5	13.4	28.0	6	-	-	-
17	13.1	16.2	7	11.8	16.2	7	18.6	16.5	7	15.4	16.5	7	-	-	-
18	9.1	13.4	5	9.7	13.7	6	13.6	7.0	5	10.5	11.3	6	-	-	-
19	16.0	16.1	7	15.8	16.1	7	20.7	16.4	7	18.8	16.4	7	-	-	-
20	12.6	16.1	7	12.6	16.1	7	19.1	12.6	5	17.0	16.3	7	-	-	-
21	16.0	16.1	7	15.8	16.1	7	20.7	16.4	7	18.8	16.4	7	-	-	-
	Fort Sill - Traverse 4														
1	12.8	19.3	7	12.9	19.3	7	15.5	19.8	7	16.2	19.8	7	-	-	-
2	20.7	30.0	5	17.0	17.8	6	18.2	20.8	6	19.0	15.3	6	-	-	-
3	21.3	30.0	5	18.0	25.2	6	19.8	23.3	6	20.7	21.8	6	-	-	-
4	20.3	30.0	5	23.0	34.0	5	23.8	36.8	5	26.6	28.0	6	-	-	-
5	27.6	30.0	5	23.8	34.4	5	28.8	37.0	5	29.9	28.0	6	-	-	-
6	29.0	30.0	5	20.1	25.3	6	27.3	23.3	6	28.4	21.8	6	-	-	-
7	22.0	30.0	5	14.8	30.3	6	25.3	26.8	6	25.5	24.3	6	-	-	-
8	13.3	30.0	5	15.8	22.8	6	21.9	21.8	6	22.5	19.3	6	-	-	-
9	27.6	30.0	5	23.8	31.7	5	28.8	35.6	5	29.9	28.0	6	-	-	-
10	17.8	16.0	5	16.1	16.1	5	20.4	10.2	5	19.5	28.0	6	-	-	-
11	8.4	7.1	7	7.4	7.1	7	8.4	4.4	5	7.3	7.1	7	-	-	-
12	15.0	28.0	5	8.6	17.8	6	12.2	19.3	6	11.5	14.3	6	-	-	-
13	19.8	30.0	5	11.8	28.5	6	19.6	28.0	6	19.2	24.3	6	-	-	-
	Yuma - Traverse 1														
1	21.1	30.0	5	12.7	26.9	5	18.0	21.9	6	-	-	-	14.7	15.9	6
2	21.8	13.0	5	8.6	13.9	5	8.9	6.7	5	-	-	-	5.8	11.4	9
3	21.8	30.0	5	16.4	33.4	5	17.5	21.9	6	-	-	-	18.5	13.0	9

(Continued)

(Sheet 3 of 10)

Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
	Yuma - Traverse 1 (Continued)														
4	8.3	15.9	5	8.0	16.1	5	12.5	10.1	5	-	-	-	10.7	15.4	6
5	15.7	30.0	5	12.6	26.1	5	14.5	21.9	6	-	-	-	13.1	12.3	6
6	7.3	8.9	5	6.3	10.3	5	8.0	4.4	5	-	-	-	8.2	15.0	9
7	17.7	30.0	5	13.1	34.0	5	17.2	21.9	6	-	-	-	18.1	16.8	6
8	9.1	9.9	5	9.1	11.2	5	15.2	4.8	5	-	-	-	13.0	11.8	9
9	17.1	30.0	5	12.7	31.6	5	17.4	21.5	6	-	-	-	15.3	16.5	6
10	8.0	12.1	5	7.8	13.2	5	11.9	6.2	5	-	-	-	9.4	15.7	9
11	13.6	20.3	5	11.0	19.2	5	11.0	13.4	9	-	-	-	9.7	10.4	9
12	18.5	30.0	5	13.9	28.9	5	18.5	21.9	6	-	-	-	18.9	18.9	6
13	12.3	22.8	5	12.7	20.7	5	18.3	19.3	9	-	-	-	22.1	14.7	9
14	20.3	30.0	5	13.9	37.7	5	22.4	21.9	6	-	-	-	21.3	16.7	6
15	10.4	11.9	5	8.7	13.0	5	11.2	6.1	5	-	-	-	9.0	13.2	9
16	22.6	30.0	5	16.7	26.7	5	19.5	21.7	6	-	-	-	20.8	16.4	6
17	5.8	1.4	10	6.1	1.5	10	7.2	2.3	10	-	-	-	6.2	14.4	9
18	15.3	30.0	5	12.1	34.6	5	14.7	21.9	6	-	-	-	13.9	16.8	6
19	7.1	17.4	5	5.6	17.2	5	9.9	12.1	5	-	-	-	18.0	16.4	9
20	18.8	30.0	5	12.1	28.6	5	13.6	21.9	6	-	-	-	21.2	16.9	6
21	8.8	2.7	10	10.9	15.8	10	19.6	12.3	10	-	-	-	21.3	6.9	10
22	13.4	30.0	5	10.8	16.9	5	17.2	21.9	6	-	-	-	17.4	16.7	6
23	7.5	1.3	10	5.9	1.2	10	11.6	1.1	10	-	-	-	8.2	4.9	10
24	14.3	9.6	10	9.3	26.3	10	9.6	14.0	10	-	-	-	14.2	9.7	10
25	12.8	4.5	10	9.3	11.1	7	11.5	10.9	9	-	-	-	15.3	12.4	6
26	12.7	19.2	5	9.5	18.6	5	13.4	14.4	9				13.9	15.0	9
27	12.1	14.8	5	10.7	15.3	5	14.1	8.7	5	-	-	-	12.4	15.6	6
28	14.0	4.5	10	11.4	11.1	7	12.4	11.4	9	-	-	-	15.6	12.8	7
29	14.1	17.7	5	11.1	17.4	5	12.3	12.5	5	-	-	-	17.8	12.9	9
30	12.1	4.5	10	10.3	21.0	5	15.9	12.4	9	-	-	-	17.3	16.6	6
31	9.9	11.6	5	8.0	12.8	5	12.6	5.9	5	-	-	-	11.0	14.5	9
32	11.7	18.2	5	13.6	17.8	5	14.2	13.2	5	-	-	-	12.7	15.6	9

(Continued)

(Sheet 4 of 10)

Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
	Yuma - Traverse 1 (Continued)														
33	12.3	21.8	5	10.5	20.1	5	16.7	18.5	5	-	-	-	16.5	18.4	6
34	10.2	18.9	5	10.3	18.2	5	14.9	14.1	5	-	-	-	14.6	16.4	6
35	9.0	7.5	5	12.7	9.0	5	11.2	3.7	5	-	-	-	11.3	14.2	9
36	13.2	17.9	5	10.8	17.5	5	15.5	12.7	5	-	-	-	14.2	18.9	6
37	11.7	29.0	5	10.3	24.4	5	13.7	19.3	6	-	-	-	15.7	13.4	6
38	7.4	3.0	10	6.5	3.4	10	7.2	3.8	10	-	-	-	8.4	15.7	9
39	11.2	20.6	5	10.4	19.4	5	17.3	16.5	5	-	-	-	16.4	17.4	6
40	9.8	21.2	5	9.5	19.7	5	13.4	17.5	5	-	-	-	15.6	16.4	6
41	9.8	21.9	5	10.5	20.1	5	18.4	18.6	5	-	-	-	18.8	18.4	6
42	12.3	15.8	5	11.3	16.1	5	17.1	10.1	5	-	-	-	16.4	16.3	6
43	9.0	21.0	5	8.8	19.6	5	18.0	17.1	5	-	-	-	18.0	18.4	6
44	9.5	24.8	5	8.6	21.9	5	16.4	21.9	6	-	-	-	15.5	18.4	6
45	10.4	17.2	5	8.5	17.0	5	12.7	11.8	5	-	-	-	19.4	16.4	6
46	12.3	20.8	5	10.6	19.5	5	15.3	16.8	5	-	-	-	16.6	16.4	6
47	11.5	21.3	5	9.9	19.8	5	18.7	17.6	5	-	-	-	19.4	19.4	6
48	11.5	12.1	5	9.1	13.2	5	15.5	6.2	5	-	-	-	14.2	15.2	9
49	14.4	12.0	5	9.8	13.0	5	15.4	6.1	5	-	-	-	13.6	15.6	6
50	13.4	8.0	5	5.6	9.5	5	9.7	4.0	5	-	-	-	10.4	14.8	6
51	17.5	16.7	5	12.4	16.7	5	19.0	11.2	5	-	-	-	16.8	15.1	6
	Yuma - Traverse 2														
1	27.2	30.0	-	19.0	27.6	-	19.2	21.3	6	-	-	-	19.9	14.9	-
2	23.2	28.2	-	18.5	23.9	-	19.2	21.3	6	-	-	-	19.9	14.9	-
	Yuma - Traverse 3														
1	12.6	16.7	5	13.2	16.7	5	14.3	11.2	5	-	-	-	14.0	13.4	9
2	21.4	30.0	5	23.6	28.0	5	22.9	21.3	6	-	-	-	13.6	14.9	6
3	9.9	8.9	5	7.1	10.0	5	8.9	4.4	5	-	-	-	7.2	10.4	9

(Continued)

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Table 6 (Continued)

Terrain Unit No.	M151 Meas	M151 Pred	M151 FCS*	M35A2 Meas	M35A2 Pred	M35A2 FCS	M113A1 Meas	M113A1 Pred	M113A1 FCS	M48 Meas	M48 Pred	M48 FCS	M60 Meas	M60 Pred	M60 FCS
	Vehicle														
	Yuma - Traverse 3 (Continued)														
4	16.6	30.0	5	13.0	33.8	5	12.5	21.7	6	-	-	-	14.9	16.9	6
5	11.8	11.7	5	8.7	12.8	5	12.0	5.9	5	-	-	-	12.1	15.1	9
6	10.1	13.0	5	8.4	14.0	5	12.1	6.7	5	-	-	-	11.5	15.6	6
7	22.2	30.0	5	17.5	34.4	5	20.5	21.3	6	-	-	-	21.2	14.9	6
8	14.2	30.0	-	14.5	34.4	5	18.6	21.3	6	-	-	-	20.6	14.9	6
9	10.8	6.7	5	8.4	7.9	5	9.4	3.3	5	-	-	-	10.2	13.7	6
10	18.1	22.8	5	15.2	20.7	5	17.2	20.1	5	-	-	-	18.1	14.9	6
11	10.5	11.8	5	8.1	12.9	5	12.0	6.0	5	-	-	-	11.2	10.4	9
12	22.6	12.3	7	14.5	12.5	7	19.8	14.2	7	-	-	-	18.1	14.2	7
13	10.9	7.3	5	9.0	8.8	5	10.5	3.6	5	-	-	-	11.1	14.3	9
14	22.9	30.0	5	18.6	37.9	5	15.0	21.9	6	-	-	-	22.9	15.9	6
15	9.8	10.7	5	9.2	11.9	5	10.9	5.3	5	-	-	-	8.1	12.9	9
16	17.8	30.0	5	16.2	30.1	5	17.7	21.7	6	-	-	-	19.8	16.7	6
17	14.3	11.7	5	11.6	12.8	5	13.5	5.9	5	-	-	-	12.6	15.4	9
18	8.5	14.7	5	8.3	15.2	5	9.8	8.5	5	-	-	-	10.4	14.4	9
19	21.5	30.0	5	19.8	32.9	5	20.4	21.9	6	-	-	-	21.8	15.4	6
20	10.1	12.3	5	8.1	13.3	5	10.1	6.0	8	-	-	-	9.5	11.7	8
21	23.1	30.0	5	15.4	37.7	5	17.7	20.3	9	-	-	-	17.2	14.4	6
22	27.5	39.0	5	22.2	42.0	7	21.6	21.7	6	-	-	-	23.0	16.9	6
23	44.6	39.0	5	29.6	42.4	7	25.4	21.3	6	-	-	-	28.4	14.9	6
	Yuma - Traverse 4														
1	15.9	26.3	5	17.2	22.8	5	19.7	21.9	6	-	-	-	19.5	18.9	6
2	17.0	19.7	5	15.0	18.8	5	16.7	15.1	5	-	-	-	16.2	16.9	6
3	16.2	18.2	5	15.3	17.7	5	16.0	13.1	5	-	-	-	15.7	18.9	6
4	21.4	26.1	5	18.2	22.7	5	19.0	21.9	6	-	-	-	18.0	17.4	9
5	18.3	28.6	5	18.7	24.2	5	19.7	21.9	6	-	-	-	20.2	18.4	6

(Continued)

Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Yuma - Traverse 5								
1	13.9	21.5	5	12.8	19.9	5	18.3	18.0	5	-	-	-	-	-	-
2	12.1	9.4	10	11.3	10.3	10	15.1	9.7	10	-	-	-	-	-	-
3	4.1	7.5	5	8.0	9.0	5	11.5	3.7	5	-	-	-	-	-	-
4	11.5	13.8	5	8.2	14.6	5	12.4	7.3	5	-	-	-	-	-	-
5	15.6	17.1	5	11.5	15.5	5	14.2	11.8	5	-	-	-	-	-	-
6	17.1	18.4	5	14.4	17.9	5	17.8	13.5	5	-	-	-	-	-	-
7	14.4	16.0	5	12.8	16.1	5	12.0	10.2	5	-	-	-	-	-	-
8	13.0	15.7	5	8.4	15.0	9	9.3	10.2	5	-	-	-	-	-	-
							Eglin - Traverse 1								
1	7.6	21.4	7	8.8	17.3	9	12.7	19.8	9	-	-	-	-	-	-
2	6.4	14.0	8	7.1	13.7	9	10.3	14.8	9	-	-	-	-	-	-
3	13.4	17.3	5	10.3	17.1	5	4.2	12.0	5	-	-	-	-	-	-
4	9.7	22.5	8	9.2	14.5	9	9.6	17.7	9	-	-	-	-	-	-
5	14.3	10.6	8	5.6	9.0	8	10.9	9.3	9	-	-	-	-	-	-
6	11.1	19.2	8	10.5	13.7	9	12.0	16.9	9	-	-	-	-	-	-
7	9.6	19.4	8	5.4	13.2	9	7.5	15.3	8	-	-	-	-	-	-
8	8.9	18.4	8	5.4	14.1	8	10.1	16.2	8	-	-	-	-	-	-
9	12.3	22.1	8	8.8	17.3	9	12.0	15.0	8	-	-	-	-	-	-
10	9.0	20.4	8	6.6	16.7	9	10.2	19.3	9	-	-	-	-	-	-
11	11.0	26.0	8	6.6	14.2	8	9.7	15.2	8	-	-	-	-	-	-
							Eglin - Traverse 2								
1	7.2	18.1	7	5.8	17.2	8	9.5	21.9	9	-	-	-	-	-	-
2	17.7	16.8	5	11.1	16.7	5	12.4	11.3	5	-	-	-	-	-	-
3	12.5	24.0	5	8.2	17.2	6	12.2	21.9	6	-	-	-	-	-	-
4	7.8	23.8	8	3.7	14.7	9	9.1	17.8	8	-	-	-	-	-	-
5	9.9	22.7	8	5.9	13.4	8	10.6	15.1	8	-	-	-	-	-	-

(Continued)

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Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Eglin - Traverse 2 (Continued)								
6	9.0	19.3	8	4.9	11.6	8	8.1	12.6	8	-	-	-	-	-	-
7	15.7	18.7	5	11.5	18.1	5	13.6	13.8	5	-	-	-	-	-	-
8	7.5	23.5	8	4.0	13.5	8	9.2	15.3	8	-	-	-	-	-	-
9	5.5	18.0	8	3.4	9.9	9	8.2	13.9	9	-	-	-	-	-	-
10	5.9	20.7	8	3.8	14.0	9	8.6	18.3	9	-	-	-	-	-	-
11	6.3	13.3	7	6.3	14.0	7	10.4	19.6	7	-	-	-	-	-	-
12	8.4	29.6	7	6.9	17.2	9	10.7	21.3	9	-	-	-	-	-	-
13	8.8	25.1	7	7.6	15.8	9	10.9	19.8	9	-	-	-	-	-	-
14	8.1	18.9	7	6.5	19.7	9	9.6	21.9	9	-	-	-	-	-	-
15	5.2	5.7	10	4.1	14.7	9	10.7	14.4	8	-	-	-	-	-	-
16	8.2	27.2	7	7.7	29.1	7	14.1	38.5	5	-	-	-	-	-	-
							Eglin - Traverse 3								
1	13.6	19.5	7	11.2	20.3	7	15.7	21.7	9	-	-	-	-	-	-
2	7.5	24.5	8	7.4	15.0	9	11.3	16.8	8	-	-	-	-	-	-
3	7.0	22.8	8	6.2	14.8	8	11.0	19.3	9	-	-	-	-	-	-
4	7.0	27.7	8	6.3	15.3	9	10.5	19.1	9	-	-	-	-	-	-
5	8.8	17.6	8	7.9	14.5	9	11.6	17.0	9	-	-	-	-	-	-
6	9.6	23.9	7	7.8	14.7	9	10.8	16.9	9	-	-	-	-	-	-
7	5.6	24.5	8	7.4	17.3	9	10.7	19.6	8	-	-	-	-	-	-
8	8.7	13.6	8	6.7	15.2	8	12.2	15.5	5	-	-	-	-	-	-
9	12.4	24.2	8	7.5	14.4	9	11.6	16.5	9	-	-	-	-	-	-
10	8.7	22.5	5	8.6	16.3	9	12.3	19.0	9	-	-	-	-	-	-
							Houghton - Traverse 1								
1	24.0	19.6	7	19.0	19.8	5	18.9	17.6	5	15.4	15.9	6	-	-	-
2	16 0	15.5	7	13.5	16.0	7	17.5	17.5	8	14.6	13.0	6	-	-	-
3	16.2	17.7	7	13.4	18.4	5	17.8	14.3	5	12.6	13.9	6	-	-	-

(Continued)

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Table 6 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Houghton - Traverse 1 (Continued)								
4	6.7	6.3	7	6.8	6.4	7	10.9	7.7	7	11.0	12.4	9	-	-	-
5	19.2	29.6	5	17.1	24.8	5	16.6	21.3	9	13.9	12.3	6	-	-	-
6	7.6	7.5	8	9.6	8.5	5	12.6	10.4	7	11.8	11.4	9	-	-	-
7	9.8	4.6	10	8.7	22.4	8	9.8	20.2	9	10.2	10.4	9	-	-	-
8	7.8	8.1	10	5.4	10.6	7	9.5	13.1	9	9.7	11.0	6	-	-	-
9	4.4	4.4	8	3.7	7.3	7	6.9	9.2	7	6.5	11.2	8	-	-	-
							Houghton - Traverse 2								
1	6.0	14.2	8	3.8	9.3	6	5.3	8.9	8	2.4	5.4	9	-	-	-
2	5.4	9.1	10	3.2	13.9	9	5.4	11.5	9	6.6	7.3	8	-	-	-
3	3.2	6.2	10	3.7	15.3	5	5.8	8.6	5	11.6	28.5	6	-	-	-
4	4.9	4.2	10	2.6	7.1	7	7.7	8.3	7	9.9	6.9	9	-	-	-
5	5.5	6.8	8	2.9	2.9	8	4.6	3.6	8	2.3	2.8	9	-	-	-
6	5.0	5.7	10	3.6	13.0	7	7.2	12.7	9	7.9	10.1	9	-	-	-
7	3.9	2.2	8	-	-	-	8.4	10.3	9	7.9	9.9	9	-	-	-
8	6.2	7.7	10	-	-	-	8.6	8.4	5	7.4	10.4	9	-	-	-
9	5.4	9.6	10	-	-	-	7.3	7.9	5	8.3	10.4	9	-	-	-
10	6.2	13.0	8	12.2	15.4	7	11.1	14.0	5	9.6	12.4	9	-	-	-
							Houghton - Traverse 3								
1	5.2	10.3	8	-	-	-	6.6	5.6	8	3.4	6.8	8	-	-	-
2	4.8	6.2	8	-	-	-	5.6	3.9	8	8.2	9.3	8	-	-	-
3	4.7	8.0	10	-	-	-	4.3	8.0	8	5.4	2.9	8	-	-	-
4	4.0	6.5	8	-	-	-	5.8	4.2	5	4.8	10.3	8	-	-	-
5	5.5	6.4	10	-	-	-	6.5	3.9	8	3.5	7.5	8	-	-	-
6	12.6	7.9	7	-	-	-	15.9	6.9	5	10.9	9.9	7	-	-	-
7	5.0	10.3	10	-	-	-	8.3	7.1	5	7.6	16.4	9	-	-	-
8	4.2	10.3	8	-	-	-	5.7	5.8	5	6.5	11.5	8	-	-	-

(Continued)

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Table 6 (Concluded)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
						Fort Knox - Traverse 1									
1	8.3	20.3	8	4.8	13.9	8	9.0	17.8	8	-	-	-	-	-	-
2	8.0	15.6	10	4.7	9.9	8	8.4	14.3	9	-	-	-	-	-	-
3	8.5	28.9	8	4.5	9.6	9	10.5	17.7	9	-	-	-	-	-	-
4	8.7	27.1	8	5.2	12.1	8	10.4	18.2	9	-	-	-	-	-	-
5	13.1	18.0	5	7.0	4.5	6	11.7	11.2	9	-	-	-	-	-	-
5A	14.9	16.6	7	7.7	4.5	6	14.7	12.7	9	-	-	-	-	-	-
6	15.8	19.4	7	6.4	4.5	6	15.7	13.2	6	-	-	-	-	-	-
7	5.6	8.3	10	5.1	1.5	8	9.6	9.0	8	-	-	-	-	-	-
8	17.0	25.2	7	10.2	7.3	6	15.6	15.7	6	-	-	-	-	-	-
9	21.6	20.8	5	13.2	15.6	9	19.5	16.8	5	-	-	-	-	-	-
						Fort Knox, - Traverse 2									
1	10.7	11.7	5	6.8	12.5	8	12.4	5.8	8	-	-	-	-	-	-
2	7.2	2.9	10	5.1	7.0	10	10.2	3.1	5	-	-	-	-	-	-
3	15.2	18.9	5	11.1	18.2	5	18.9	14.0	5	-	-	-	-	-	-
4	8.2	9.7	5	7.1	11.1	5	10.8	4.8	5	-	-	-	-	-	-
5	9.2	3.5	10	6.1	2.9	10	10.0	2.5	10	-	-	-	-	-	-
6	6.4	17.4	8	4.4	15.6	8	10.3	11.5	8	-	-	-	-	-	-
7	8.5	13.6	5	4.8	9.8	66	7.7	7.2	5	-	-	-	-	-	-
8	18.6	26.6	5	15.6	23.0	5	17.3	25.8	6	-	-	-	-	-	-
9	8.9	17.4	8	5.2	14.9	8	10.5	13.8	9	-	-	-	-	-	-
10	7.1	10.3	10	3.9	13.4	8	10.0	6.7	8	-	-	-	-	-	-
11	6.7	14.8	8	6.3	14.2	9	8.7	10.4	8	-	-	-	-	-	-
12	7.4	5.6	10	6.5	5.8	10	8.0	4.5	10	-	-	-	-	-	-
13	7.4	15.1	8	5.3	15.1	8	11.6	8.9	8	-	-	-	-	-	-
14	12.8	8.1	10	9.0	12.8	5	13.4	5.9	5	-	-	-	-	-	-
15	16.9	8.8	10	12.6	15.5	9	14.3	11.0	5	-	-	-	-	-	-

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Table 7

Vehicle Speed (mph) in Terrain Units, Traverse Tests (Classed Terrain Values)

Terrain Unit No.	M151 Meas	M151 Pred	M151 FCS*	M35A2 Meas	M35A2 Pred	M35A2 FCS	M113A1 Meas	M113A1 Pred	M113A1 FCS	M48 Meas	M48 Pred	M48 FCS	M60 Meas	M60 Pred	M60 FCS
							Fort Sill - Traverse 1								
1	18.7	20.0	5	10.3	19.0	5	18.1	15.5	5	15.9	27.8	6	-	-	-
2	19.0	30.0	5	10.5	24.8	6	20.1	21.8	6	20.8	20.3	6	-	-	-
3	19.8	25.6	7	16.9	25.6	7	20.5	26.3	7	23.4	26.3	7	-	-	-
4	20.5	18.1	7	12.8	18.1	7	18.6	18.5	7	20.8	18.5	7	-	-	-
5	21.3	17.9	7	13.1	17.9	7	20.0	18.3	7	21.3	18.3	7	-	-	-
6	20.0	25.4	7	15.5	25.0	5	21.7	26.0	7	19.6	26.0	7	-	-	-
7	11.4	13.5	5	12.3	14.4	5	15.8	7.0	5	10.6	18.2	7	-	-	-
8	16.4	17.6	7	15.8	17.6	7	19.9	18.0	7	18.6	18.0	7	-	-	-
9	9.5	13.5	5	6.8	14.4	5	8.3	7.0	5	8.5	18.2	7	-	-	-
10	14.8	17.8	7	11.9	17.8	7	16.3	18.2	7	15.9	18.2	7	-	-	-
11	15.3	13.5	5	11.7	14.4	5	15.7	7.0	5	15.0	18.2	7	-	-	-
12	14.7	13.5	5	16.2	14.4	5	20.8	7.0	5	20.8	18.0	7	-	-	-
13	7.9	13.5	5	8.3	14.4	5	16.2	7.0	5	8.9	15.6	9	-	-	-
14	14.6	18.4	7	9.8	16.9	6	10.2	15.5	5	10.1	13.2	6	-	-	-
15	17.6	17.9	7	14.6	17.9	7	18.3	18.3	7	16.0	18.3	7	-	-	-
16	4.8	10.0	5	5.2	11.3	5	11.8	4.9	5	6.2	22.0	5	-	-	-
17	14.4	25.4	7	11.6	25.0	5	15.0	26.0	7	14.2	26.0	7	-	-	-
18	13.3	13.5	5	11.9	14.4	5	17.5	7.0	5	13.3	25.7	7	-	-	-
19	13.9	25.1	7	12.9	25.0	5	19.3	25.7	7	17.2	25.7	7	-	-	-
20	9.4	10.7	7	10.6	10.7	7	16.6	10.9	7	17.5	10.9	7	-	-	-
21	11.0	25.6	7	10.8	25.0	5	19.7	26.3	7	19.4	26.3	7	-	-	-
22	13.3	25.4	7	10.2	25.0	5	20.8	26.0	7	22.2	26.0	7	-	-	-
23	7.5	25.1	7	10.4	25.0	5	17.8	25.7	7	17.4	25.7	7	-	-	-
24	10.3	25.1	7	9.7	25.0	5	17.8	25.7	7	17.4	25.7	7	-	-	-

(Continued)

* Factor controlling predicted speed (paragraph 10b).

Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
Fort Sill - Traverse 2															
1	19.7	25.0	7	13.5	25.0	5	22.1	25.7	7	21.4	25.7	7	-	-	-
2	19.1	25.6	7	17.3	25.0	5	20.8	26.3	7	22.5	26.3	7	-	-	-
3	24.0	20.0	5	15.3	15.9	6	13.9	15.5	5	13.5	12.6	6	-	-	-
4	18.4	13.5	5	11.0	14.4	5	12.7	7.0	5	15.4	25.7	7	-	-	-
5	16.6	13.5	5	12.1	14.4	5	17.8	7.0	5	13.2	25.2	7	-	-	-
6	18.2	30.0	5	13.7	17.7	9	17.3	21.4	9	14.7	16.3	9	-	-	-
7	27.6	30.0	5	21.5	25.0	5	20.3	32.0	5	21.5	27.9	6	-	-	-
8	24.7	30.0	5	18.7	25.0	5	18.5	32.0	5	22.4	27.9	6	-	-	-
9	28.9	30.0	5	23.4	25.0	5	21.1	32.0	5	23.2	27.9	6	-	-	-
10	14.5	20.0	5	13.4	17.5	6	14.6	15.5	5	16.9	18.4	6	-	-	-
11	22.0	25.6	7	15.8	25.0	5	17.4	26.3	7	18.9	26.3	7	-	-	-
12	21.4	20.0	5	18.1	19.0	5	20.0	15.5	5	18.8	20.3	6	-	-	-
13	27.8	25.6	6	25.3	25.0	5	20.8	26.3	7	23.0	26.3	7	-	-	-
Fort Sill - Traverse 3															
1	11.2	12.1	9	8.2	11.4	9	10.6	12.7	9	10.1	21.4	9	-	-	-
2	11.4	12.3	9	10.2	16.5	9	12.8	20.9	9	11.0	27.9	9	-	-	-
3	13.1	11.5	9	9.6	11.1	9	13.4	7.0	5	10.3	16.3	9	-	-	-
4	9.4	11.6	9	9.1	9.5	9	11.2	10.7	9	8.6	14.7	9	-	-	-
5	9.2	12.3	9	6.2	15.8	9	9.8	15.5	5	8.3	27.9	9	-	-	-
6	3.6	3.3	10	3.9	11.5	10	8.3	7.0	5	7.4	6.2	6	-	-	-
7	11.7	26.4	7	5.9	14.7	9	8.1	12.9	9	9.6	10.8	9	-	-	-
8	14.3	25.6	7	9.4	25.0	5	13.4	26.3	7	12.0	26.3	7	-	-	-
9	10.7	10.8	7	8.3	10.8	7	12.7	11.1	7	9.1	11.0	7	-	-	-
10	10.8	14.1	7	10.5	14.1	7	14.6	14.4	7	14.6	14.4	7	-	-	-
11	12.9	17.6	7	12.3	17.6	7	18.7	18.0	7	14.2	18.0	7	-	-	-
12	10.1	13.5	5	9.7	11.4	5	16.0	7.0	5	9.4	18.2	7	-	-	-

(Continued)

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Table 7 (Continued)

Terrain Unit No.	M151 Meas	M151 Pred	M151 FCS*	M35A2 Meas	M35A2 Pred	M35A2 FCS	M113A1 Meas	M113A1 Pred	M113A1 FCS	M48 Meas	M48 Pred	M48 FCS	M60 Meas	M60 Pred	M60 FCS
Fort Sill - Traverse 3 (Continued)															
13	12.0	17.6	7	14.1	17.6	7	20.9	18.0	7	16.7	18.0	7	-	-	-
14	8.2	13.5	5	8.5	14.4	5	14.2	7.0	5	8.8	17.0	7	-	-	-
15	4.9	6.3	5	5.3	7.5	5	10.1	3.1	5	6.9	11.4	9	-	-	-
16	14.3	30.0	5	13.2	25.0	5	18.3	32.0	5	13.4	27.9	6	-	-	-
17	13.1	17.9	7	11.8	17.9	7	18.6	18.3	7	15.4	18.3	7	-	-	-
18	9.1	13.5	5	9.7	12.8	6	13.6	7.0	5	10.5	11.2	6	-	-	-
19	16.0	17.9	7	15.8	17.9	7	20.7	18.3	7	18.8	18.3	7	-	-	-
20	12.6	17.8	7	12.6	17.3	6	19.1	15.5	5	17.0	16.0	6	-	-	-
21	16.0	17.9	7	15.8	17.9	7	20.7	18.3	7	18.8	18.3	7	-	-	-
Fort Sill - Traverse 4															
1	12.8	17.8	7	12.9	17.8	7	15.5	18.3	7	16.2	18.3	7	-	-	-
2	20.7	25.8	7	17.0	17.4	6	18.2	20.6	6	19.0	15.1	6	-	-	-
3	21.3	30.0	5	18.0	22.8	6	19.8	21.8	6	20.7	19.8	6	-	-	-
4	20.3	30.0	5	23.0	25.0	5	23.8	32.0	5	26.6	27.9	6	-	-	-
5	27.6	30.0	5	23.8	25.0	5	28.8	32.0	5	29.9	27.9	6	-	-	-
6	29.0	30.0	5	20.1	23.0	6	27.3	21.7	6	28.4	19.1	6	-	-	-
7	22.0	30.0	5	14.8	24.8	6	25.3	21.8	6	25.5	20.3	6	-	-	-
8	13.3	30.0	5	15.8	25.0	5	21.9	21.7	6	22.5	19.1	6	-	-	-
9	27.6	30.0	5	23.8	25.0	5	28.8	32.0	5	29.9	27.9	6	-	-	-
10	17.8	13.5	5	16.1	14.4	5	20.4	7.0	5	19.5	27.9	6	-	-	-
11	8.4	5.6	7	7.4	5.6	7	8.4	4.9	5	7.3	5.6	7	-	-	-
12	15.0	30.0	5	8.6	15.0	6	12.2	14.3	6	11.5	11.8	6	-	-	-
13	19.8	30.0	5	11.8	24.2	6	19.6	25.5	6	19.2	22.4	6	-	-	-
Yuma - Traverse 1															
1	21.1	30.0	5	12.7	25.0	5	18.0	21.0	9	-	-	-	14.7	14.6	9
2	21.8	13.5	5	8.6	14.4	5	8.9	7.0	5	-	-	-	5.8	11.5	9

(Continued)

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Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
	Yuma - Traverse 1 (Continued)														
3	21.8	30.0	5	16.4	25.0	5	17.5	21.4	9	-	-	-	14.7	14.6	9
4	8.3	13.5	5	8.0	14.4	5	12.5	7.0	5	-	-	-	10.7	13.0	9
5	15.7	30.0	5	12.6	25.0	5	14.5	21.8	6	-	-	-	13.1	13.3	9
6	7.3	10.0	5	6.3	11.3	5	8.0	4.9	5	-	-	-	8.2	13.5	9
7	17.7	30.0	5	13.1	25.0	5	17.2	21.4	9	-	-	-	18.1	16.2	9
8	9.1	10.0	5	9.1	11.3	5	15.2	4.9	5	-	-	-	13.0	12.4	9
9	17.1	30.0	5	12.7	25.0	5	17.4	21.4	9	-	-	-	15.3	16.2	9
10	8.0	13.5	5	7.8	14.4	5	11.9	7.0	7	-	-	-	9.4	16.1	9
11	13.6	20.0	5	11.0	19.0	5	11.0	12.9	9	-	-	-	9.7	10.3	9
12	16.5	30.0	5	13.9	25.0	5	18.5	21.8	6	-	-	-	18.9	18.3	9
13	12.3	20.0	5	12.7	19.0	5	18.3	15.5	5	-	-	-	22.1	14.3	9
14	20.3	30.0	5	13.9	32.6	7	22.4	21.8	6	-	-	-	21.3	18.3	9
15	10.4	13.5	5	8.7	14.4	5	11.2	7.0	5	-	-	-	9.0	12.5	9
16	22.6	30.0	5	16.7	13.6	9	19.5	10.2	9	-	-	-	20.8	7.5	9
17	5.8	10.0	5	6.1	11.3	5	7.2	4.9	5	-	-	-	6.2	11.5	9
18	15.3	30.0	5	12.1	25.0	5	14.7	21.4	9	-	-	-	13.9	16.2	9
19	7.1	20.0	5	5.6	19.0	5	9.9	15.5	5	-	-	-	18.0	16.7	9
20	18.8	30.0	5	12.1	25.0	5	13.6	21.4	9	-	-	-	21.2	16.2	9
21	8.8	2.2	10	10.9	11.5	10	19.6	9.7	10	-	-	-	21.3	6.2	10
22	13.4	30.0	5	10.8	25.0	5	17.2	21.3	9	-	-	-	17.4	16.2	9
23	7.5	7.5	5	5.9	9.0	5	11.6	3.7	5	-	-	-	8.2	10.1	9
24	14.3	30.0	5	9.3	25.0	5	9.6	14.1	9	-	-	-	14.2	10.6	9
25	12.8	12.0	7	9.3	12.3	7	11.5	11.9	9	-	-	-	15.3	10.0	9
26	12.7	20.0	5	9.5	19.0	5	13.4	15.2	9	-	-	-	13.9	15.3	9
27	12.1	13.5	5	10.7	14.4	5	14.1	7.0	5	-	-	-	12.4	14.4	9
28	14.0	11.8	7	11.4	12.1	7	12.4	14.4	7	-	-	-	15.6	10.4	9

(Continued)

Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
	Yuma - Traverse 1 (Continued)														
29	14.1	20.0	5	11.1	19.0	5	12.3	15.5	5	-	-	-	17.8	12.8	9
30	12.1	20.0	5	10.3	19.0	5	15.9	15.5	5	-	-	-	17.3	11.4	9
31	9.9	13.5	5	8.0	14.4	5	12.6	7.0	5	-	-	-	11.0	14.1	9
32	11.7	20.0	5	13.6	19.0	5	14.2	15.0	9	-	-	-	12.7	15.0	9
33	12.3	20.0	5	10.5	19.0	5	16.7	15.5	5	-	-	-	16.5	18.3	9
34	10.2	20.0	5	10.3	19.0	5	14.9	15.4	9	-	-	-	14.6	15.7	9
35	9.0	7.5	5	12.7	9.0	5	11.2	3.7	5	-	-	-	11.3	13.5	9
36	13.2	20.0	5	10.8	19.0	5	15.5	15.5	5	-	-	-	14.2	18.6	6
37	11.7	30.0	5	10.3	25.0	5	13.7	21.0	9	-	-	-	15.7	14.6	9
38	7.4	10.0	5	6.5	11.3	5	7.2	4.9	5	-	-	-	8.4	14.3	9
39	11.2	20.0	5	10.4	19.0	5	17.3	15.5	5	-	-	-	16.4	18.3	9
40	9.8	20.0	5	9.5	19.0	5	13.4	15.4	9	-	-	-	15.6	15.7	9
41	9.8	20.0	5	10.5	19.0	5	18.4	15.5	5	-	-	-	18.8	18.3	9
42	12.3	13.5	5	11.3	14.4	5	17.1	7.0	5	-	-	-	16.4	15.7	9
43	9.0	20.0	5	8.8	19.0	5	18.0	15.5	5	-	-	-	18.0	23.8	9
44	9.5	30.0	5	8.6	25.0	5	16.4	21.8	6	-	-	-	15.5	18.3	9
45	10.4	20.0	5	8.5	19.0	5	12.7	15.5	5	-	-	-	19.4	14.6	9
46	12.3	20.0	5	10.6	19.0	5	15.3	15.4	9	-	-	-	16.6	15.7	9
47	11.5	20.0	5	9.9	19.0	5	18.7	15.5	5	-	-	-	19.4	18.3	9
48	11.5	13.5	5	9.1	14.4	5	15.5	7.0	5	-	-	-	13.6	14.8	9
49	14.4	13.5	5	9.8	14.4	5	15.4	7.0	5	-	-	-	13.6	14.8	9
50	13.4	7.5	5	5.6	9.0	5	9.7	3.7	5	-	-	-	10.4	14.2	6
51	17.5	20.0	5	12.4	19.0	5	19.0	14.6	9	-	-	-	16.8	14.2	9
	Yuma - Traverse 2														
1	27.2	30.0	5	19.0	25.0	5	19.2	21.0	9	-	-	-	19.9	14.6	9
2	23.2	30.0	5	18.5	25.0	5	19.2	21.0	9	-	-	-	19.9	14.6	9

(Continued)

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Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Yuma - Traverse 3								
1	12.6	20.0	5	13.2	19.0	5	14.3	15.5	5	-	-	-	14.0	14.0	9
2	21.4	30.0	5	23.6	25.0	5	22.9	21.0	9	-	-	-	13.6	14.6	9
3	9.9	10.0	5	7.1	10.5	9	8.9	4.9	5	-	-	-	7.2	10.6	9
4	16.6	30.0	5	13.0	25.0	5	12.5	21.4	9	-	-	-	14.9	16.2	9
5	11.8	13.5	5	8.7	14.4	5	12.0	7.0	5	-	-	-	12.1	15.2	9
6	10.1	13.5	5	8.4	14.4	5	12.1	7.0	5	-	-	-	11.5	14.3	9
7	22.2	30.0	5	17.5	25.0	5	20.5	21.0	9	-	-	-	21.2	14.6	9
8	14.2	30.0	5	14.5	25.0	5	18.6	21.0	9	-	-	-	20.6	14.6	9
9	10.8	6.3	5	8.4	7.5	5	9.4	3.1	5	-	-	-	10.2	13.2	9
10	18.1	20.0	5	15.2	19.0	5	17.2	15.5	5	-	-	-	18.1	14.6	9
11	10.5	13.5	5	8.1	14.4	5	12.0	7.0	5	-	-	-	11.2	10.3	9
12	22.6	11.8	7	14.5	12.1	7	19.8	14.4	7	-	-	-	18.1	14.4	7
13	10.9	7.5	5	9.0	9.0	5	10.5	3.7	5	-	-	-	11.1	13.8	9
14	22.9	30.0	5	18.6	33.3	7	15.0	21.0	9	-	-	-	22.9	14.6	9
15	9.8	10.0	5	9.2	11.3	5	10.9	4.9	5	-	-	-	8.1	12.9	9
16	17.8	30.0	5	16.2	25.0	5	17.7	21.4	9	-	-	-	19.8	16.2	9
17	14.3	13.5	5	11.6	14.4	5	13.5	7.0	5	-	-	-	12.6	14.7	9
18	8.5	13.5	5	8.3	14.4	5	9.8	7.0	5	-	-	-	10.4	13.6	9
19	21.5	30.0	5	19.0	25.0	5	20.4	21.0	9	-	-	-	21.8	14.6	9
20	10.1	13.5	5	8.1	12.4	8	10.1	5.6	8	-	-	-	9.5	7.1	8
21	23.1	30.0	5	15.4	33.3	7	17.7	21.0	9	-	-	-	17.2	14.6	9
22	27.5	30.0	5	22.2	32.9	7	21.6	21.4	9	-	-	-	23.0	16.2	9
23	44.6	30.0	5	29.6	33.3	7	25.4	21.0	9	-	-	-	28.4	16.2	9
							Yuma - Traverse 4								
1	15.9	30.0	5	17.2	25.0	5	19.7	21.8	6	-	-	-	19.5	18.3	9
2	17.0	20.0	5	15.0	19.0	5	16.7	15.5	5	-	-	-	16.2	17.2	9

(Continued)

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Table 7 (Continued)

Terrain Unit No.	M151 Meas	M151 Pred	M151 FCS*	M35A2 Meas	M35A2 Pred	M35A2 FCS	M113A1 Meas	M113A1 Pred	M113A1 FCS	M48 Meas	M48 Pred	M48 FCS	M60 Meas	M60 Pred	M60 FCS
Yuma - Traverse 4 (Continued)															
3	16.2	20.0	5	15.3	19.0	5	16.0	15.5	5	-	-	-	15.7	17.2	9
4	21.4	30.0	5	18.2	25.0	5	19.0	21.7	9	-	-	-	18.0	17.9	9
5	18.3	30.0	5	18.7	25.0	5	19.7	21.8	6	-	-	-	20.2	18.3	9
Yuma - Traverse 5															
1	13.9	20.0	5	12.8	19.0	5	18.3	15.5	5	-	-	-	-	-	-
2	12.1	5.5	10	11.3	7.7	10	15.1	8.7	10	-	-	-	-	-	-
3	4.1	7.5	5	8.0	9.0	5	11.5	3.7	5	-	-	-	-	-	-
4	11.5	13.5	5	8.2	14.4	5	12.4	7.0	5	-	-	-	-	-	-
5	15.6	20.0	5	11.5	17.7	6	14.2	15.5	5	-	-	-	-	-	-
6	17.1	20.0	5	14.4	19.0	5	17.8	15.5	5	-	-	-	-	-	-
7	14.4	13.5	5	12.8	14.4	5	12.0	7.0	5	-	-	-	-	-	-
8	13.0	13.5	5	8.4	12.1	9	9.3	7.0	5	-	-	-	-	-	-
Eglin - Traverse 1															
1	7.6	18.2	7	8.8	16.9	9	12.7	20.0	9	-	-	-	-	-	-
2	6.4	10.2	8	7.1	12.4	9	10.3	12.5	9	-	-	-	-	-	-
3	13.4	20.0	5	10.3	19.0	5	4.2	15.5	5	-	-	-	-	-	-
4	9.7	24.5	8	9.2	14.1	8	9.6	17.4	8	-	-	-	-	-	-
5	14.3	9.4	8	5.6	7.3	8	10.9	7.4	8	-	-	-	-	-	-
6	11.1	18.3	8	10.5	14.8	8	12.0	12.5	8	-	-	-	-	-	-
7	9.6	15.0	8	5.4	14.5	9	7.5	15.1	9	-	-	-	-	-	-
8	8.9	25.3	8	5.4	16.8	9	10.1	17.5	8	-	-	-	-	-	-
9	12.3	15.0	8	8.8	14.5	9	12.0	15.1	9	-	-	-	-	-	-
10	9.0	25.3	8	6.6	17.2	9	10.2	17.6	8	-	-	-	-	-	-
11	11.0	24.5	9	6.6	15.4	9	9.7	15.7	9	-	-	-	-	-	-

(Continued)

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Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
						Eglin - Traverse 2									
1	7.2	16.6	7	5.8	16.2	9	9.5	21.6	9	-	-	-	-	-	-
2	17.7	20.0	5	11.1	19.0	5	12.4	15.5	5	-	-	-	-	-	-
3	12.5	20.0	5	8.2	15.8	9	12.2	15.5	5	-	-	-	-	-	-
4	7.8	24.1	8	3.7	13.7	9	9.1	17.5	8	-	-	-	-	-	-
5	9.9	24.1	8	5.9	13.7	9	10.6	17.5	8	-	-	-	-	-	-
6	9.0	14.5	8	4.9	8.8	9	8.1	11.3	9	-	-	-	-	-	-
7	15.7	20.0	5	11.5	19.0	5	13.6	15.5	5	-	-	-	-	-	-
8	7.5	30.0	5	4.0	13.7	9	9.2	17.5	8	-	-	-	-	-	-
9	5.5	14.7	8	3.4	7.9	8	8.2	9.8	9	-	-	-	-	-	-
10	5.9	15.8	8	3.8	10.8	9	8.6	15.0	9	-	-	-	-	-	-
11	6.3	10.3	9	6.3	13.2	7	10.4	18.4	7	-	-	-	-	-	-
12	8.4	23.6	9	6.9	17.0	9	10.7	19.2	9	-	-	-	-	-	-
13	8.3	26.8	7	7.6	14.2	8	10.9	18.9	-	-	-	-	-	-	-
14	8.1	17.5	7	6.5	18.4	7	9.6	21.8	9	-	-	-	-	-	-
15	5.2	5.7	10	4.1	16.7	9	10.7	21.7	9	-	-	-	-	-	-
16	8.2	24.7	7	7.7	26.4	7	14.1	40.0	5	-	-	-	-	-	-
						Eglin - Traverse 3									
1	13.6	19.2	7	11.2	20.0	7	15.7	21.4	9	-	-	-	-	-	-
2	7.5	25.7	8	7.4	16.3	8	11.3	17.9	8	-	-	-	-	-	-
3	7.0	25.3	8	6.2	17.2	9	11.0	19.4	9	-	-	-	-	-	-
4	7.0	24.7	8	6.3	14.1	8	10.5	18.6	8	-	-	-	-	-	-
5	8.8	16.8	8	7.9	15.4	9	11.6	15.7	9	-	-	-	-	-	-
6	9.6	22.2	9	7.8	14.9	9	10.8	15.6	9	-	-	-	-	-	-
7	5.6	25.3	8	7.4	16.8	9	10.7	17.6	8	-	-	-	-	-	-
8	8.7	11.1	8	6.7	16.6	8	12.2	15.5	5	-	-	-	-	-	-

(Continued)

Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
					Eglin - Traverse 3 (Continued)										
[illegible]	12.4	24.5	8	7.5	14.1	8	11.6	17.4	8	-	-	-	-	-	-
10	8.7	20.0	5	8.6	16.1	9	12.3	15.1	9	-	-	-	-	-	-
					Houghton - Traverse 1										
1	[illegible]4.0	19.9	7	19.0	19.0	5	18.9	15.5	5	15.4	14.3	6	-	-	-
2	16.0	20.6	7	13.5	21.3	7	17.5	20.0	9	14.6	13.1	6	-	-	-
3	16.2	19.9	7	13.4	19.0	5	17.8	15.5	5	12.6	14.3	6	-	-	-
4	6.7	6.8	7	6.8	7.0	7	10.9	8.5	7	11.0	12.0	9	-	-	-
5	19.2	30.0	5	17.1	25.0	5	16.6	21.4	9	13.9	12.0	9	-	-	-
6	7.6	8.1	8	9.6	9.1	7	12.6	11.1	7	11.8	11.8	9	-	-	-
7	9.8	30.0	5	8.7	25.0	5	9.8	21.1	9	10.2	10.5	9	-	-	-
8	7.8	10.0	10	5.4	11.4	7	9.5	14.3	9	9.7	10.8	9	-	-	-
9	4.4	5.6	8	3.7	6.6	7	6.9	8.4	7	6.5	11.8	8	-	-	-
					Houghton - Traverse 2										
1	6.0	12.4	8	3.8	8.5	9	5.3	7.0	5	2.4	4.6	9	-	-	-
2	5.4	9.9	10	3.2	10.6	8	5.4	10.7	9	6.6	5.4	8	-	-	-
3	3.2	10.1	10	3.7	14.4	5	5.8	7.0	5	11.6	28.6	6	-	-	-
4	4.9	3.8	10	2.6	7.4	7	7.7	8.6	7	9.9	5.9	9	-	-	-
5	5.5	12.3	8	2.9	7.6	9	4.6	3.5	9	2.3	1.6	9	-	-	-
6	5.0	5.2	10	3.6	12.8	8	7.2	11.7	9	7.9	9.4	9	-	-	-
7	3.9	4.8	8	-	-	-	8.4	6.2	9	7.9	8.2	9	-	-	-
8	6.2	10.1	10	-	-	-	8.6	7.0	5	7.4	10.0	9	-	-	-
9	5.4	7.7	8	-	-	-	7.3	7.0	5	8.3	10.3	9	-	-	-
10	6.2	4.3	8	12.2	4.8	7	11.1	5.6	7	9.6	12.0	8	-	-	-

(Continued)

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Table 7 (Continued)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
							Houghton - Traverse 3								
1	5.2	11.9	10	-	-	-	6.6	7.0	5	3.4	8.9	8	-	-	-
2	4.8	5.0	8	-	-	-	5.6	3.9	8	[illegible]	9.7	8	-	-	-
3	4.7	8.0	8	-	-	-	4.3	8.3	8	5.4	5.4	8	-	-	-
4	4.0	4.2	8	-	-	-	5.8	3.7	5	4.8	9.8	8	-	-	-
5	5.5	5.4	8	-	-	-	6.5	3.9	8	3.5	6.2	8	-	-	-
6	12.6	6.9	7	-	-	-	15.9	7.0	5	10.9	8.5	7	-	-	-
7	5.0	11.1	10	-	-	-	8.3	7.0	5	7.6	16.2	9	-	-	-
8	4.2	9.9	8	-	-	-	5.7	7.0	5	6.5	10.8	8	-	-	-
							Fort Knox - Traverse 1								
1	8.3	17.3	10	4.8	14.9	9	[illegible]	17.5	8	-	-	-	-	-	-
2	8.0	15.5	10	4.7	9.2	9	8.4	10.8	9	-	-	-	-	-	-
3	8.5	23.0	9	4.5	8.1	8	10.5	11.7	9	-	-	-	-	-	-
4	8.7	23.8	8	5.2	12.4	9	10.4	17.5	8	-	-	-	-	-	-
5	13.1	20.0	5	7.0	2.5	9	11.7	10.7	9	-	-	-	-	-	-
5A	14.9	16.5	7	7.7	3.3	9	14.7	12.6	9	-	-	-	-	-	-
6	15.8	23.3	7	6.4	3.5	6	15.7	13.2	6	-	-	-	-	-	-
7	5.6	9.0	10	5.1	1.7	8	9.6	7.7	9	-	-	-	-	-	-
8	17.0	23.0	7	10.2	3.5	6	15.6	13.2	6	-	-	-	-	-	-
9	21.6	20.0	5	13.2	15.9	9	19.5	15.5	5	-	-	-	-	-	-
							Fort Knox - Traverse 2								
1	10.7	13.5	5	6.8	14.1	9	12.4	7.0	5	-	-	-	-	-	-
2	7.2	6.3	5	[illegible]	7.5	5	10.2	3.1	5	-	-	-	-	-	-
3	15.2	20.0	5	11.1	19.0	5	18.9	15.5	5	-	-	-	-	-	-
4	8.2	10.0	5	7.1	11.3	5	10.8	4.9	5	-	-	-	-	-	-

(Continued)

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Table 7 (Concluded)

Terrain Unit No.	Vehicle														
	M151			M35A2			M113A1			M48			M60		
	Meas	Pred	FCS*	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS	Meas	Pred	FCS
				Fort Knox - Traverse 2 (Continued)											
5	9.2	6.3	5	6.1	7.5	5	10.0	3.1	5	-	-	-	-	-	-
6	6.4	18.4	8	4.4	16.1	9	10.3	14.3	8	-	-	-	-	-	-
7	8.5	13.5	5	4.8	11.2	9	7.7	7.0	5	-	-	-	-	-	-
8	18.6	30.0	5	15.6	24.9	6	17.3	28.9	6	-	-	-	-	-	-
9	8.9	16.9	9	5.2	15.3	8	10.5	12.5	8	-	-	-	-	-	-
10	7.1	7.5	8	3.9	12.4	8	10.0	7.0	5	-	-	-	-	-	-
11	6.7	12.3	8	6.3	12.4	9	8.7	7.0	5	-	-	-	-	-	-
12	7.4	9.1	8	6.5	10.6	9	8.0	4.9	5	-	-	-	-	-	-
13	7.4	12.3	8	5.3	12.5	8	11.6	5.6	8	-	-	-	-	-	-
14	12.8	13.5	5	9.0	14.4	5	13.4	9.0	5	-	-	-	-	-	-
15	16.9	20.0	5	12.6	18.4	9	14.3	15.5	5	-	-	-	-	-	-

(Sheet 11 of 11)

Table 8

Vehicle Speed Data, Traverse Tests (Specific Terrain Values)

Traverse No.	Location	Distance Miles	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
			M151		
1	FS	2.15	17.0	13.4	3.6
2	FS	1.54	22.4	22.0	0.4
3	FS	1.28	14.4	11.4	3.0
4	FS	1.00	24.3	18.9	5.4
1	YPG	3.76	11.8	12.4	-0.6
2	YPG	0.55	29.0	25.2	3.8
3	YPG	1.70	19.8	17.0	2.8
4	YPG	1.14	23.9	17.4	6.5
5	YPG	1.25	14.1	13.5	0.6
1	EAFB	0.73	19.4	8.9	10.5
2	EAFB	1.07	19.6	8.0	11.6
3	EAFB	0.68	21.0	8.4	12.6
1	HTN	0.86	11.1	11.1	0.0
2	HTN	0.77	6.0	5.0	1.0
3	HTN	0.57	7.8	5.2	2.6
1	FK	2.69	19.7	10.8	8.9
2	FK	2.22	8.8	8.8	0.0
			M35A2		
1	FS	2.15	16.7	12.4	4.3
2	FS	1.54	21.1	17.8	3.3
3	FS	1.28	15.1	10.0	5.1
4	FS	1.00	22.8	16.2	6.6
1	YPG	3.76	14.6	10.1	4.5
2	YPG	0.55	25.4	18.8	6.6
3	YPG	1.70	21.7	14.2	7.5
4	YPG	1.14	21.5	16.8	4.7
5	YPG	1.25	14.1	11.1	3.0
1	EAFB	0.73	15.0	7.4	7.6
2	EAFB	1.07	14.9	5.5	9.4
3	EAFB	0.68	15.7	7.6	8.1

(Continued) (Sheet 1 of 3)

Table 8 (Continued)

Traverse No.	Location	Distance Miles	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
		M35A2 (Continued)			
1	HTN	0.86	12.5	9.7	2.8
2	HTN	0.77	11.0	4.1	6.9
1	FK	2.69	6.5	6.0	0.5
2	FK	2.22	9.3	6.2	3.1
		M113A1			
1	FS	2.15	15.3	18.3	-3.0
2	FS	1.54	19.8	19.1	0.7
3	FS	1.28	14.4	14.1	0.3
4	FS	1.00	21.2	20.0	1.2
1	YPG	3.76	9.8	14.6	-4.8
2	YPG	0.55	21.3	19.2	2.1
3	YPG	1.70	11.8	16.1	-4.3
4	YPG	1.14	18.7	18.2	0.5
5	YPG	1.25	13.3	11.1	2.2
1	EAFB	0.73	16.3	10.4	5.9
2	EAFB	1.07	17.5	9.8	7.7
3	EAFB	0.68	17.9	11.7	6.2
1	HTN	0.86	13.2	13.8	-0.6
2	HTN	0.77	9.5	7.3	2.2
3	HTN	0.57	5.2	6.8	-1.6
1	FK	2.69	14.9	13.2	1.7
2	FK	2.22	6.5	11.6	-5.1
		M48			
1	FS	2.15	18.2	17.7	0.5
2	FS	1.54	21.6	19.7	1.9
3	FS	1.28	17.0	12.6	4.4
4	FS	1.00	21.4	20.3	1.1
1	HTN	0.86	12.8	12.0	0.8
2	HTN	0.77	9.3	7.1	2.2
3	HTN	0.57	8.1	5.3	2.8

(Continued) (Sheet 2 of 3)

Table 8 (Concluded)

Traverse No.	Location	Distance Miles	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
			M60		
1	YPG	3.76	15.0	14.8	0.2
2	YPG	0.55	14.9	19.9	-5.0
3	YPG	1.70	14.9	16.5	-1.6
4	YPG	1.14	18.0	18.2	0.2

(Sheet 3 of 3)

Table 9

Summary Evaluation of Vehicle Speed Data, Traverse Tests (Specific Terrain Values)

Test Location	Vehicle	No. of Tests	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation
FS	M1151	4	0.4 to 5.4	3.1	3.1	18.9	3.6
	M35A2	4	3.3 to 6.6	4.8	4.8	34.0	5.0
	M113A1	4	- 3.0 to 1.2	-0.2	1.3	7.3	1.7
	M48	4	0.5 to 4.4	2.0	2.0	11.4	2.5
YPG	M151	5	- 0.6 to 6.5	2.6	2.9	17.0	3.6
	M35A2	5	3.0 to 7.5	5.3	5.3	37.3	5.5
	M113A1	5	- 4.8 to 2.2	-0.9	2.8	17.7	3.2
	M60	4	- 5.0 to 0.2	-1.6	1.8	10.3	2.6
EAFB	M151	3	10.5 to 12.6	11.6	11.6	131.7	11.6
	M35A2	3	7.6 to 9.4	8.4	8.4	123.5	8.4
	M113A1	3	5.9 to 7.7	6.6	6.6	62.3	6.6
HTN	M151	3	0.0 to 2.6	1.2	1.2	16.4	1.6
	M35A2	2	2.8 to 6.9	4.8	4.8	69.6	5.3
	M113A1	3	-1.6 to 2.2	0.0	1.5	16.1	1.6
	M48	3	0.8 to 2.8	1.9	1.9	24.7	2.1
FK	M151	2	0.0 to 8.9	4.5	4.5	45.9	6.3
	M35A2	2	0.5 to 3.1	1.8	1.8	29.5	2.2
	M113A1	2	-5.1 to 1.7	-1.7	3.4	27.4	3.8

Table 10

Vehicle Speed Data, Traverse Tests (Classed Terrain Values)

Traverse No.	Location	Distance Mile	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
			M151		
1	FS	2.15	18.5	13.4	5.1
2	FS	1.54	23.7	22.0	1.7
3	FS	1.28	15.2	11.4	3.8
4	FS	1.00	22.8	18.9	3.9
1	YPG	3.76	15.9	12.4	3.5
2	YPG	0.55	30.0	25.2	4.8
3	YPG	1.70	19.8	17.0	2.8
4	YPG	1.14	25.5	17.4	8.1
5	YPG	1.25	10.8	13.5	-2.7
1	EAFB	0.73	16.9	7.9	9.0
2	EAFB	1.07	17.7	8.0	9.7
3	EAFB	0.68	20.0	8.4	11.6
1	HTN	0.86	13.0	11.1	1.9
2	HTN	0.77	6.4	5.0	1.4
3	HTN	0.57	6.5	5.2	1.3
1	FK	2.69	18.9	10.8	8.1
2	FK	2.22	11.9	8.8	3.1
			M35A2		
1	FS	2.15	18.6	12.4	6.2
2	FS	1.54	22.0	17.8	4.2
3	FS	1.28	15.2	10.0	5.2
4	FS	1.00	19.4	16.2	3.2
1	YPG	3.76	16.1	10.1	6.0
2	YPG	0.55	25.0	18.8	6.2
3	YPG	1.70	19.8	14.2	5.6
4	YPG	1.14	22.5	16.8	5.7
5	YPG	1.25	12.2	11.1	1.1

(Continued)

Table 10 (Continued)

Traverse No.	Location	Distance Mile	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
			M35A2 (Continued)		
1	EAFB	0.73	14.7	7.4	7.3
2	EAFB	1.07	13.3	5.5	7.8
3	EAFB	0.68	16.3	7.6	8.7
1	HTN	0.86	13.4	9.7	3.7
2	HTN	0.43	8.3	4.1	4.2
1	FK	2.69	5.3	6.0	-0.7
2	FK	2.22	12.7	6.2	6.5
			M113A1		
1	FS	2.15	15.8	18.3	-2.5
2	FS	1.54	20.8	19.1	1.7
3	FS	1.28	14.7	14.1	0.6
4	FS	1.00	18.5	20.0	-1.5
1	YPG	3.76	10.2	14.6	-4.4
2	YPG	0.55	21.0	19.2	1.8
3	YPG	1.70	12.1	16.1	-4.0
4	YPG	1.14	19.1	18.2	0.9
5	YPG	1.25	9.6	13.3	-3.7
1	EAFB	0.73	15.5	10.4	5.1
2	EAFB	1.07	16.6	9.8	6.8
3	EAFB	0.68	17.1	11.7	5.4
1	HTN	0.86	13.9	13.8	0.1
2	HTN	0.77	7.2	7.3	-0.1
3	HTN	0.57	5.3	6.8	-1.5
1	FK	2.69	13.0	13.2	-0.2
2	FK	2.22	6.8	11.6	-4.8
			M48		
1	FS	2.15	19.8	17.7	2.1
2	FS	1.54	22.9	19.7	3.2
3	FS	1.28	17.4	12.6	4.8
4	FS	1.00	19.9	20.3	-0.4

(Continued) (Sheet 2 of 3)

Table 10 (Concluded)

Traverse No.	Location	Distance Mile	Predicted Speed mph (P)	Measured Speed mph (M)	Deviation (P-M)
			M48 (Continued)		
1	HTN	0.86	12.7	12.0	0.7
2	HTN	0.77	7.9	7.1	0.8
3	HTN	0.50	8.6	5.3	-3.3
			M60		
1	YPG	3.76	14.1	14.8	-0.7
2	YPG	0.55	14.6	19.9	-5.3
3	YPG	1.70	14.4	16.5	-2.1
4	YPG	1.14	17.9	18.2	-0.3

(Sheet 3 of 3)

Table 11

Summary Evaluation of Vehicle Speed Data, Traverse Tests (Classed Terrain Values)

Test Location	Vehicle	No. of Tests	Range of Deviation mph	Mean Algebraic Deviation mph	Mean Absolute Deviation mph	Relative Deviation %	rms Deviation mph
FS	M151	4	1.7 to 5.1	3.6	3.6	22.0	3.8
	M35A2	4	3.2 to 6.2	4.7	4.7	33.3	4.8
	M113A1	4	-2.5 to 1.7	-0.4	1.6	8.9	1.7
	M48	4	-0.4 to 4.8	2.4	2.6	14.8	3.1
YPG	M151	5	-2.7 to 4.8	3.3	4.4	25.7	4.8
	M35A2	5	1.1 to 6.0	4.9	4.9	34.5	5.3
	M113A1	5	-4.4 to 1.8	-1.9	3.0	18.4	3.3
	M60	4	-5.3 to -0.3	-2.1	2.1	12.1	2.9
EAFB	M151	3	9.0 to 11.6	10.1	10.1	120.2	10.2
	M35A2	3	7.3 to 8.7	7.9	7.9	116.2	8.0
	M113A1	3	5.1 to 6.8	5.8	5.8	54.7	5.8
HTN	M151	3	1.3 to 1.9	1.5	1.5	21.1	1.6
	M35A2	2	3.7 to 4.2	4.0	4.0	58.0	4.0
	M113A1	3	-1.5 to 0.1	-0.5	0.6	6.5	0.9
	M48	3	0.7 to 3.3	1.6	1.6	19.8	2.0
FK	M151	2	3.1 to 8.1	5.6	5.6	57.1	6.1
	M35A2	2	-0.7 to 6.5	2.9	3.6	59.0	4.6
	M113A1	2	-4.8 to -0.2	-2.5	2.5	20.2	3.4

Table 12

Vehicle Performance Data, Drawbar-Pull Tests

Traverse and Terrain Unit No.	Predicted D/W_{20} (P)	Measured D/W_{20} (M)	Deviation (P-M)
Fort Sill			
M151			
0-1A	0.53	0.56	-0.03
0-2A	0.49	0.43	0.06
0-3A	0.44	0.42	0.02
0-4A	0.29	0.28	0.01
0-5A	0.24	0.13	0.11
0-6A	0.39	0.36	0.03
0-8A	0.57	0.61	-0.04
M35A2			
0-1B	0.53	0.52	0.01
0-2B	0.49	0.41	0.08
0-3B	0.43	0.37	0.06
0-4B	0.29	0.28	0.01
0-5B	0.25	0.25	0
0-6B	0.39	0.39	0
M113A1			
0-1C	0.63	0.63	0
0-2C	0.59	0.59	0
0-3C	0.52	0.53	-0.01
0-4C	0.38	0.38	0
0-5C	0.33	0.32	0.01
0-6C	0.48	0.48	0
0-7	0.66	0.78	-0.12
0-8B	0.67	0.69	-0.02
M48			
0-1A	0.62	0.63	-0.01
0-2A	0.58	0.60	-0.02
0-3A	0.52	0.49	0.03
0-4A	0.37	0.32	0.05
0-5A	0.33	0.28	0.05
0-6A	0.47	0.51	-0.04
0-8A	0.66	0.68	-0.02

(Continued)

Table 12 (Concluded)

Traverse and Terrain Unit No.	Predicted D/W_{20} (P)	Measured D/W_{20} (M)	Deviation (P-M)
	Yuma		
	M151		
0-49	0.42	0.44	-0.02
0-50	0.40	0.34	0.06
0-51	0.22	0.25	-0.03
0-52	0.42	0.35	0.07
	M35A2		
0-49	0.45	0.48	-0.03
0-50	0.44	0.37	0.07
0-51	0.25	0.26	-0.01
0-52	0.45	0.36	0.09
	M113A1		
0-49	0.50	0.47	0.03
0-50	0.50	0.40	0.10
0-51	0.50	0.35	0.15
0-52	0.50	0.36	0.14
	M60		
0-49	0.50	0.60	-0.10
0-50	0.50	0.51	-0.01
	Eglin		
	M35A2		
0-1	0.19	0.35	-0.16
0-2	0.18	0.32	-0.14
0-3	0.24	0.37	-0.13
	M113A1		
0-4	0.50	0.50	0
0-5	0.50	0.59	-0.09
0-6	0.50	0.55	-0.05
0-7	0.50	0.55	-0.05

Table 13

Vehicle Performance Data, Motion-Resistance Tests

Traverse and Terrain Unit No.	Predicted MR/W (P)	Measured MR/W (M)	Deviation (P-M)
	Fort Sill		
	M151		
0-1A	0.10	0.08	0.02
0-2A	0.13	0.15	-0.02
0-3A	0.19	0.19	0
0-4A	0.32	0.32	0
0-5A	0.36	0.41	-0.05
0-6A	0.23	0.24	-0.01
0-8A	0.06	0.06	0
	M35A2		
0-1B	0.10	0.10	0
0-2B	0.14	0.15	-0.01
0-3B	0.19	0.20	-0.01
0-4B	0.32	0.32	0
0-5B	0.36	0.36	0
0-6B	0.23	0.23	0
	M113A1		
0-1C	0.09	0.08	0.01
0-2C	0.12	0.14	-0.02
0-3C	0.19	0.19	0
0-4C	0.31	0.32	-0.01
0-5C	0.35	0.37	-0.02
0-6C	0.22	0.21	0.01
0-7	0.06	0.06	0
0-8B	0.05	0.05	0
	M48		
0-1A	0.10	0.10	0
0-2A	0.14	0.14	0
0-3A	0.19	0.18	0.01
0-4A	0.32	0.32	0
0-5A	0.36	0.41	-0.05
0-6A	0.23	0.24	-0.01
0-8A	0.06	0.06	0

(Continued)

(Sheet 1 of 3)

Table 13 (Continued)

Traverse and Terrain Unit No.	Predicted MR/W (P)	Measured MR/W (M)	Deviation (P-M)
	Yuma		
	M151		
0-49	0.03	0.05	-0.02
0-50	0.03	0.06	-0.03
0-51	0.08	0.08	0
0-52	0.03	0.04	-0.01
	M35A2		
0-49	0.04	0.06	-0.02
0-50	0.04	0.04	0
0-51	0.08	0.08	0
0-52	0.04	0.04	0
	M113A1		
0-49	0.10	0.06	0.04
0-50	0.10	0.07	0.03
0-51	0.10	0.10	0
0-52	0.10	0.06	0.04
	M60		
0-49	0.10	0.06	0.04
0-50	0.10	0.07	0.03
	Eglin		
	M151		
0-4	0.05	0.08	-0.03
0-5	0.13	0.10	0.03
0-6	0.13	0.09	0.04
0-7	0.10	0.09	0.01
0-17	0.11	0.10	0.01
	M35A2		
0-1	0.11	0.08	0.03
0-2	0.12	0.09	0.03
0-3	0.09	0.08	0.01
0-18	0.11	0.10	0.01

(Continued)

(Sheet 2 of 3)

Table 13 (Concluded)

Traverse and Terrain Unit No.	Predicted R/W (P)	Measured R/W (M)	Deviation (P-M)
	Eglin (Continued)		
	M113A1		
0-4	0.09	0.06	0.03
0-5	0.10	0.08	0.02
0-6	0.10	0.09	0.01
0-7	0.10	0.09	0.01

(Sheet 3 of 3)

Table 14

Vehicle Performance Data, Slope Tests

Terrain Unit No.	Location	% Slope	Measured Go	Measured No-Go	Predicted Go	Predicted No-Go	0-6 CI
M151 (15 psi)							
Gravel							
1	YPG	40.9		X		X	376
2	YPG	40.6		X		X	321
3	YPG	43.0		X		X	402
4	YPG	41.0		X		X	406
5	YPG	33.2	X		X		379
Sand							
16	YPG	14.8	X		X		112
17	YPG	10.0	X		X		160
18	YPG	12.1	X		X		124
20	YPG	18.3	X		X		123
21	YPG	25.2		X		X	103
53	YPG	12.1		X		X	30
2	HTN	23.9		X		X	110
M151 (7.5 psi)							
Sand							
28	YPG	25.4		X		X	39
37	YPG	31.5		X		X	17
38	YPG	20.0	X			X	36
40	YPG	23.0	X			X	56
M151 (30 psi)							
Gravel							
4	YPG	41.0		X		X	406
5	YPG	33.2	X			X	376
Sand							
16	YPG	14.8		X		X	112
17	YPG	10.0	X		X		160
18	YPG	12.1	X		X		124
41	YPG	8.5	X			X	68
42	YPG	14.5		X		X	66

(Continued) (Sheet 1 of 4)

Table 14 (Continued)

Terrain Unit No.	Location	% Slope	Measured Go	Measured No-Go	Predicted Go	Predicted No-Go	0-6 CI
			M151 (40 psi)				
			Gravel				
5	YPG	33.2		X		X	379
8	YPG	40.1		X		X	379
9	YPG	29.0		X		X	461
10	YPG	24.9	X		X		527
			Sand				
16	YPG	14.8		X		X	112
17	YPG	10.0	X		X		160
18	YPG	12.1		X		X	124
			M35A2 (15 psi)				
			Gravel				
3	YPG	43.0		X		X	402
4	YPG	41.0		X	X		406
5	YPG	33.2	X		X		379
			Sand				
16	YPG	14.8	X		X		112
19	YPG	25.2		X		X	85
20	YPG	18.3	X		X		123
21	YPG	24.3		X	X		103
24	YPG	43.0		X		X	31
25	YPG	19.5		X		X	26
26	YPG	11.7	X		X		56
28	YPG	25.4		X		X	39
30	YPG	17.0	X		X		50
53	YPG	12.1		X		X	30
2	HTN	23.9		X		X	110

(Continued) (Sheet 2 of 4)

Table 14 (Continued)

Terrain Unit No.	Location	% Slope	Measured Go	Measured No-Go	Predicted Go	Predicted No-Go	0-6 CI
			M35A2 (10 psi)				
			Sand				
37	YPG	31.5		X		X	17
38	YPG	20.0	X			X	36
39	YPG	26.0		X		X	42
40	YPG	23.0	X			X	56
			M35A2 (30 psi)				
			Gravel				
5	YPG	33.2		X		X	379
9	YPG	29.0		X	X		461
10	YPG	24.9	X		X		527
			Sand				
16	YPG	14.9		X	X		112
17	YPG	10.0	X		X		160
18	YPG	12.1	X		X		124
41	YPG	8.5	X		X		68
42	YPG	14.5		X		X	66
43	YPG	12.0		X		X	55
44	YPG	9.5		X		X	38
			M113A1				
			Gravel				
1	YPG	40.9	X		X		376
2	YPG	46.1	X		X		321
3	YPG	43.0	X		X		402
6	YPG	52.8	X		X		417
11	YPG	52.4	X		X		308
12	YPG	61.8		X	X		278
13	YPG	53.3	X		X		361

(Continued) (Sheet 3 of 4)

Table 14 (Concluded)

Terrain Unit No.	Location	% Slope	Measured Go	Measured No-Go	Predicted Go	Predicted No-Go	0-6 CI
			M113A1 (Continued)				
			Sand				
14	YPG	46.7	X		X		74
15	YPG	49.7		X	X		82
22	YPG	33.5	X		X		98
23	YPG	32.8	X		X		83
24	YPG	43.0		X	X		31
25	YPG	19.5	X		X		26
27	YPG	39.0	X		X		32
28	YPG	25.4	X		X		39
29	YPG	32.9	X		X		22
31	YPG	37.4	X		X		23
32	YPG	49.0		X	X		12
33	YPG	40.2		X	X		44
34	YPG	32.2	X		X		22
35	YPG	40.4		X	X		36
36	YPG	36.4	X		X		15
40	YPG	40.0	X		X		32
46	YPG	43.0	X		X		20
53	YPG	12.1	X		X		30
2	HTN	23.9	X		X		110
			M60				
			Gravel				
2	YPG	46.1	X		X		321
6	YPG	52.8		X	X		417
7	YPG	47.8		X	X		532
11	YPG	52.4		X	X		308
			Sand				
22	YPG	33.5		X	X		98
23	YPG	32.3	X		X		83

(Sheet 4 of 4)

Table 15

Vehicle Performance Data, Tree-Override Tests

Vehicle	Location	Stem Diameter, in.	Species	Test Results
M151	EAFB	2.9	Pine	Easy go
		3.0	Oak	Easy go
		3.2	Pine	Hard go
		3.2	Oak	Go
		3.3	Pine	Hard go
		3.4	Pine	No-go
		3.5	Oak	Hard go
		3.5	Oak	No-go
		3.9	Pine	No-go
		4.7	Oak	No-go
	HTN	1.8	Maple	Easy go
		2.5	Birch	Hard go
		2.5	Maple	Hard go
		3.0	Maple	Very hard go
		3.2	Maple	No-go
		3.5	Maple	No-go
M35A2	EAFB	10.2	Oak	Hard go
		11.2	Oak	No-go
M113A1	EAFB	9.5	Pine	Go
		9.8	Oak	Hard go
		10.2	Oak	Very hard go
		11.2	Oak	No-go
		12.0	Oak	No-go
	HTN	4.2	Maple	Easy go
		6.5	Maple	Easy go
		8.5	Maple	Hard go

Table 16

Vehicle Performance Data, Scale-Model Tests with M60 Tank on Triangular and Trapezoidal Mound Obstacles

Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
0.4	25-70	0.21	Go	Go	None	None
0.8	25-65	0.21	No-go	Go	Case 22-Traction*	None
0.8	70	0.21	No-go	No-go	Case 22-Traction	Traction
1.2	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
1.6	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
2.0	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
2.4	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.36	Go	Go	None	None
0.8	25-35	0.36	Go	Go	None	None
0.8	40-70	0.36	No-go	Go	Case 22-Traction	None
1.2	25-35	0.36	Go	Go	None	None
1.2	40	0.36	No-go	Go	Case 20-Traction	None
1.2	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
1.6	25-35	0.36	Go	Go	None	None
1.6	40	0.36	No-go	Go	Case 20-Traction	None
1.6	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
2.0	25-35	0.36	Go	Go	None	None
2.0	40	0.36	No-go	Go	Case 20-Traction	None
2.0	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
2.4	25-35	0.36	Go	Go	None	None
2.4	40	0.36	No-go	Go	Case 20-Traction	None
2.4	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.55	Go	Go	None	None
0.8	25-60	0.55	Go	Go	None	None
1.2	65-70	0.55	No-go	Go	Case 20-Traction	None
1.6	25-60	0.55	Go	Go	None	None
1.6	65-70	0.55	No-go	Go	Case 20-Traction	None
2.0	25-60	0.55	Go	Go	None	None
2.0	65-70	0.55	No-go	No-go	Case 20-Traction	Traction
2.4	25-55	0.55	Go	Go	None	None
2.4	60	0.55	Go	No-go	None	Traction
2.4	65-70	0.55	No-go	No-go	Case 20-Traction	Traction

Note: The predicted results and measured results were the same for triangular- and trapezoidal-shaped mound obstacles.

* All reasons for no-go shown here by case number are described in report referenced in first footnote, page 5, as Figures C-27 through C-49, i.e., Case 1 in this analysis refers to Figure C-27 in the referenced report, continuing through C-49 which refers to Case 23 in this analysis.

Table 17

Vehicle Performance Data, Scale-Model Test with M60 Tank on Triangular and Trapezoidal Trench Obstacles

Obstacles Height in.	Obstacles Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
0.4	25-70	0.21	Go	Go	None	None
0.8	25-55	0.21	No-go	Go	Case 23-Traction*	None
0.8	60-70	0.21	No-go	No-go	Case 23-Traction	Traction
1.2	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
1.6	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
2.0	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
2.4	25-70	0.21	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.36	Go	Go	None	None
0.8	25-35	0.36	Go	Go	None	None
0.8	40-70	0.36	No-go	Go	Case 22-Traction	None
1.2	25-35	0.36	Go	Go	None	None
1.2	40	0.36	No-go	Go	Case 22-Traction	None
1.2	45-70	0.36	No-go	No-go	Case 22-Traction	Traction
1.6	25-35	0.36	Go	Go	None	None
1.6	40	0.36	No-go	Go	Case 20-Traction	None
1.6	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
2.0	25-35	0.36	Go	Go	None	None
2.0	40	0.36	No-go	Go	Case 20-Traction	None
2.0	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
2.4	25-35	0.36	Go	Go	None	None
2.4	40	0.36	No-go	Go	Case 20-Traction	None
2.4	45-70	0.36	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.55	Go	Go	None	None
0.8	25-60	0.55	Go	Go	None	None
0.8	65-70	0.55	No-go	Go	Case 22-Traction	None
1.2	25-60	0.55	Go	Go	None	None
1.2	65-70	0.55	No-go	Go	Case 22-Traction	None
1.6	25-60	0.55	Go	Go	None	None
1.6	65-70	0.55	No-go	Go	Case 22-Traction	None
2.0	25-60	0.55	Go	Go	None	None
2.0	65-70	0.55	No-go	No-go	Case 20-Traction	Traction
2.4	25-55	0.55	Go	Go	None	None
2.4	60	0.55	Go	No-go	None	Traction
2.4	65-70	0.55	No-go	No-go	Case 20-Traction	Traction

Note: The predicted results and measured results were the same for triangular- and trapezoidal-shaped trench obstacles.

* Ibid., Table 16.

Table 18

Vehicle Performance Data, Scale-Model Tests With the M35A2 on Triangular Mound Obstacles

Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
0.4	25-70	0.12	Go	Go	None	None
0.8	25	0.12	Go	Go	None	None
0.8	30-70	0.12	Go	No-go	None	Traction
1.2	25	0.12	Go	Go	None	None
1.2	30-70	0.12	Go	No-go	None	Traction
1.6	25-70	0.12	No-go	No-go	Case 21-Traction*	Traction
2.0	25-70	0.12	No-go	No-go	Case 21-Traction	Traction
2.4	25-70	0.12	No-go	No-go	Case 21-Traction	Traction
0.4	25-70	0.27	Go	Go	None	None
0.8	25-35	0.27	Go	Go	None	None
0.8	40-70	0.27	Go	No-go	None	Traction
1.2	25-35	0.27	Go	Go	None	None
1.2	40-70	0.27	Go	No-go	None	Traction
1.6	25	0.27	Go	Go	None	None
1.6	30-70	0.27	No-go	No-go	Case 12	Hang-up
2.0	25	0.27	Go	Go	None	None
2.0	30-70	0.27	No-go	No-go	Case 12	Hang-up
2.4	25	0.27	Go	Go	None	None
2.4	30-70	0.27	No-go	No-go	Case 12	Hang-up
0.4	25-70	0.45	Go	Go	None	None
0.8	25-70	0.45	Go	Go	None	None
1.2	25-70	0.45	Go	Go	None	None
1.6	25	0.45	Go	Go	None	None
1.6	30-70	0.45	No-go	No-go	Case 12	Hang-up
2.0	25	0.45	Go	Go	None	None
2.0	30-70	0.45	No-go	No-go	Case 12	Hang-up
2.4	25	0.45	Go	Go	None	None
2.4	30-70	0.45	No-go	No-go	Case 12	Hang-up

Note: The top widths of all obstacles shown were equal to zero.
* *Ibid.*, Table 16.

Table 19

Vehicle Performance Data, Scale-Model Tests with M35A2 on Trapezoidal Mound Obstacles

Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
			Top Width of 1 in.			
0.4	25–70	0.27	Go	Go	None	None
0.8	25–35		Go	Go	None	None
0.8	40–70		Go	No-go	None	Traction
1.2	25–35		Go	Go	None	None
1.2	40–70		Go	No-go	None	Traction
1.6	25		Go	Go	None	None
1.6	30		Go	No-go	None	Hang-up
1.6	35–70		No-go	No-go	Case 12*	Hang-up
2.0	25		Go	Go	None	None
2.0	30		Go	No-go	None	Hang-up
2.0	35–70		No-go	No-go	Case 12	Hang-up
2.4	25		Go	Go	None	None
2.4	30		Go	No-go	None	Hang-up
2.4	35–70		No-go	No-go	Case 12	Hang-up
			Top Width of 2 in.			
0.4	25–70	0.27	Go	Go	None	None
0.8	25–35		Go	Go	None	None
0.8	40–70		Go	No-go	None	Traction
1.2	25–35		Go	Go	None	None
1.2	40–70		Go	No-go	None	Traction
1.6	25–30		Go	Go	None	None
1.6	35–40		Go	No-go	None	Hang-up
1.6	45–70		No-go	No-go	Case 12	Hang-up
2.0	25–30		Go	Go	None	None
2.0	35–40		Go	No-go	None	Hang-up
2.0	45–70		No-go	No-go	Case 12	Hang-up
2.4	35–40		Go	No-go	None	Hang-up
2.4	35–40		Go	No-go	None	Hang-up
2.4	45–70		No-go	No-go	Case 12	Hang-up
			Top Width of 3 in.			
0.4	25–70	0.27	Go	Go	None	None
0.8	25–35		Go	Go	None	None
0.8	40–70		Go	No-go	None	Traction
1.2	25–35		Go	Go	None	None
1.2	40–70		Go	No-go	None	Traction

(Continued)

* Ibid., Table 16

(Sheet 1 of 3)

Table 19 (Continued)

Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
			Top Width of 3 in. (Continued)			
1.6	25-35	0.27	Go	Go	None	None
1.6	40-45		Go	No-go	None	Traction
1.6	50-70		No-go	No-go	Case 12	Traction
2.0	25-35		Go	Go	None	None
2.0	40-45		Go	No-go	None	Traction
2.0	50-70		No-go	No-go	Case 12	Traction
2.4	25-35		Go	Go	None	None
2.4	40-45		Go	No-go	None	Traction
2.4	50-70		No-go	No-go	Case 12	Traction
			Top Width of 1 in.			
0.4	25-70	0.45	Go	Go	None	None
0.8	25-70		Go	Go	None	None
1.2	25-70		Go	Go	None	None
1.6	25		Go	Go	None	None
1.6	30		Go	No-go	None	Hang-up
1.6	35-70		No-go	No-go	Case 12	Hang-up
2.0	25		Go	Go	None	None
2.0	30		Go	No-go	None	Hang-up
2.0	35-70		No-go	No-go	Case 12	Hang-up
2.4	25		Go	Go	None	None
2.4	30		Go	No-go	None	Hang-up
2.4	35-70		No-go	No-go	Case 12	Hang-up
			Top Width of 2 in.			
0.4	25-70	0.45	Go	Go	None	None
0.8	25-70		Go	Go	None	None
1.2	25-70		Go	Go	None	None
1.6	25-30		Go	Go	None	None
1.6	35-40		Go	No-go	None	Hang-up
1.6	45-70		No-go	No-go	Case 12	Hang-up
2.0	25-30		Go	Go	None	None
2.0	35-40		Go	No-go	None	Hang-up
2.0	45-70		No-go	No-go	Case 12	Hang-up
2.4	25-30		Go	Go	None	None
2.4	35-40		Go	No-go	None	Hang-up
2.4	45-70		No-go	No-go	Case 12	Hang-up

(Continued) (Sheet 2 of 3)

Table 19 (Concluded)

Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
			Top Width of 3 in.			
0.4	25-70	0.45	Go	Go	None	None
0.8	25-70		Go	Go	None	None
1.2	25-70		Go	Go	None	None
1.6	25-40		Go	Go	None	None
1.6	45		Go	No-go	None	Traction
1.6	50-70		No-go	No-go	Case 12	Traction
2.0	25-40		Go	Go	None	None
2.0	45		Go	No-go	None	Traction
2.0	50-70		No-go	No-go	Case 12	Traction
2.4	25-40		Go	Go	None	None
2.4	45		Go	No-go	None	Traction
2.4	50-70		No-go	No-go	Case 12	Traction

(Sheet 3 of 3)

Table 20

Vehicle Performance Data, Scale-Model Tests with the M35A2 on Triangular and Trapezoidal Trench Obstacles

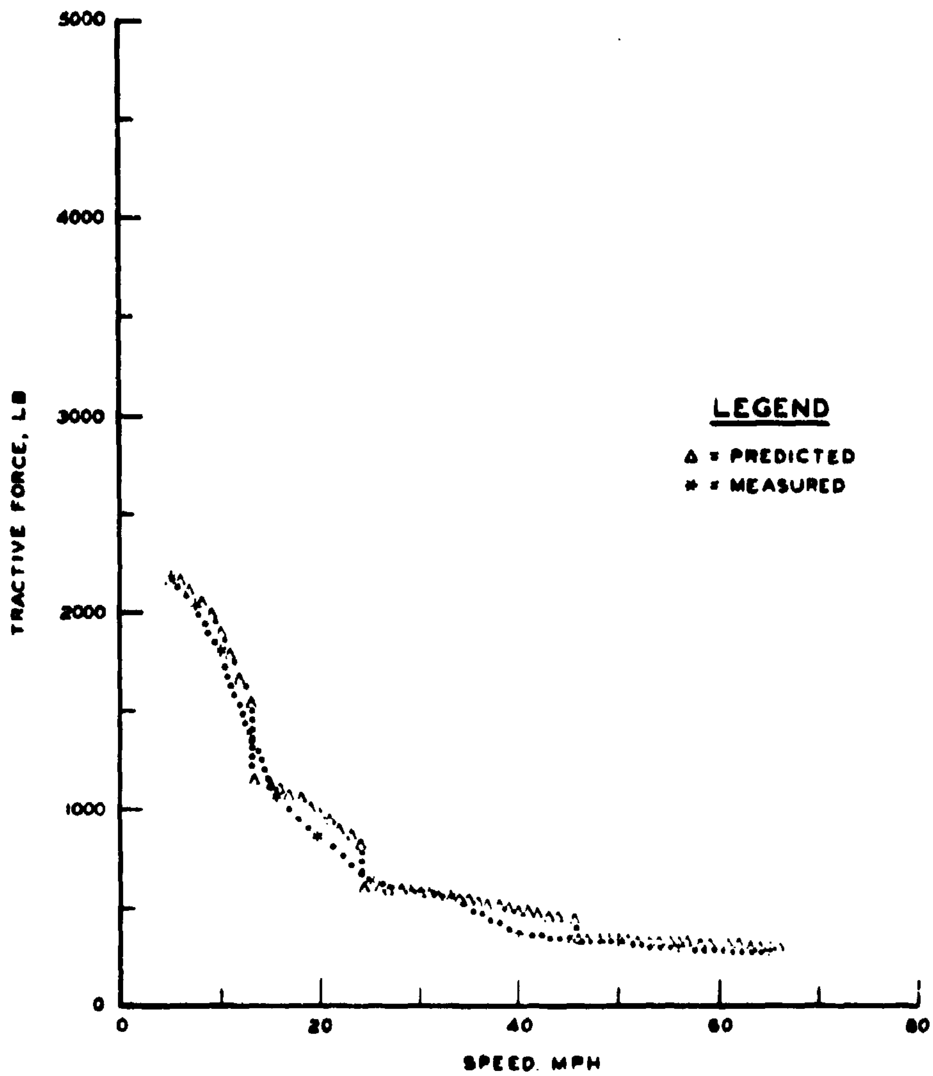
Obstacle Height in.	Obstacle Slope %	Tractive Coefficient	Test Results Predicted	Test Results Measured	Reasons for No-Go Predicted	Reasons for No-Go Measured
0.4	25-70	0.12	Go	Go	None	None
0.8	25-40	0.12	Go	Go	None	None
0.8	45-70	0.12	Go	No-go	None	Traction
1.2	25	0.12	Go	Go	None	None
1.2	30-70	0.12	Go	No-go	None	Traction
1.6	25-70	0.12	No-go	No-go	Case 20-Traction*	Traction
2.0	25-70	0.12	No-go	No-go	Case 20-Traction	Traction
2.4	25-70	0.12	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.27	Go	Go	None	None
0.8	25-45	0.27	Go	Go	None	None
0.8	50-70	0.27	Go	No-go	None	Traction
1.2	25-45	0.27	Go	Go	None	None
1.2	50-70	0.27	Go	No-go	None	Traction
1.6	25-45	0.27	Go	Go	None	None
1.6	50-70	0.27	No-go	No-go	Case 20-Traction	Traction
2.0	25-45	0.27	Go	Go	None	None
2.0	50-70	0.27	No-go	No-go	Case 20-Traction	Traction
2.4	25-45	0.27	Go	No-go	None	None
2.4	50-70	0.27	No-go	No-go	Case 20-Traction	Traction
0.4	25-70	0.45	Go	Go	None	None
0.8	25-70	0.45	Go	Go	None	None
1.2	25-70	0.45	Go	Go	None	None
1.6	25-70	0.45	Go	Go	None	None
2.0	25-45	0.45	Go	No-go	None	Traction
2.0	50-70	0.45	No-go	No-go	Case 20-Traction	Traction
2.4	25-45	0.45	Go	No-go	None	Traction
2.4	50-70	0.45	No-go	No-go	Case 20-Traction	Traction

Note: The bottom widths of all obstacles shown were equal to zero.
* *Ibid.*, Table 16.

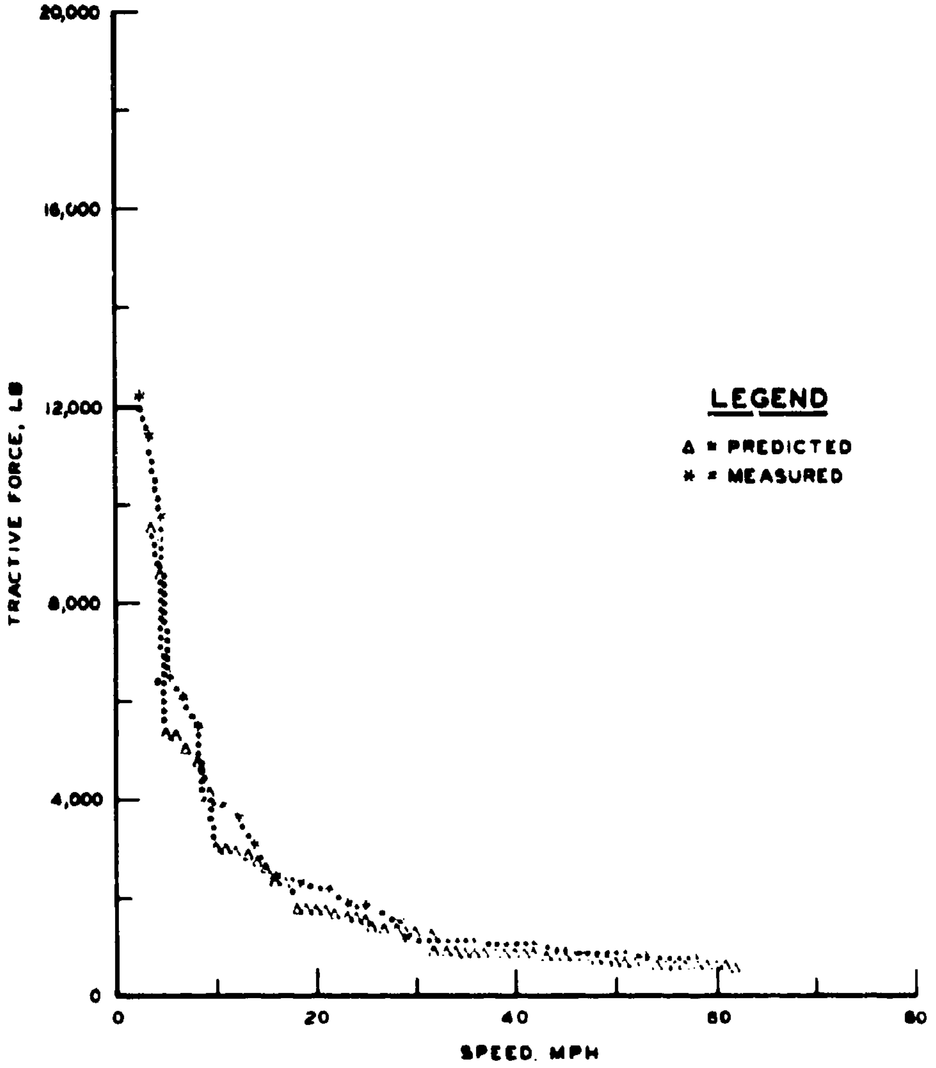
Table 21

Vehicle Performance Data, Scale-Model Slope Tests

Vehicle	Tractive Coefficient	Predicted Go % Slope	Predicted No-Go % Slope	Measured Go % Slope	Measured No-Go % Slope
M60	0.21	17	18	20	21
	0.35	33	34	33	34
	0.55	54	55	53	54
M35A2	0.12	8	9	11	12
	0.27	24	25	26	27
	0.45	46	47	43	44

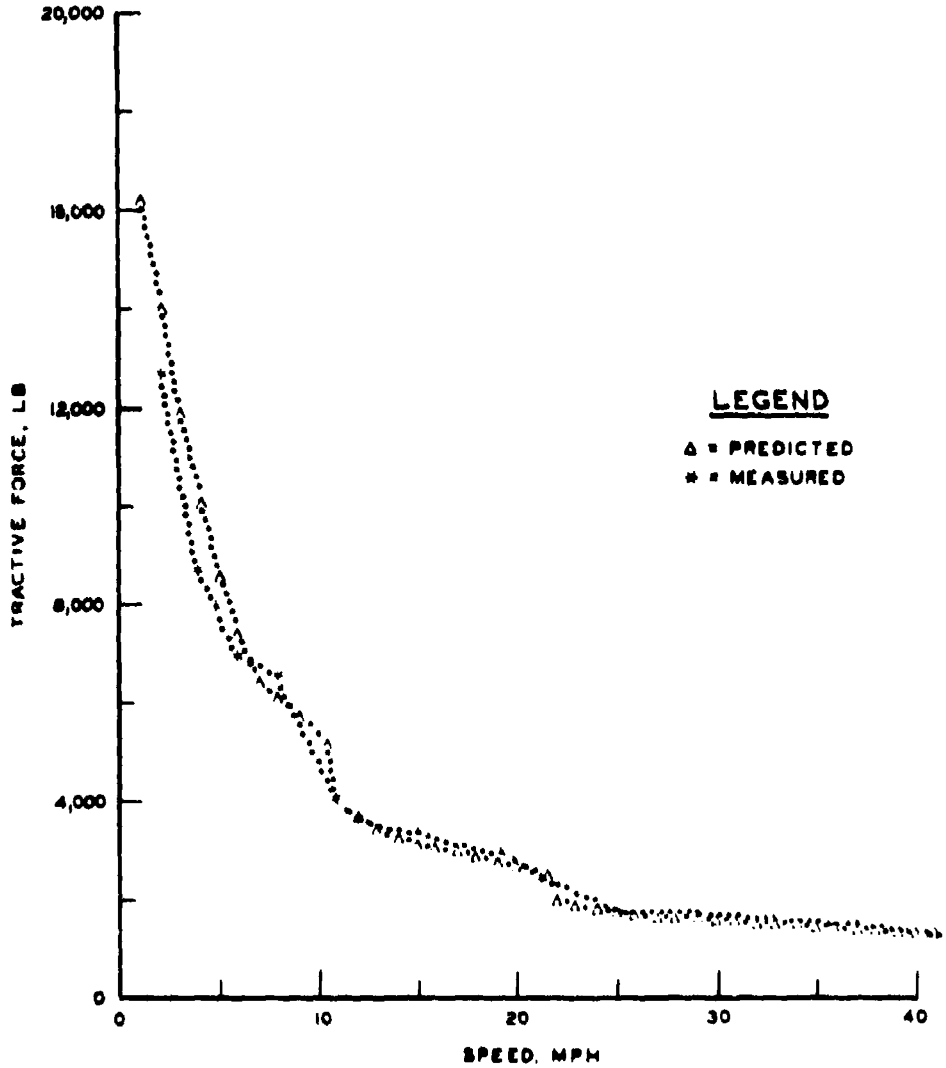


TRACTIVE FORCE VERSUS
SPEED FOR THE M151

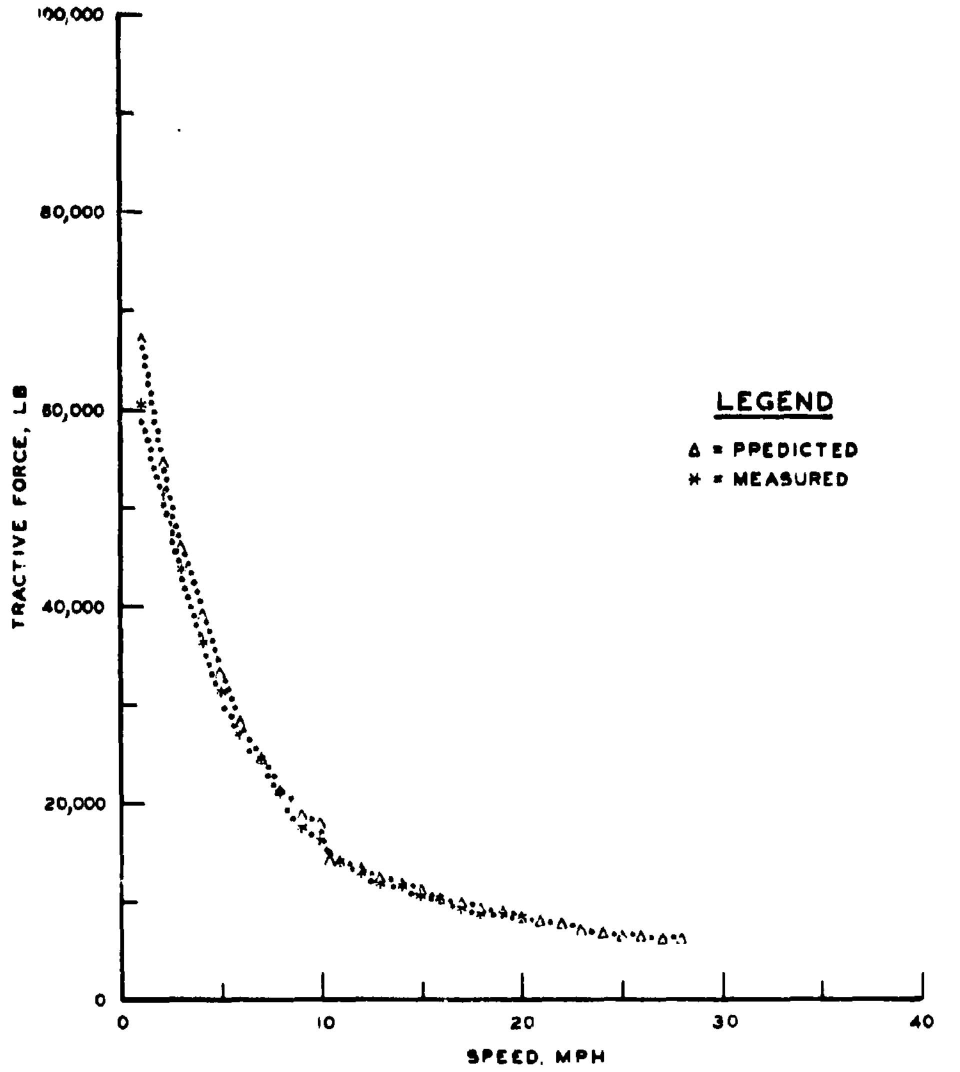


TRACTIVE FORCE VERSUS
SPEED FOR THE M35A2

PLATE 2

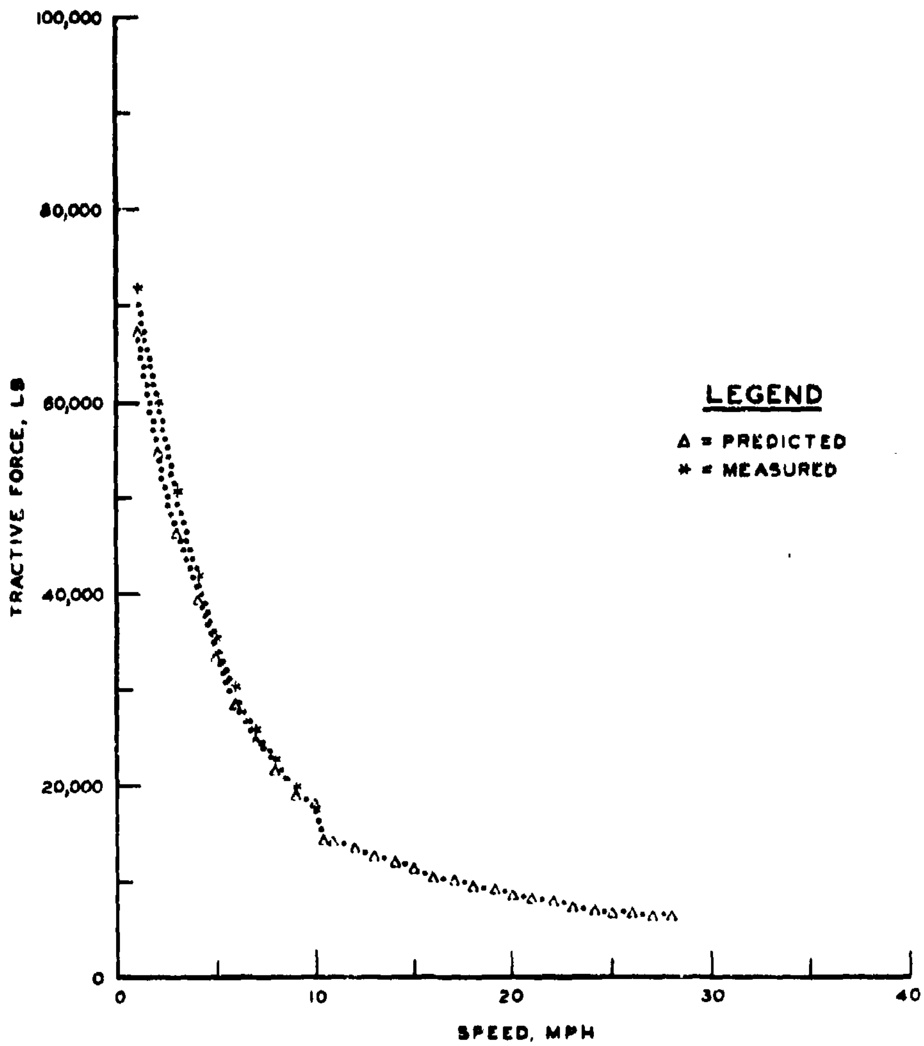


TRACTIVE FORCE VERSUS
SPEED FOR THE M113A1

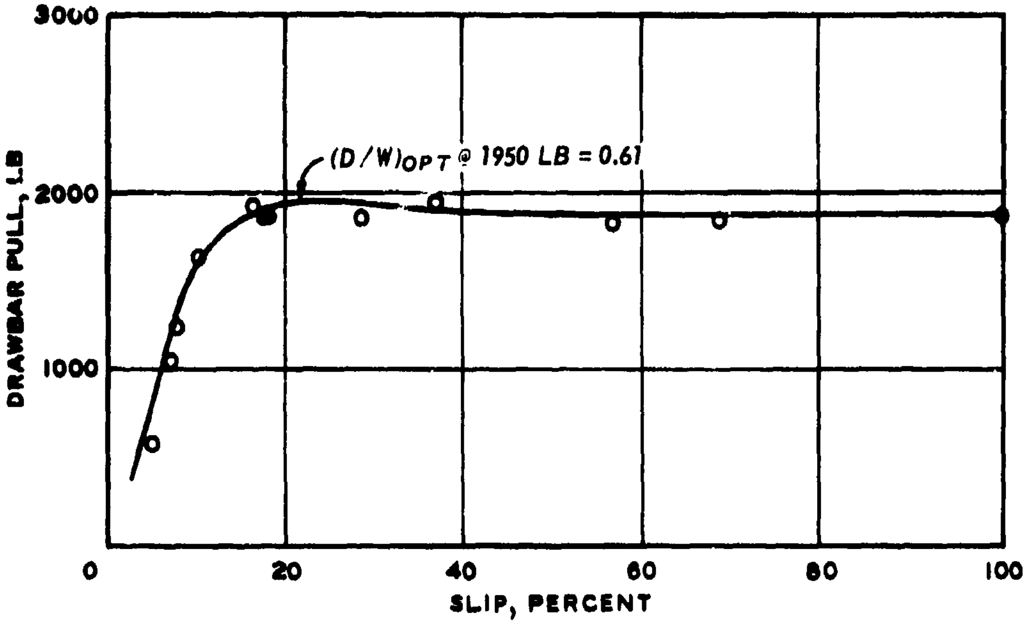


TRACTIVE FORCE VERSUS SPEED FOR THE M48

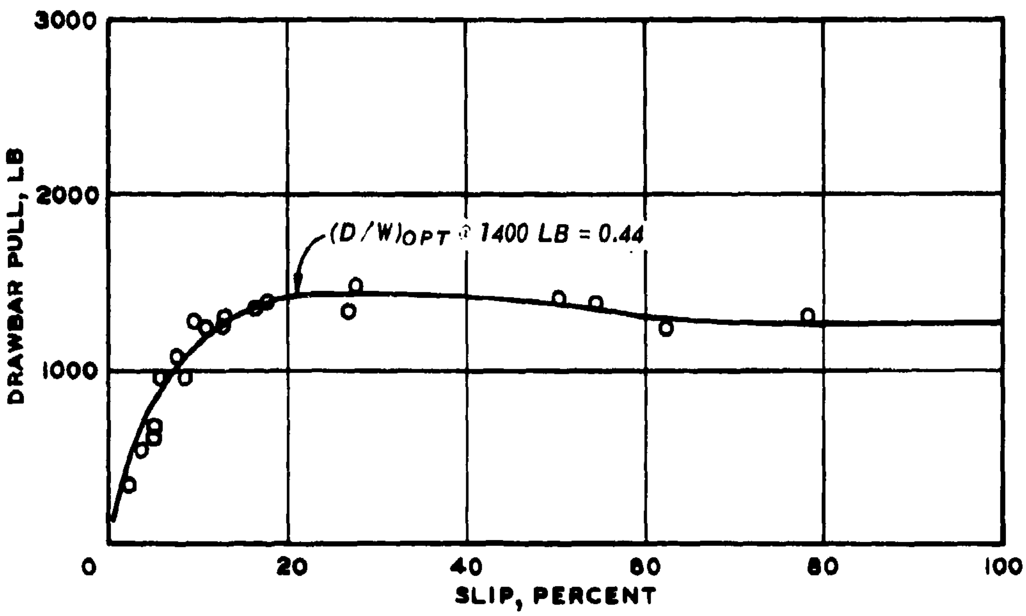
PLATE 4



TRACTIVE FORCE VERSUS SPEED FOR THE M60

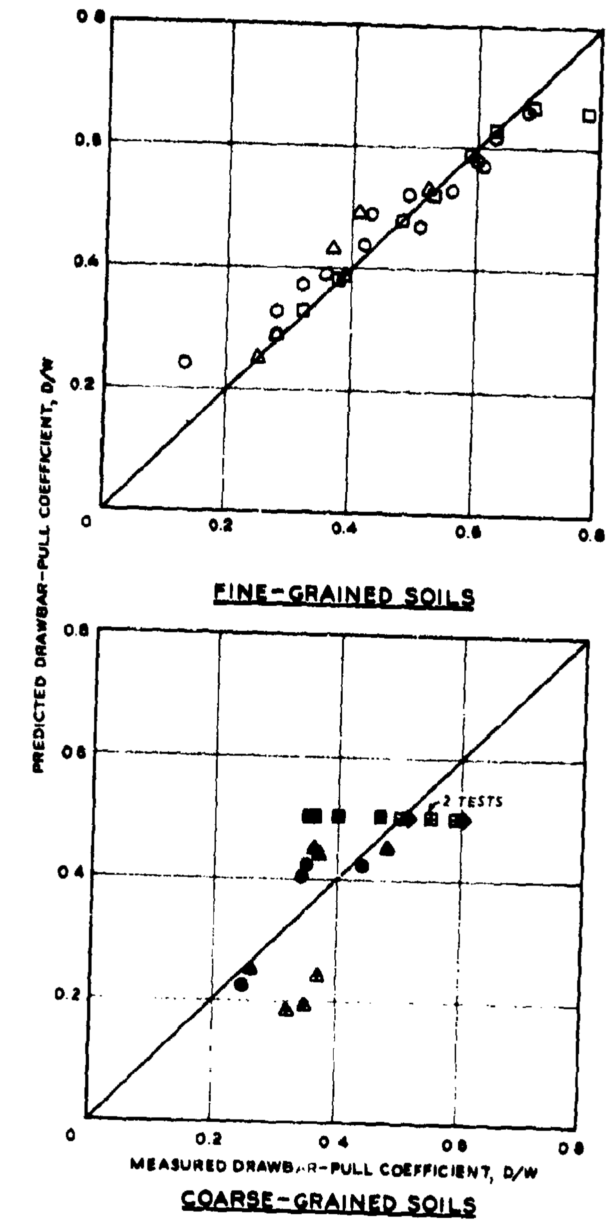


a. M151, TERRAIN UNIT 8A, FORT SILL



b. M151, TERRAIN UNIT 49, YUMA

DRAWBAR-PULL VERSUS SLIP

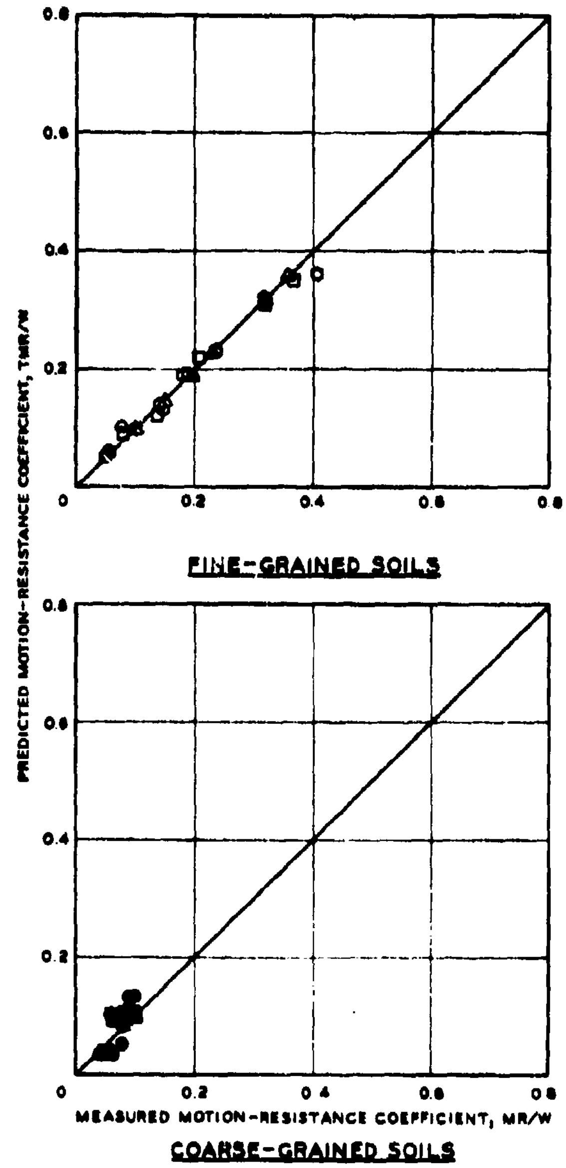


LEGEND

- ○ M151
- △ M35A2
- □ M113A1
- ○ M48
- ◇ M60

NOTE: OPEN SYMBOLS ARE FORT SILL TESTS
CLOSED SYMBOLS ARE YUMA TESTS
PLUS (+) SYMBOLS ARE EGLIN TESTS

COMPARISON OF PREDICTED AND MEASURED DRAWBAR-PULL COEFFICIENTS

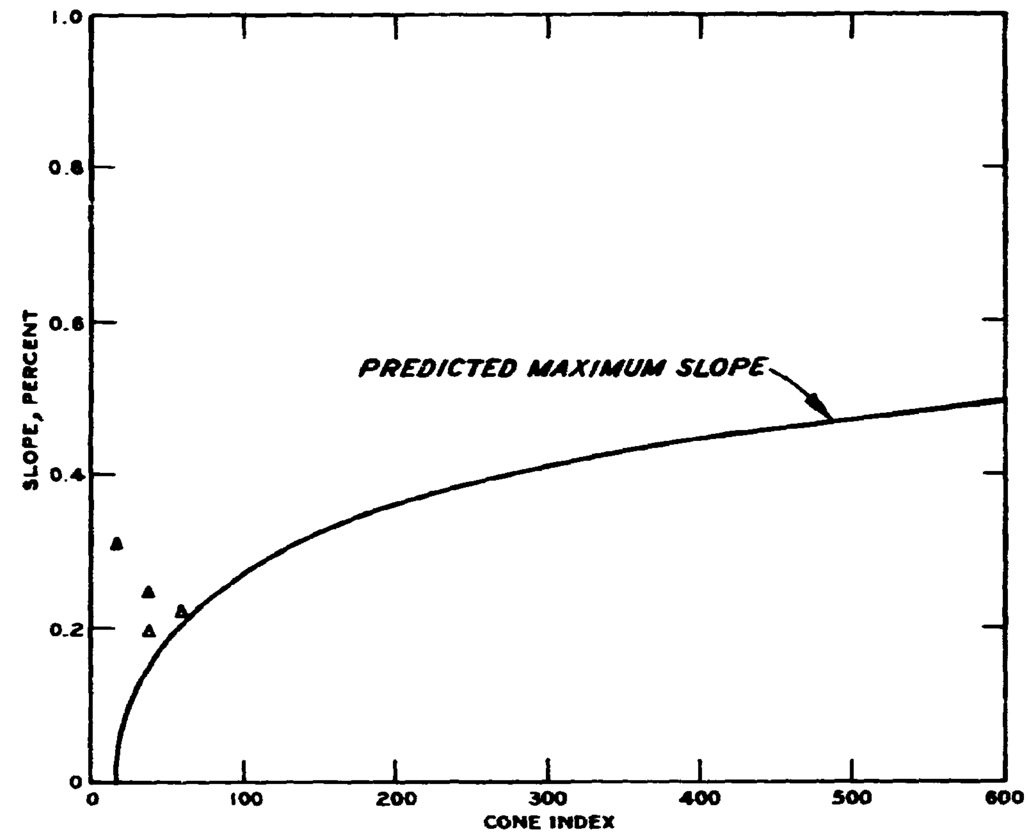


LEGEND

- ○ M151
- △ M35A2
- □ M113A1
- ○ M48
- ◇ M60

NOTE: OPEN SYMBOLS ARE FORT SILL TESTS
CLOSED SYMBOLS ARE YUMA TESTS
PLUS (+) SYMBOLS ARE EGLIN TESTS

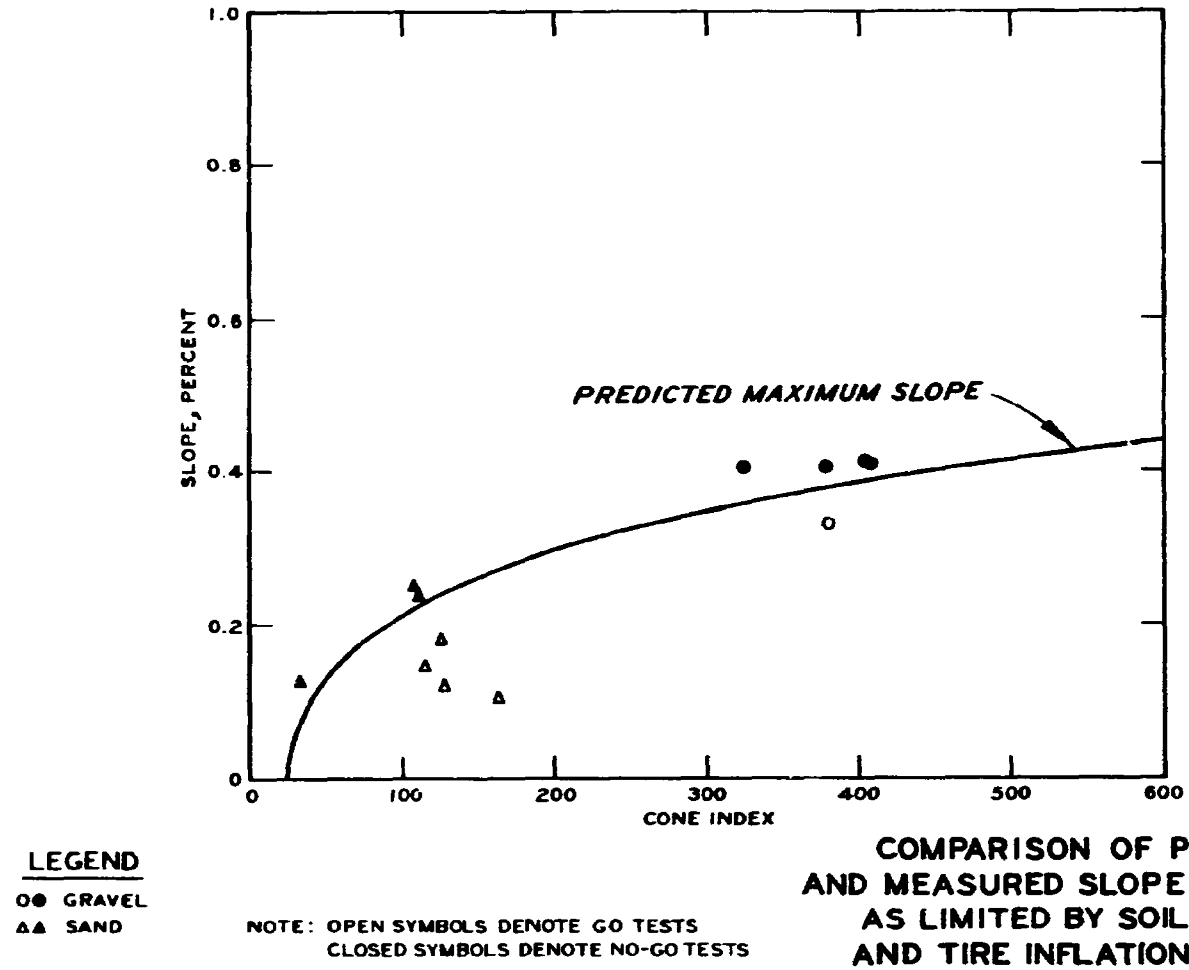
COMPARISON OF PREDICTED AND MEASURED MOTION-RESISTANCE COEFFICIENTS



LEGEND
○● GRAVEL
△▲ SAND

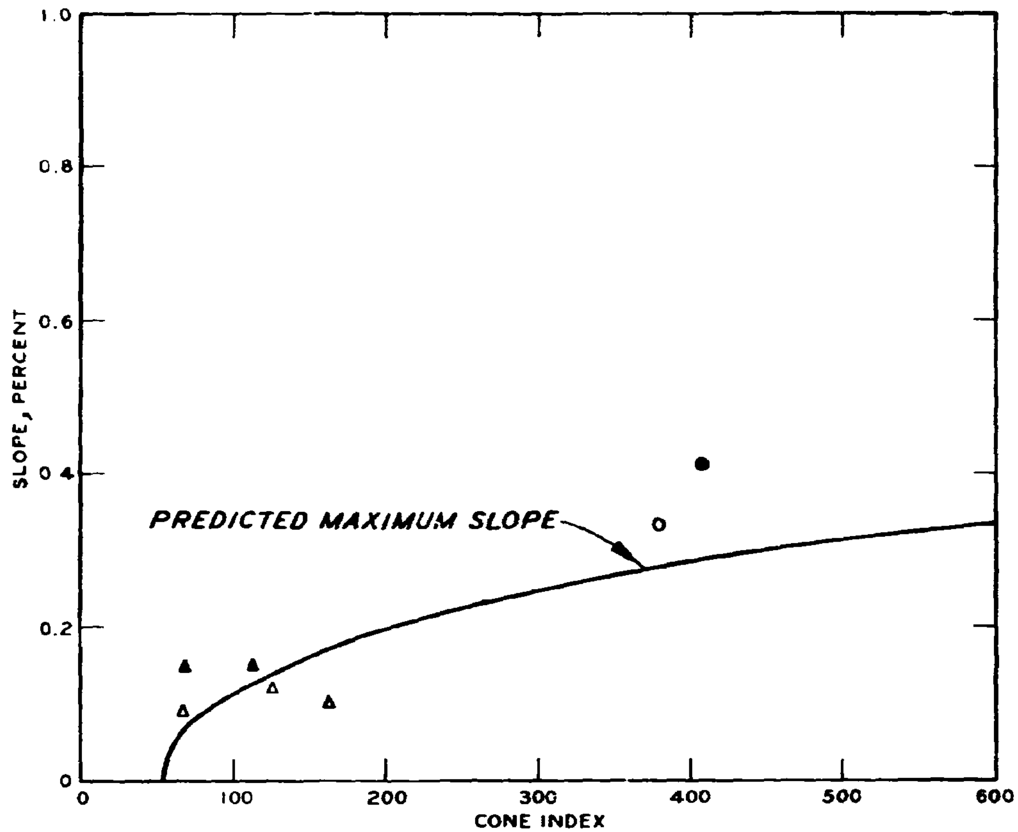
NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SOIL STRENGTH AND TIRE INFLATION PRESSURE
M151 (7.5 PSI)



COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SOIL STRENGTH AND TIRE INFLATION PRESSURE

M151 (15 PSI)



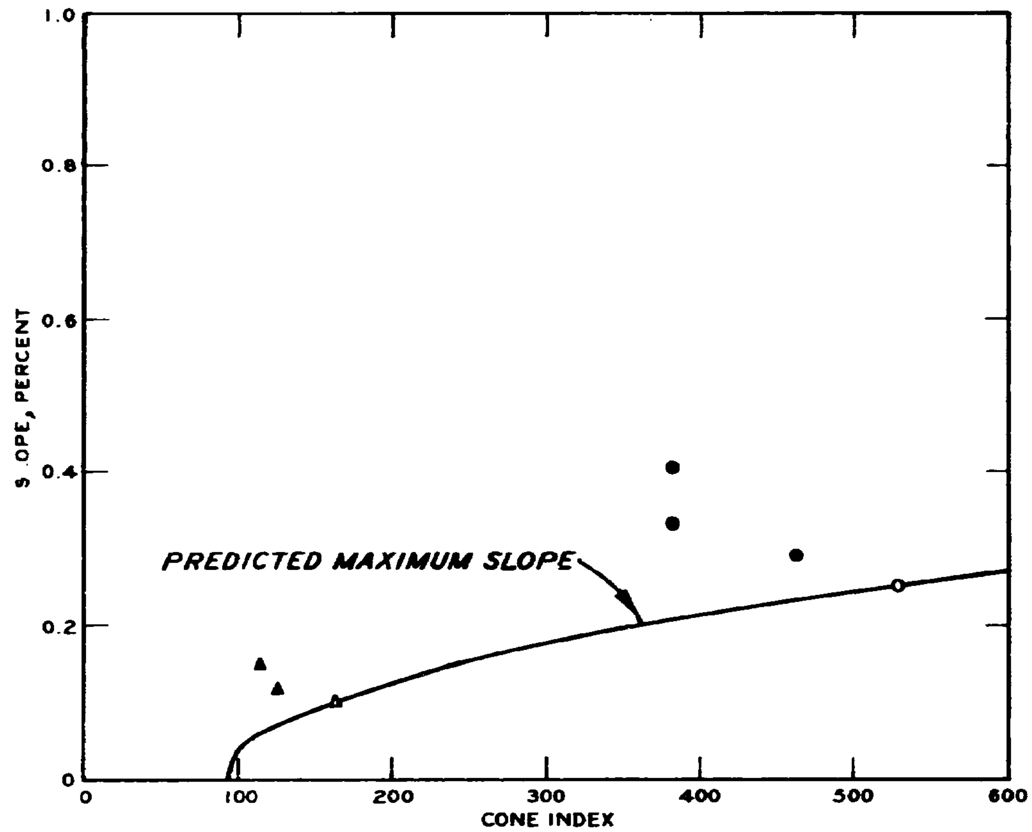
LEGEND

○● GRAVEL

△▲ SAND

NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

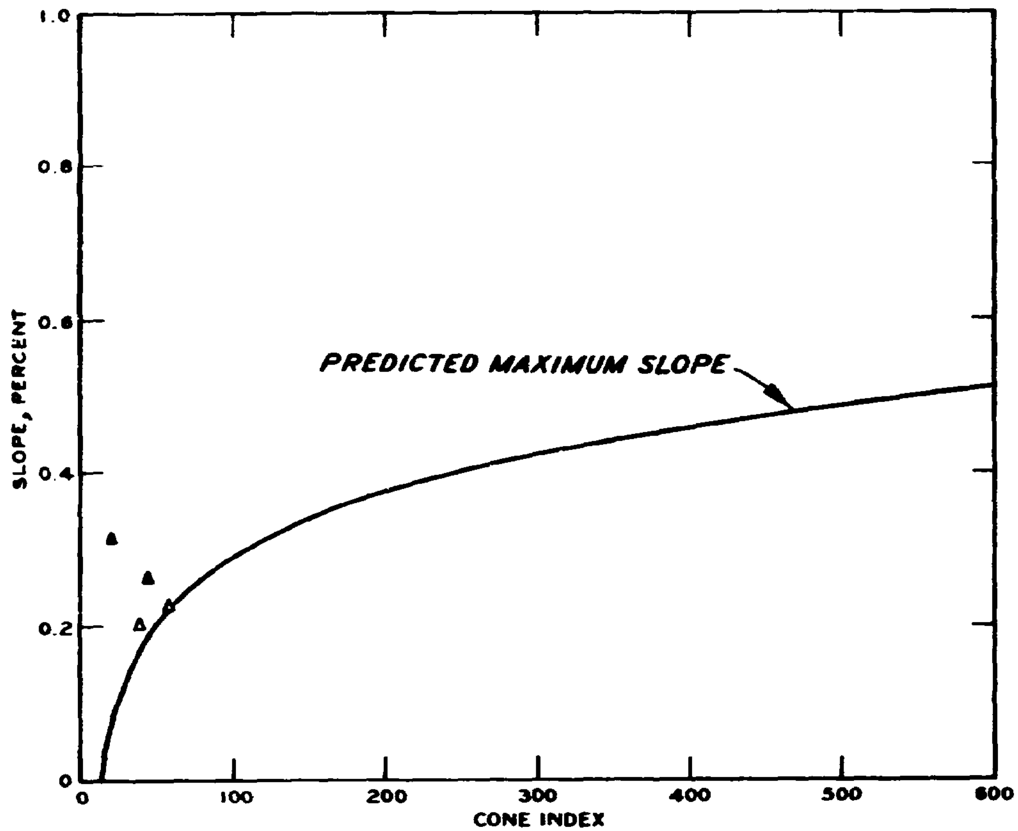
COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SOIL STRENGTH AND TIRE INFLATION PRESSURE M151 (30 PSI)



LEGEND
○● GRAVEL
△▲ SAND

NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

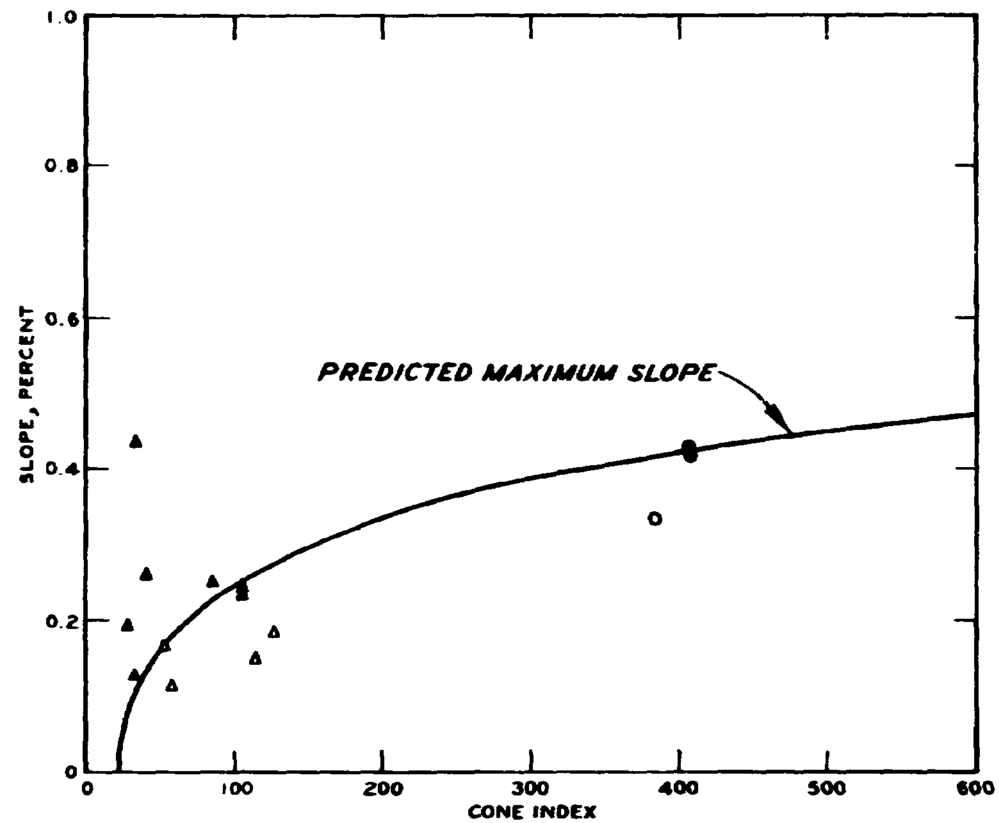
COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SOIL STRENGTH AND TIRE INFLATION PRESSURE
M151 (40 PSI)



LEGEND
○● GRAVEL
△▲ SAND

NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

COMPARISON OF PREDICTED
AND MEASURED SLOPES NEGOTIABLE
AS LIMITED BY SOIL STRENGTH
AND TIRE INFLATION PRESSURE
M35A2 (10 PSI)

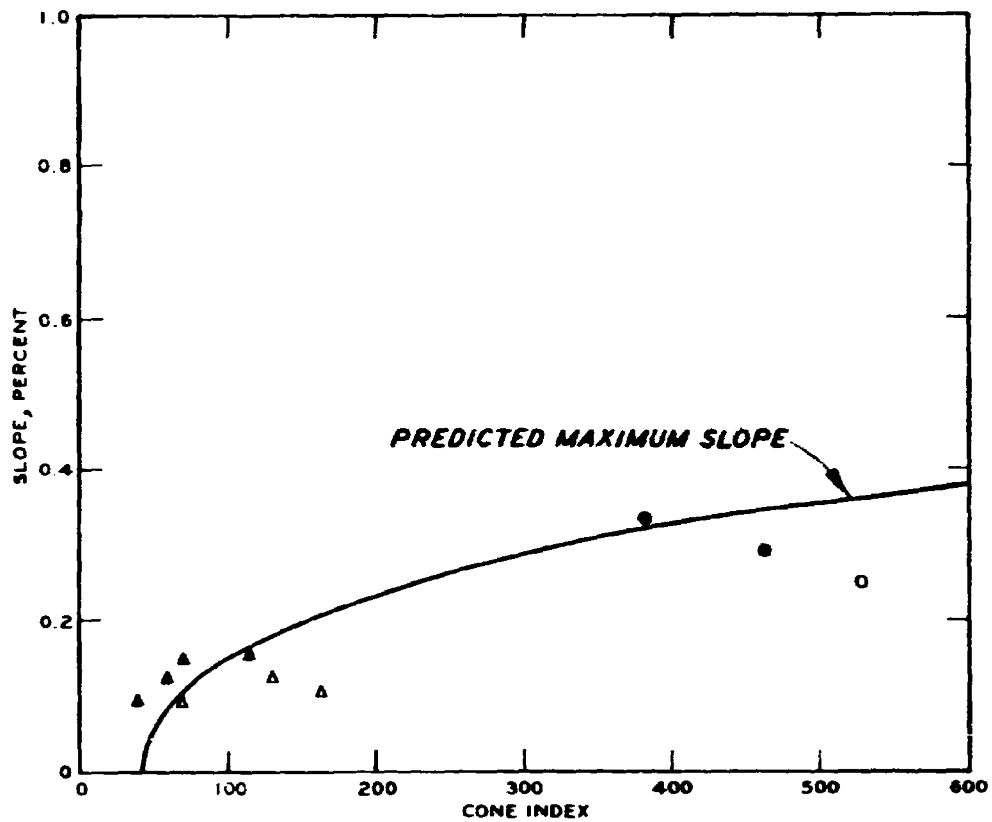


LEGEND

○● GRAVEL
△▲ SAND

NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

COMPARISON OF PREDICTED
AND MEASURED SLOPES NEGOTIABLE
AS LIMITED BY SOIL STRENGTH
AND TIRE INFLATION PRESSURE
M35A2 (15 PSI)



LEGEND

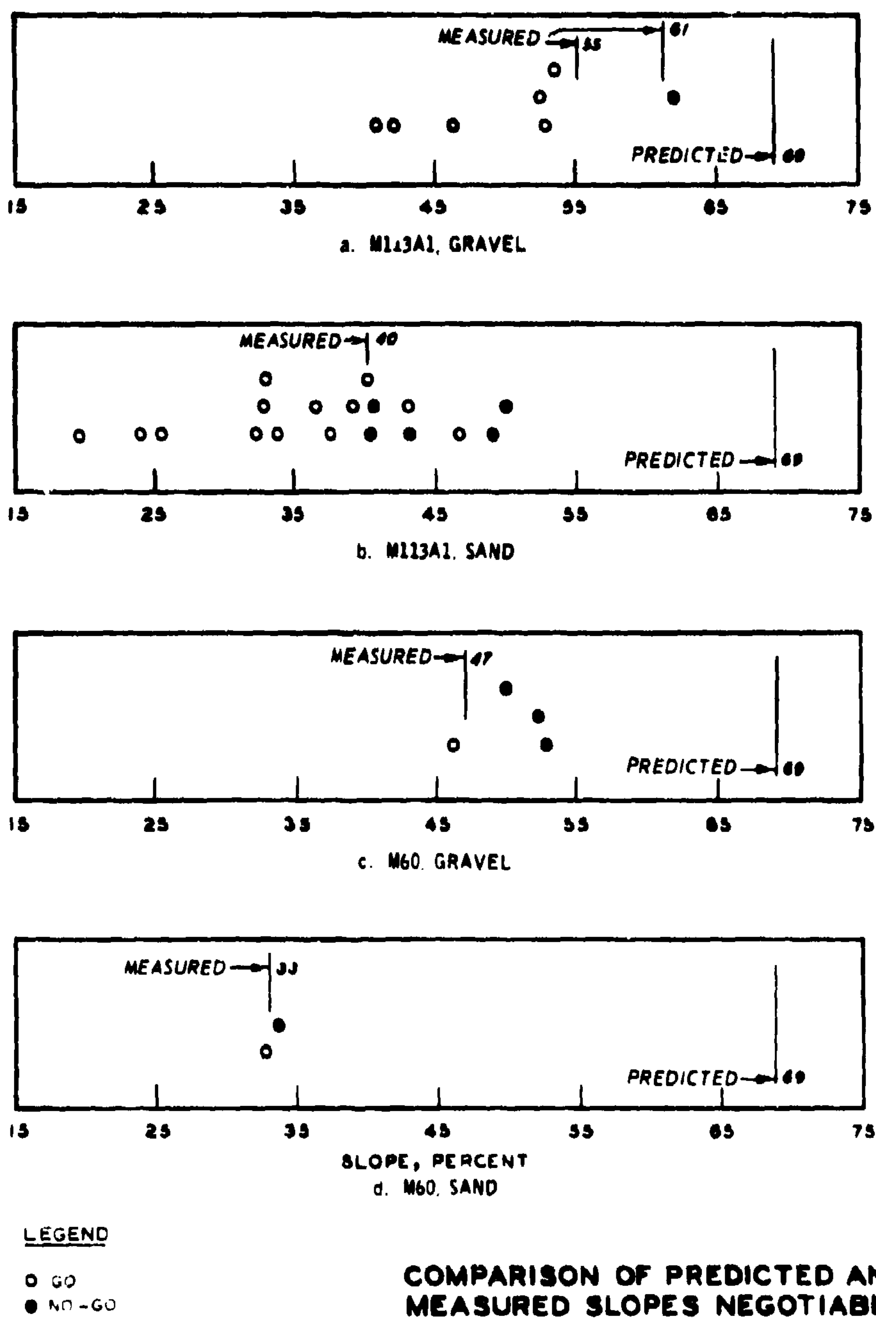
○● GRAVEL

△▲ SAND

NOTE: OPEN SYMBOLS DENOTE GO TESTS
CLOSED SYMBOLS DENOTE NO-GO TESTS

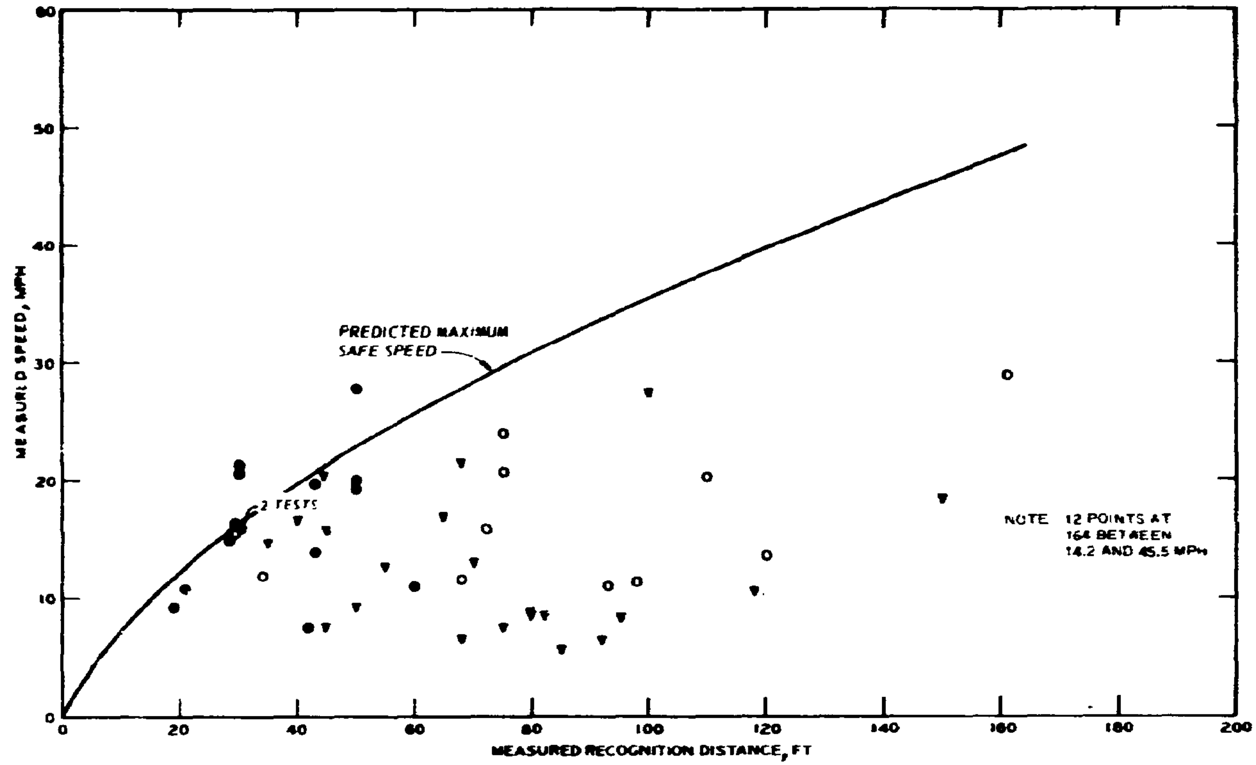
COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SOIL STRENGTH AND TIRE INFLATION PRESSURE

M35A2 (30 PSI)



COMPARISON OF PREDICTED AND MEASURED SLOPES NEGOTIABLE AS LIMITED BY SURFACE MATERIAL
M113A1 AND M60

PLATE 16



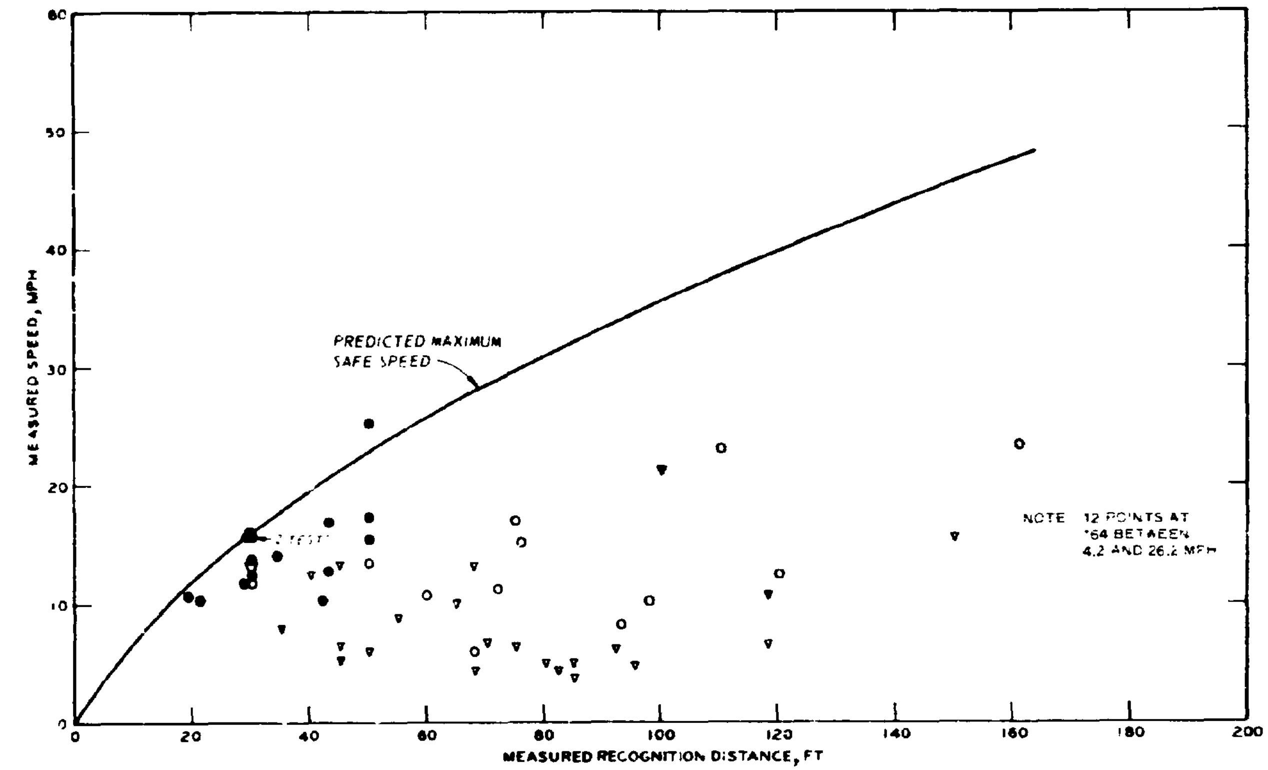
LEGEND

○● FS
▽▼ FK

NOTE - CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M151, FINE-GRAINED SOIL



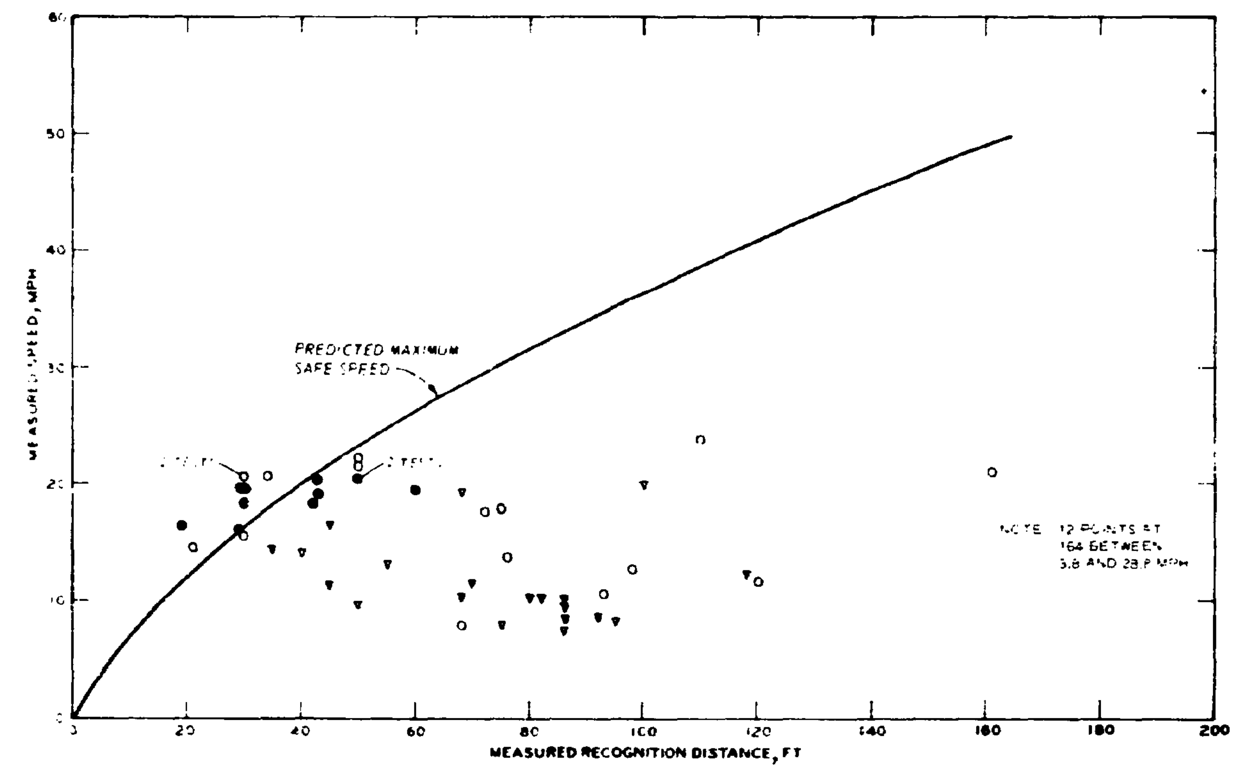
LEGEND

●○ FS
▼▽ FK

NOTE: CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M35A2, FINE-GRAINED SOIL



LEGEND

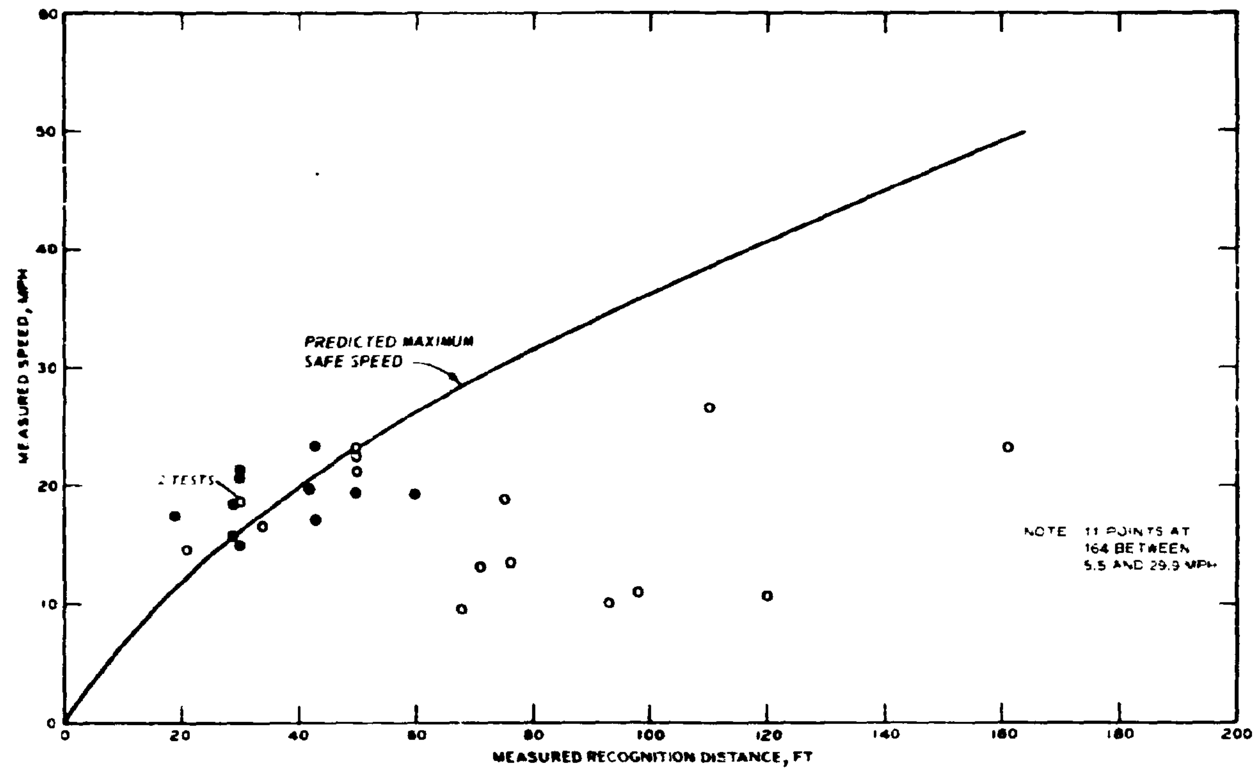
○● FS

▽▼ FM

NOTE: CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M113A1, FINE-GRAINED SOIL



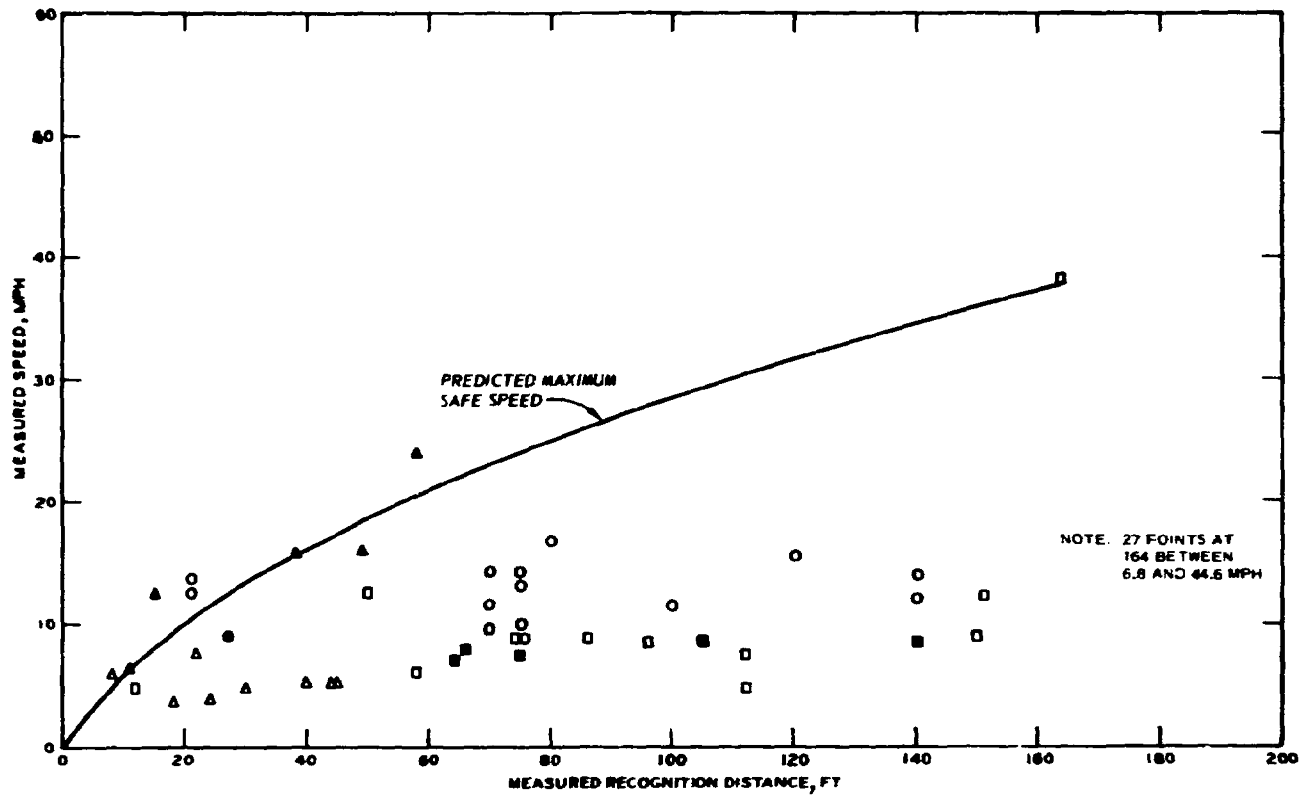
LEGEND

OO FS

NOTE CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M48, FINE-GRAINED SOIL



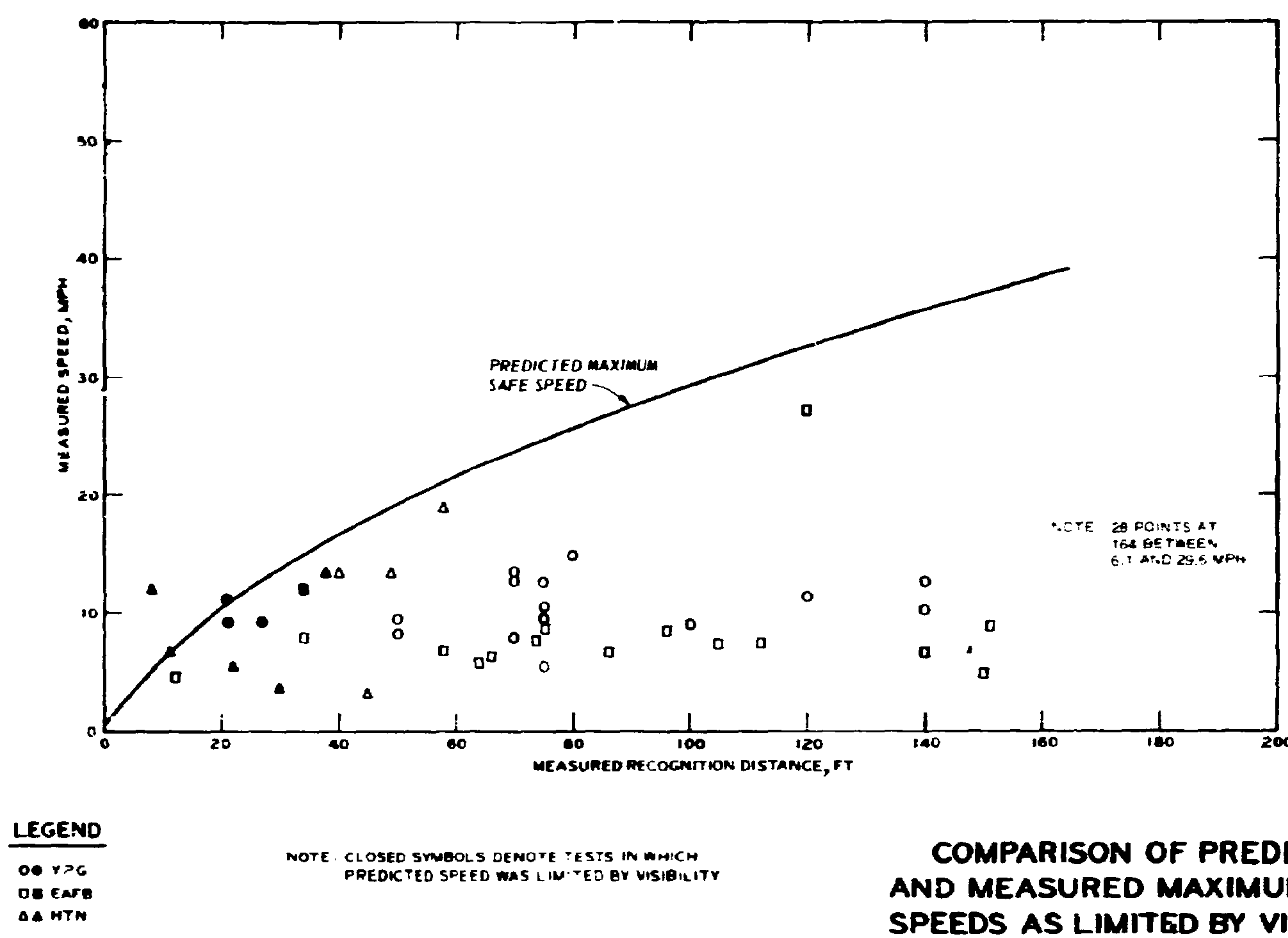
LEGEND

○● YPG
□■ EAFB
△▲ HTN

NOTE: CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

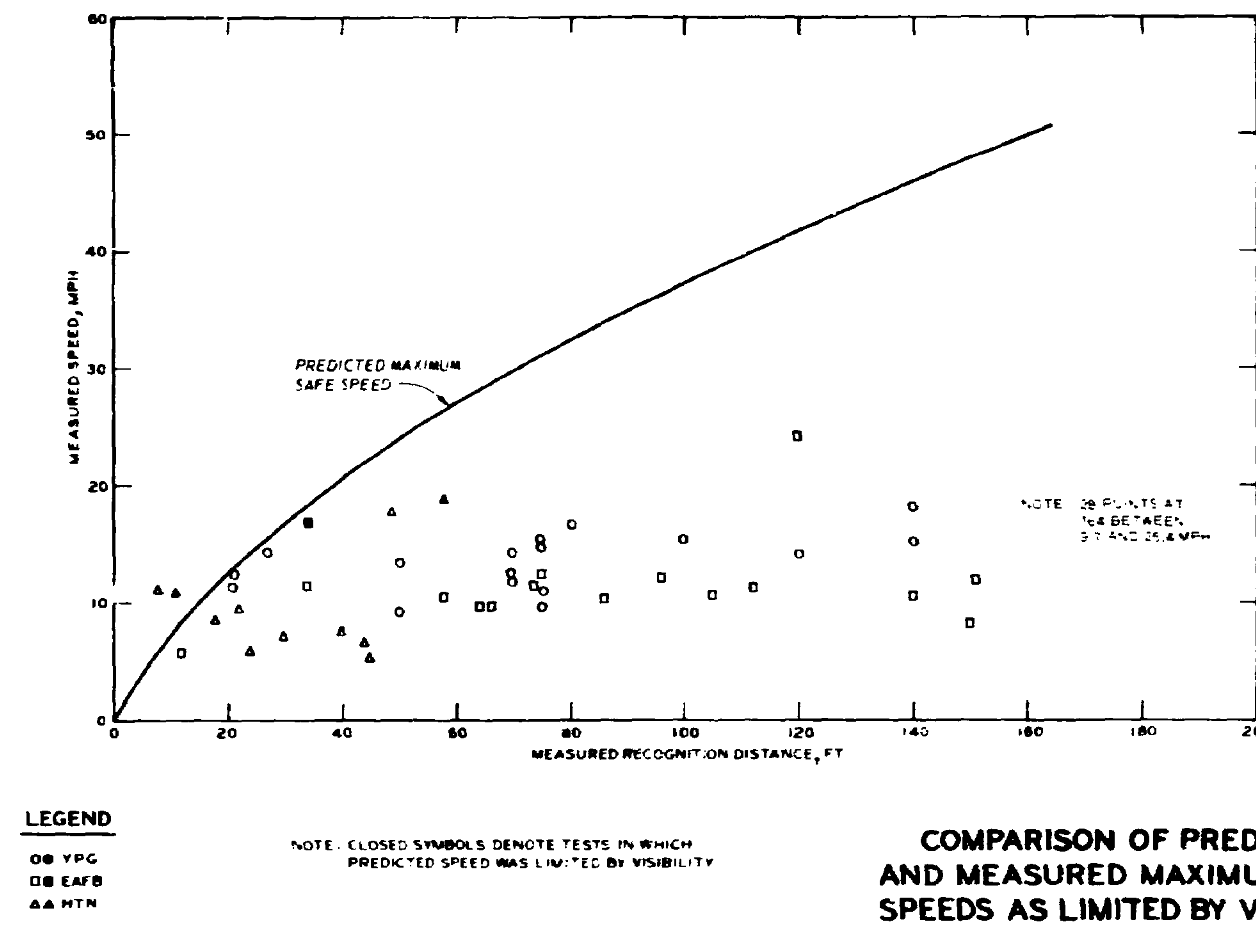
COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M151, COARSE-GRAINED SOIL



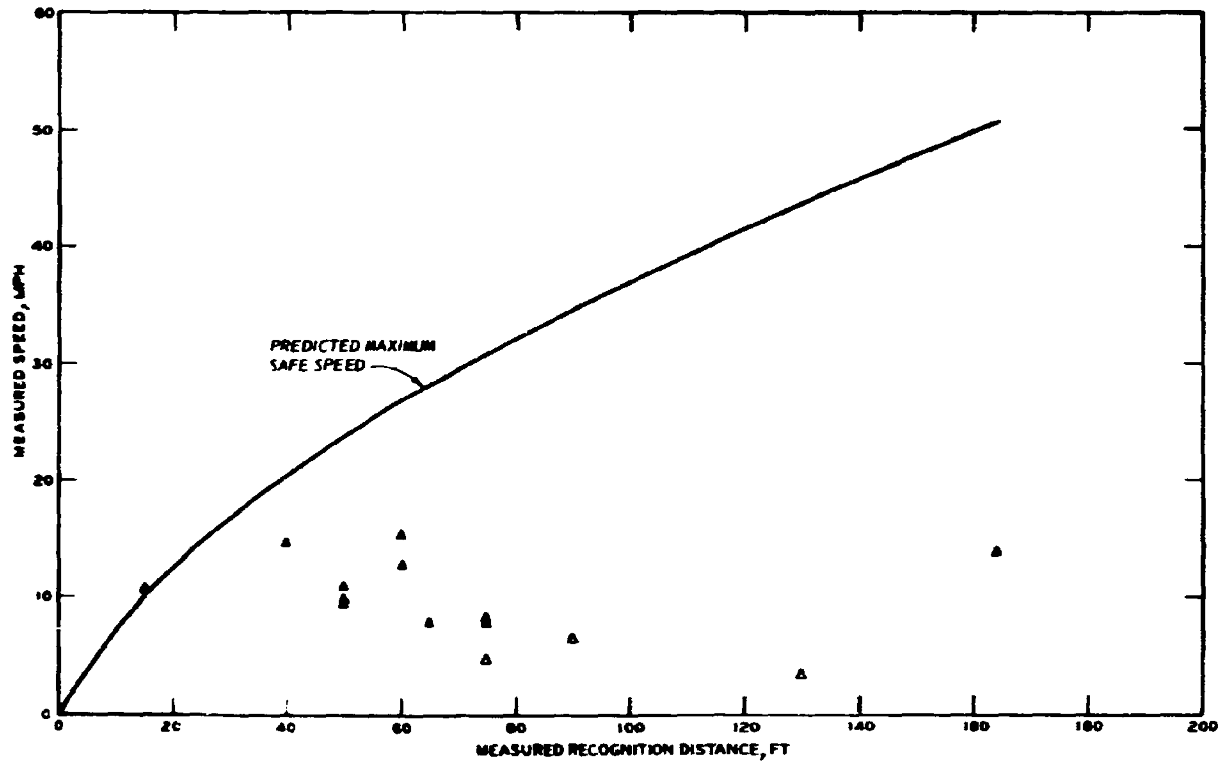
COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M35A2, COARSE-GRAINED SOIL



COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M113A1, COARSE-GRAINED SOIL



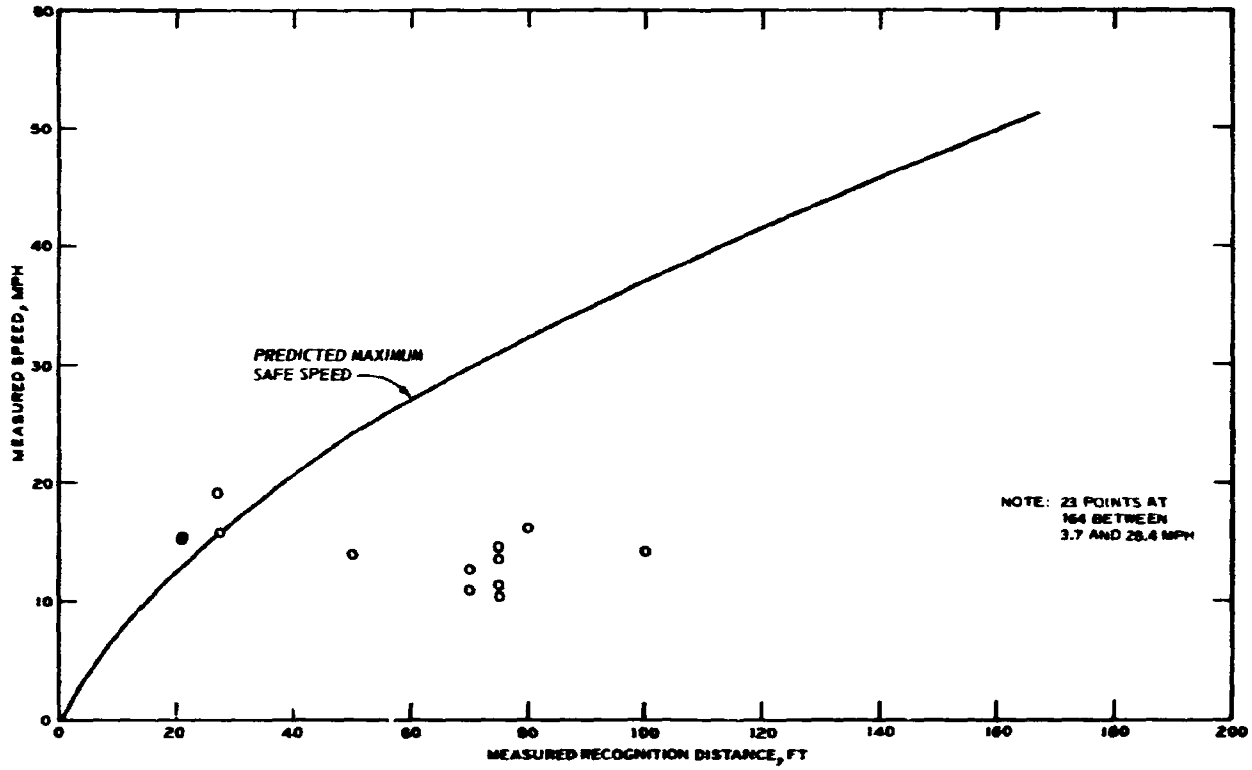
LEGEND

▲△ HTN

NOTE: CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

M48, COARSE-GRAINED SOIL



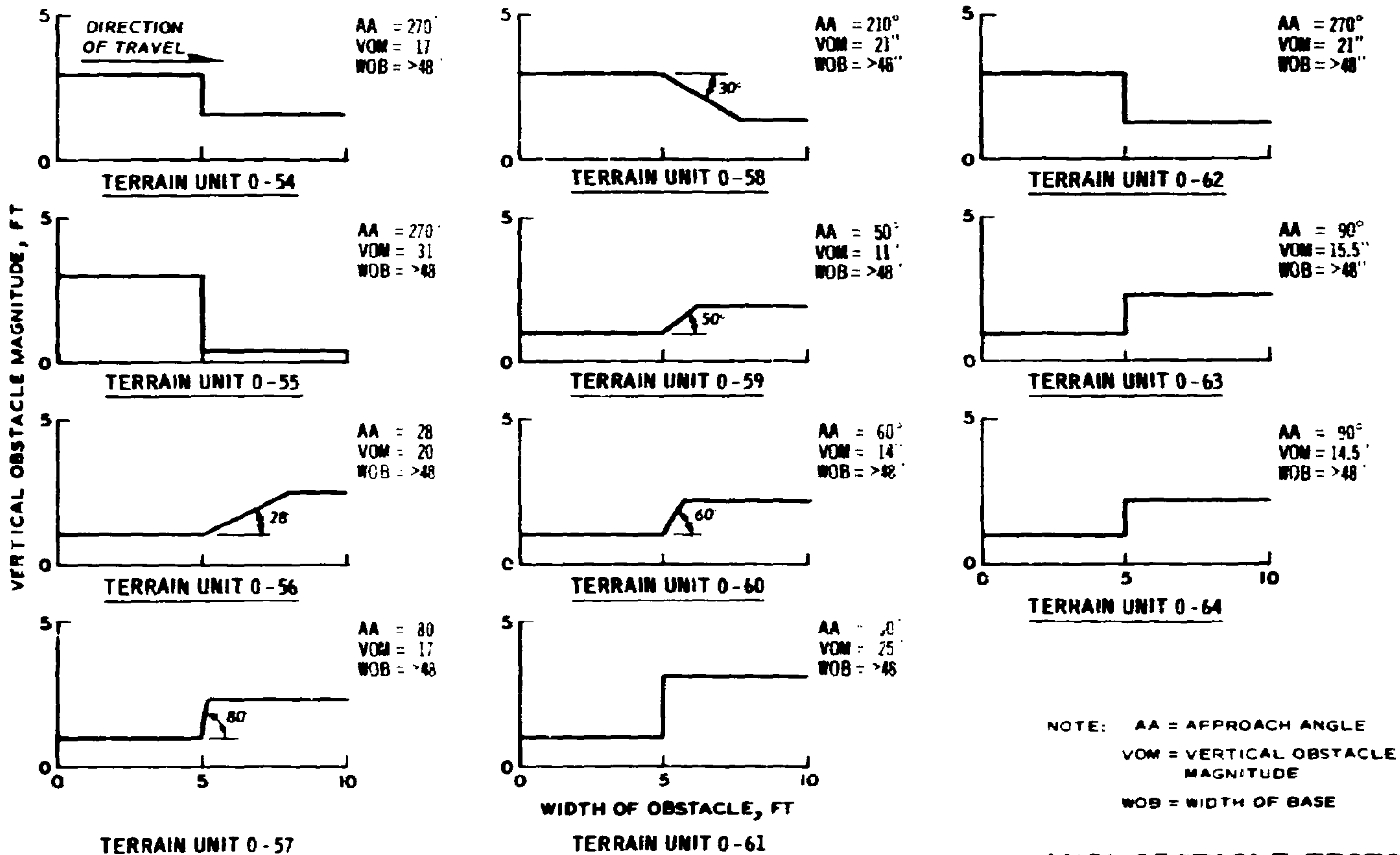
LEGEND

O● YPG

NOTE: CLOSED SYMBOLS DENOTE TESTS IN WHICH PREDICTED SPEED WAS LIMITED BY VISIBILITY

COMPARISON OF PREDICTED AND MEASURED MAXIMUM SAFE SPEEDS AS LIMITED BY VISIBILITY

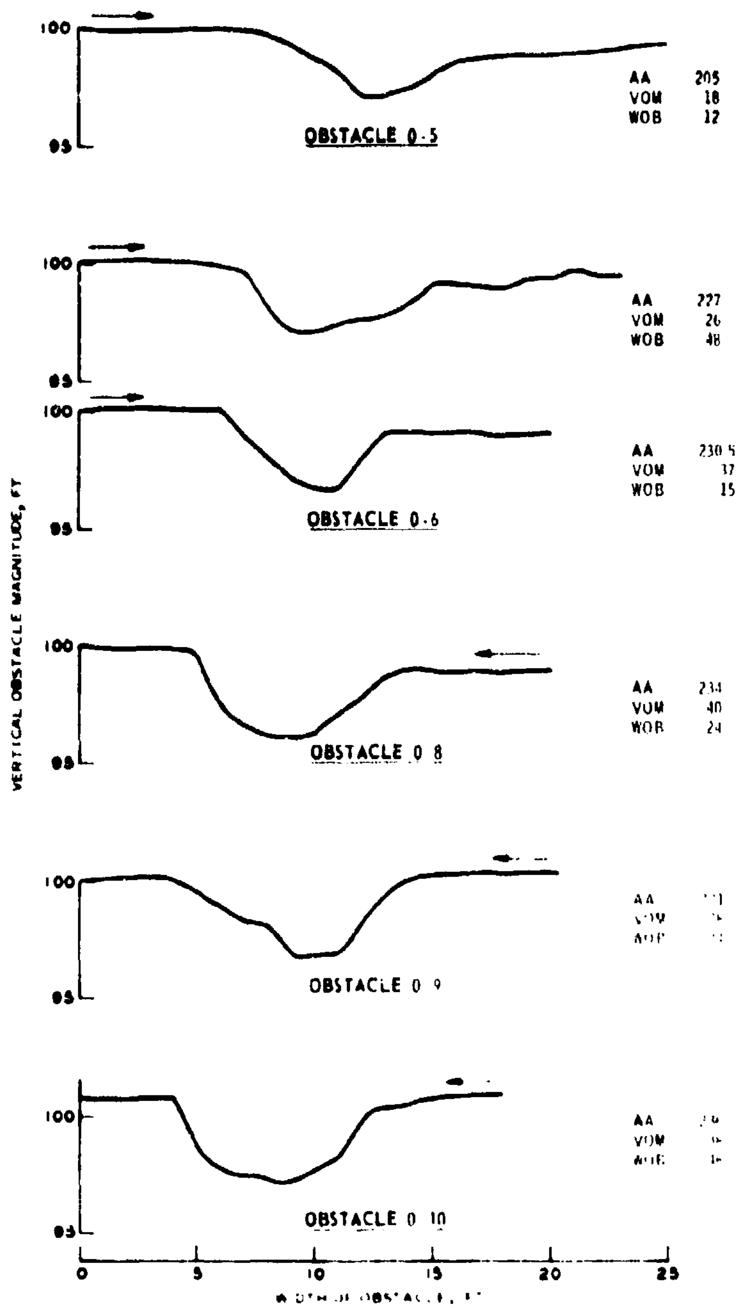
M60, COARSE - GRAINED SOIL



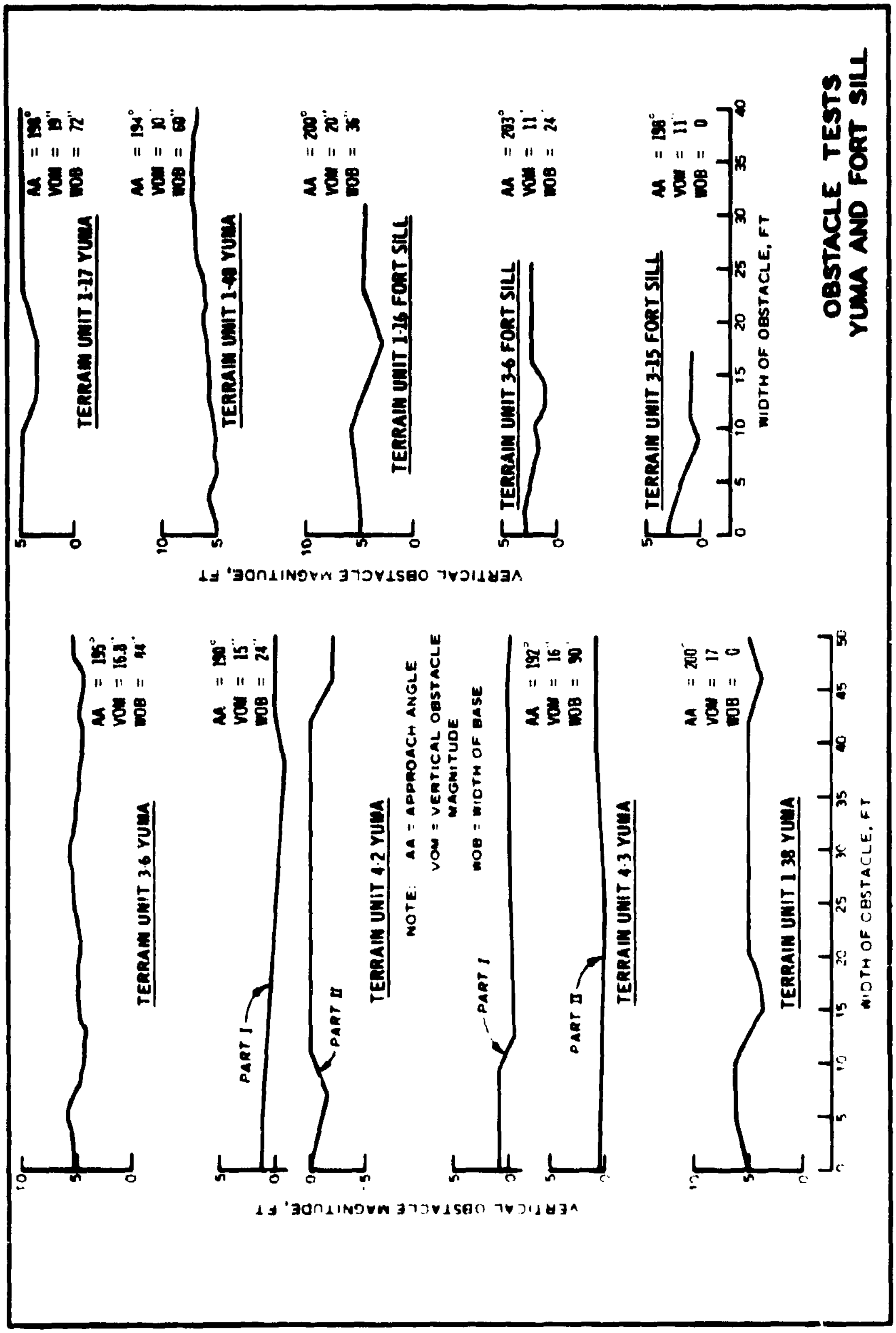
NOTE: AA = APPROACH ANGLE
VOM = VERTICAL OBSTACLE MAGNITUDE
WOB = WIDTH OF BASE

M151 OBSTACLE TESTS
YUMA PROVING GROUND

PLATE 26

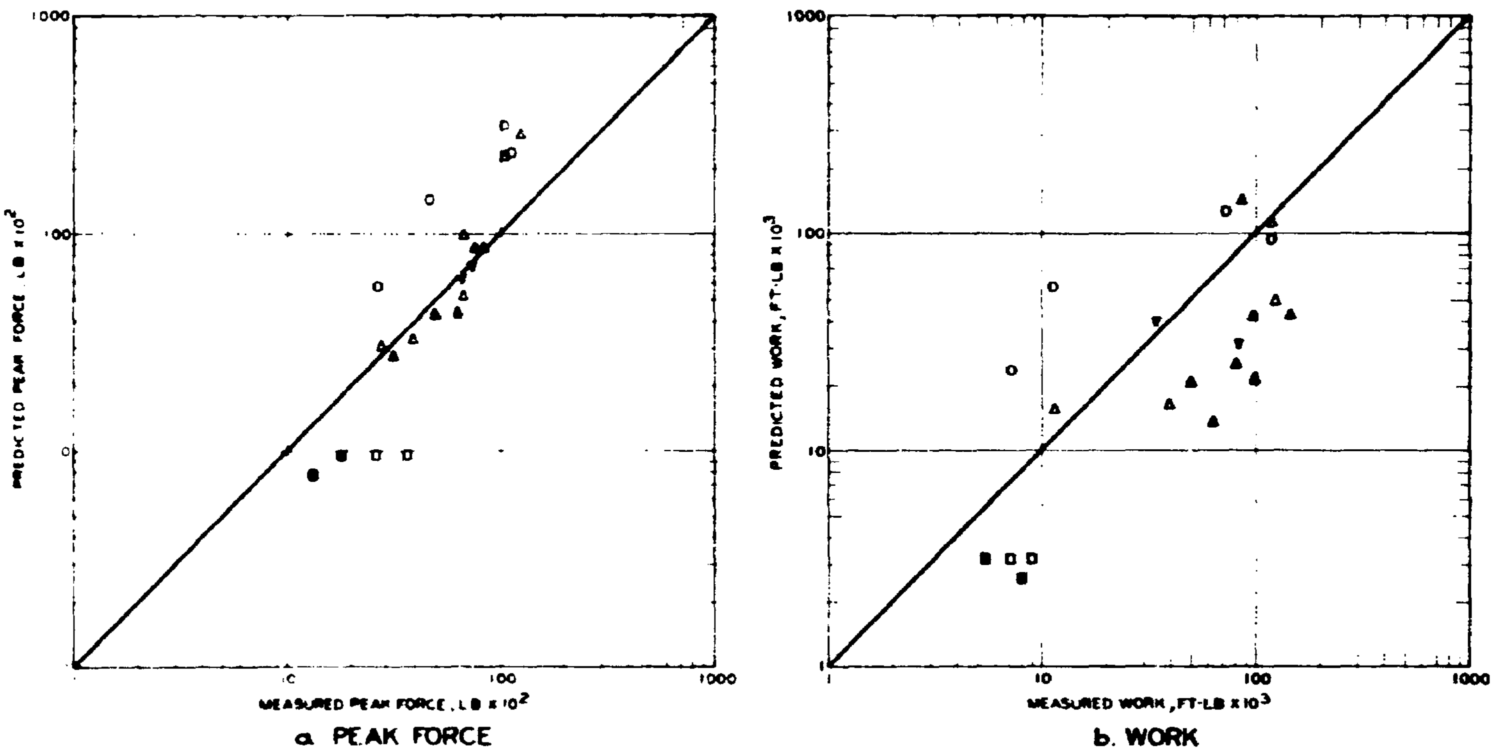


M113A1 OBSTACLE TESTS
FORT KNOX, KY



OBSTACLE TESTS
YUMA AND FORT SILL
TERRAIN UNIT 3-6 YUMA
AA = 195°
VOM = 16.8"
WOB = 44'
TERRAIN UNIT 4-2 YUMA
PART I
PART II
AA = 190°
VOM = 15"
WOB = 24'
NOTE: AA = APPROACH ANGLE
VOM = VERTICAL OBSTACLE MAGNITUDE
WOB = WIDTH OF BASE
TERRAIN UNIT 4-3 YUMA
PART I
PART II
AA = 192°
VOM = 16"
WOB = 90'
TERRAIN UNIT 1-38 YUMA
AA = 200°
VOM = 17"
WOB = 0
WIDTH OF OBSTACLE, FT
VERTICAL OBSTACLE MAGNITUDE, FT
TERRAIN UNIT 1-17 YUMA
AA = 198°
VOM = 19"
WOB = 72'
TERRAIN UNIT 1-48 YUMA
AA = 194°
VOM = 10"
WOB = 60'
TERRAIN UNIT 1-16 FORT SILL
AA = 200°
VOM = 20"
WOB = 36'
TERRAIN UNIT 3-6 FORT SILL
AA = 203°
VOM = 11"
WOB = 24'
TERRAIN UNIT 3-15 FORT SILL
AA = 198°
VOM = 11"
WOB = 0
WIDTH OF OBSTACLE, FT
VERTICAL OBSTACLE MAGNITUDE, FT

PLATE 28



a. PEAK FORCE

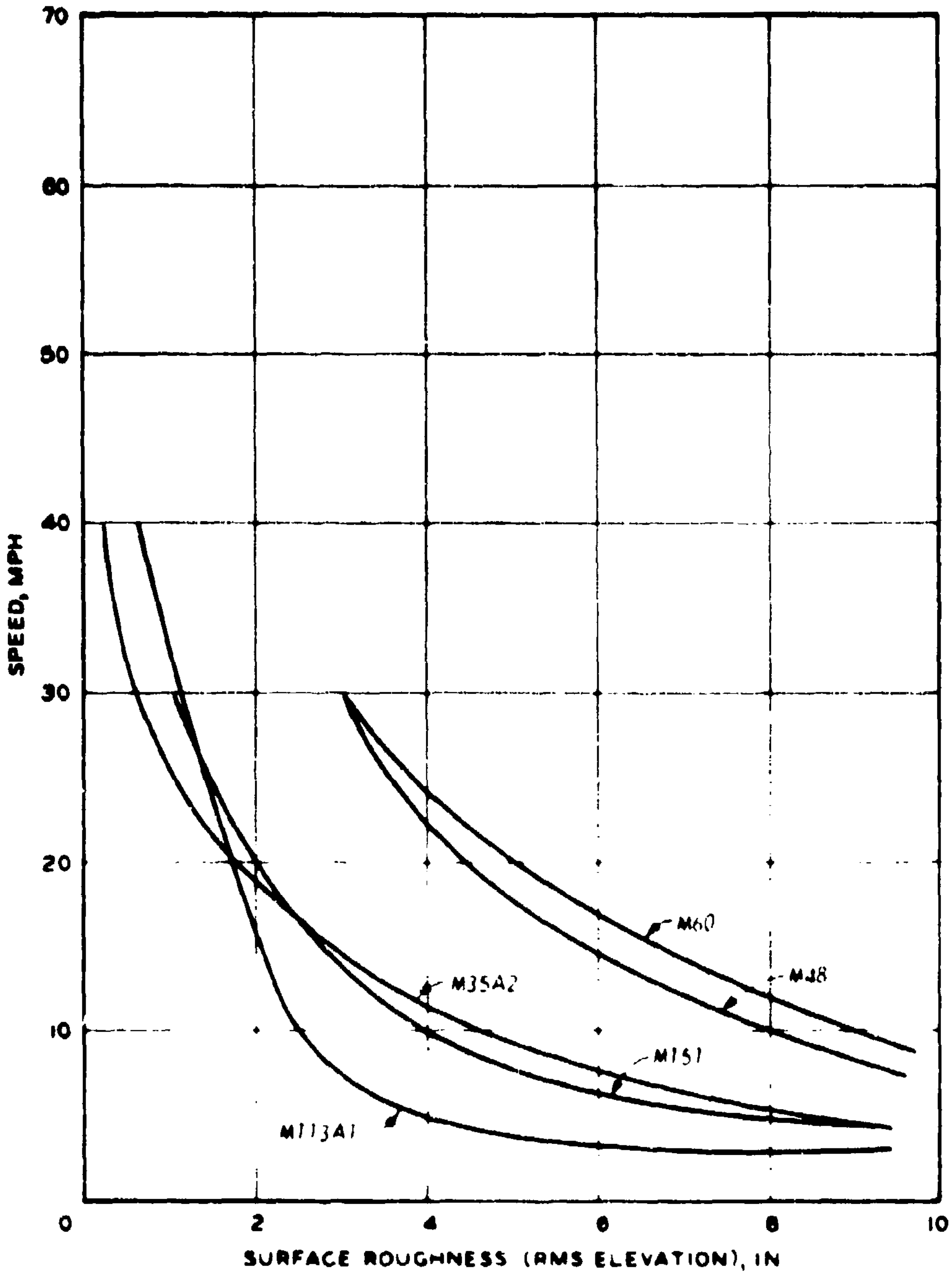
b. WORK

LEGEND

- ○● M113A1
- △▲ M35A2 / EGLIN
- □■ M151
- ▽▼ M35A2 / HOUGHTON

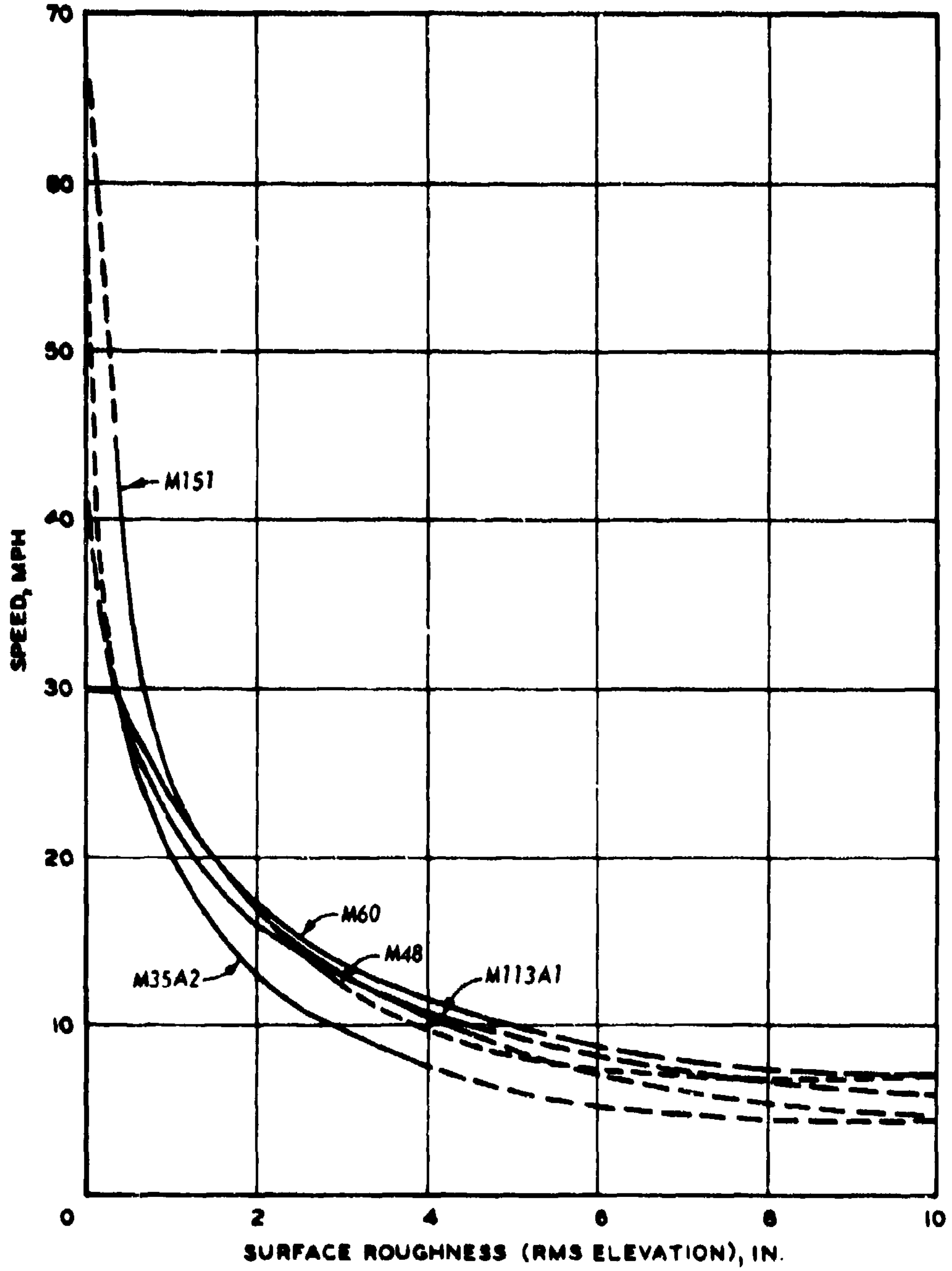
NOTE: OPEN SYMBOLS DENOTE OAK TREES
CLOSED SYMBOLS DENOTE PINE TREES

COMPARISON OF MEASURED AND PREDICTED PEAK FORCE AND WORK IN SINGLE TREE-OVERRIDE TESTS AT EGLIN AND HOUGHTON

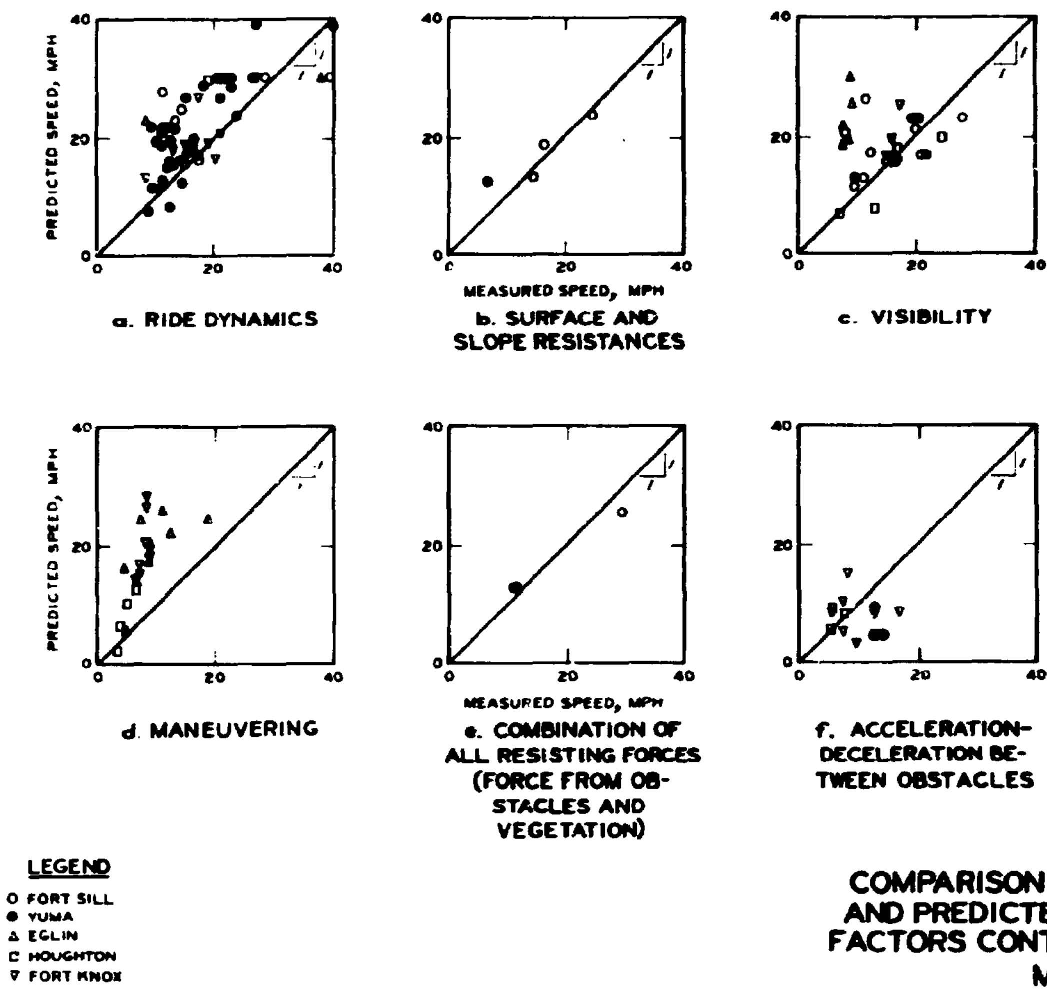


SPEED VERSUS SURFACE ROUGHNESS
COMPUTER SIMULATED DATA

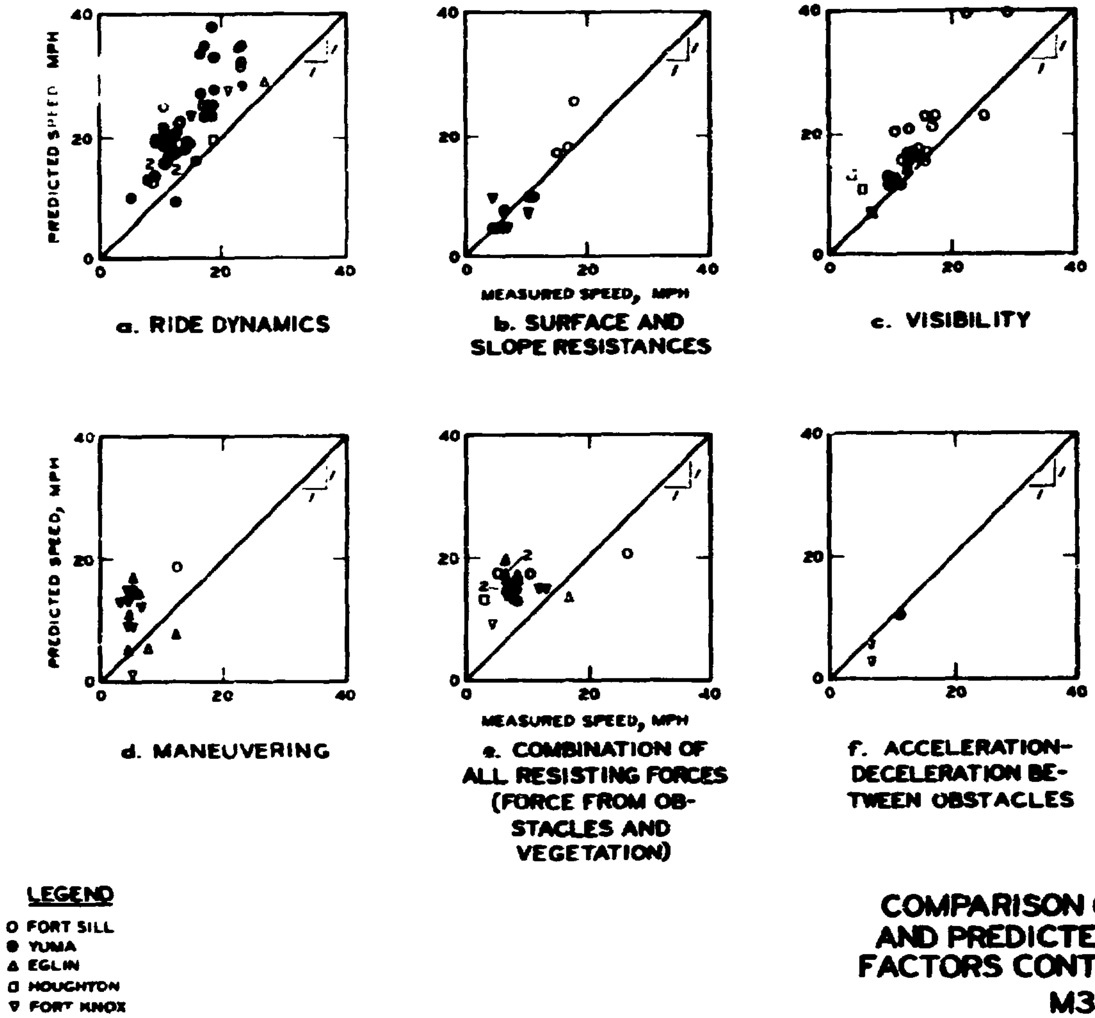
PLATE 30



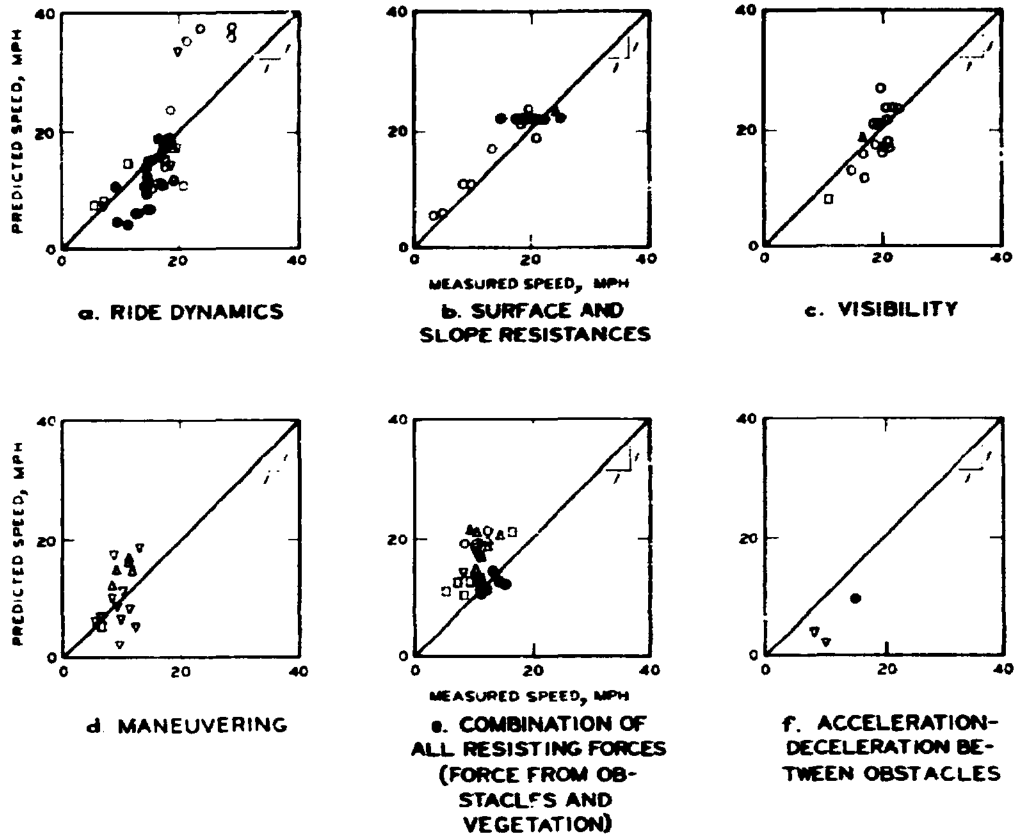
SPEED VERSUS SURFACE ROUGHNESS
FIELD-MEASURED DATA



COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR FACTORS CONTROLLING SPEED
M151



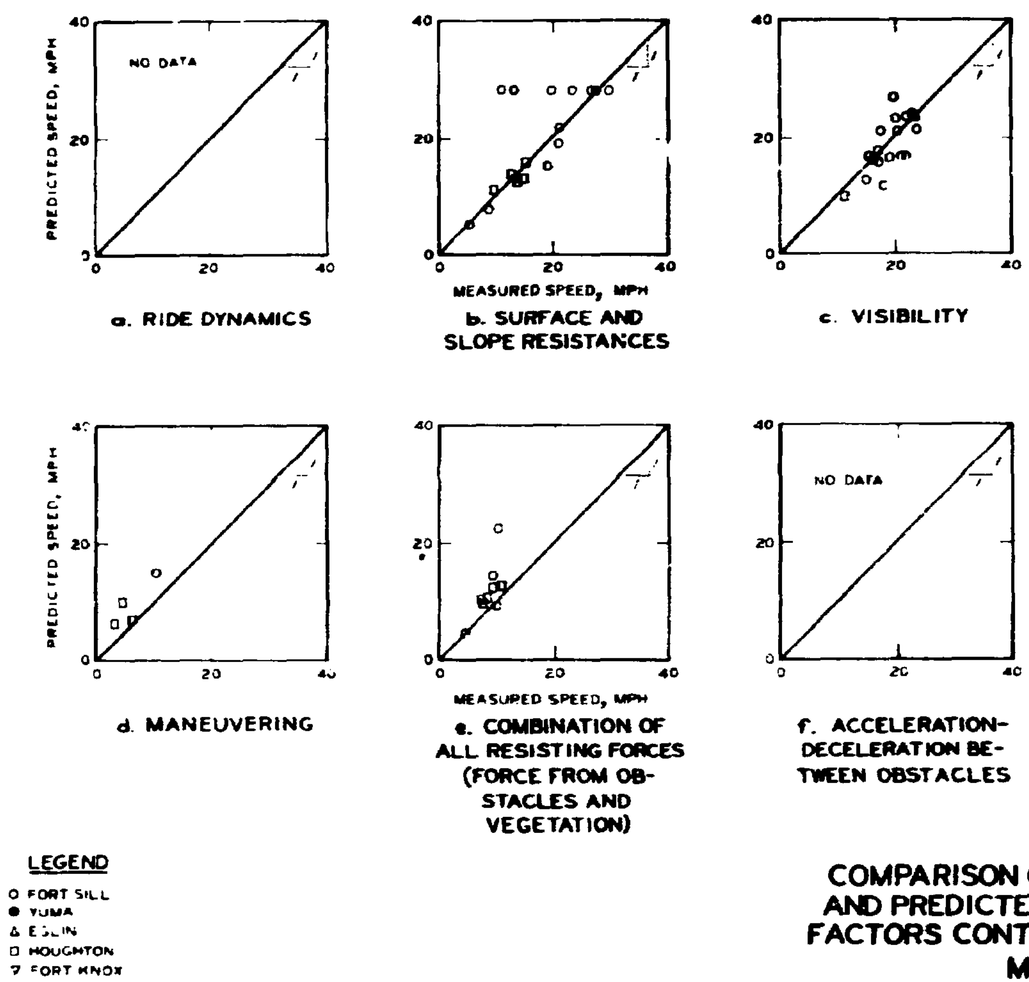
COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR FACTORS CONTROLLING SPEED M35A2



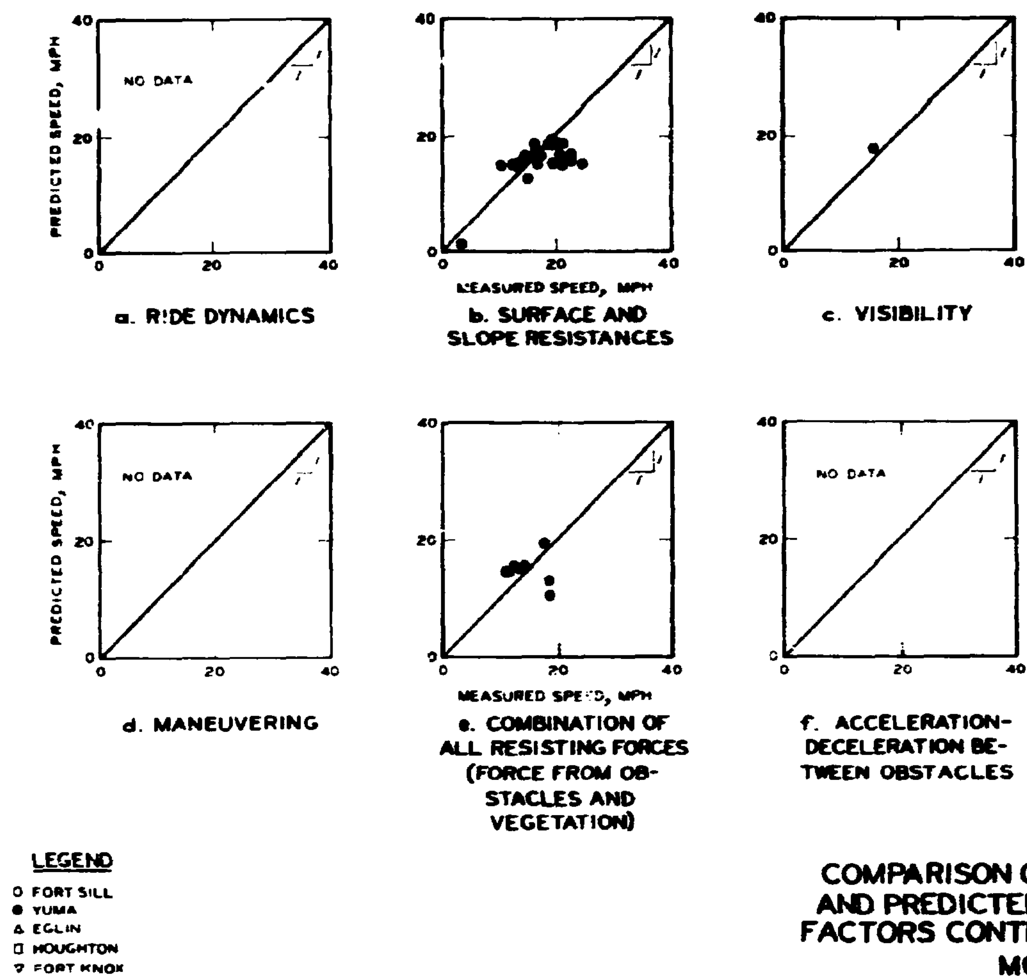
LEGEND

O FORT SILL
● YUMA
Δ EGLIN
□ HOUGHTON
∇ FORT KNOX

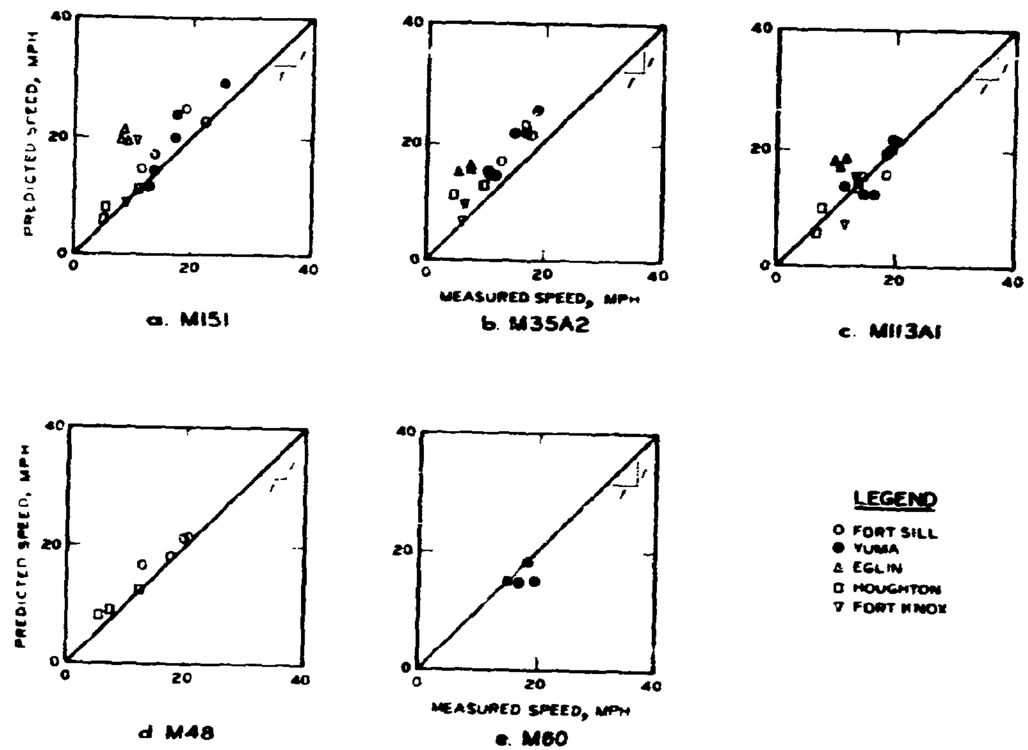
COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR FACTORS CONTROLLING SPEED
M113A1



COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR FACTORS CONTROLLING SPEED
M48

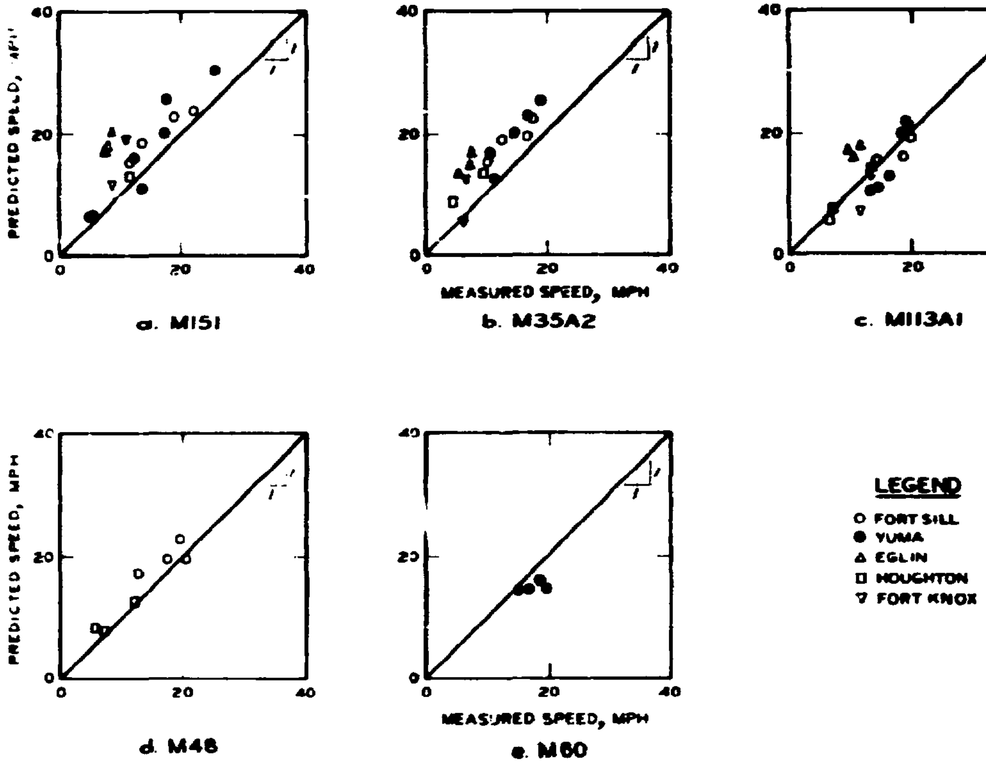


COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR FACTORS CONTROLLING SPEED M60



COMPARISON OF MEASURED AND PREDICTED SPEEDS FOR VALIDATION VEHICLES ON TRAVERSES

SPECIFIC TERRAIN VALUES



COMPARISON OF MEASURED AND PREDICTED SPEEDS MADE GOOD FOR VALIDATION VEHICLES ON TRAVERSES

CLASSED TERRAIN VALUES

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Schreiner, Barton G
   Validation of the AMC-71 mobility model, by Barton G. Schreiner [and] William E. Willoughby. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.
   2 v. illus. 27 cm. (U. S. Waterways Experiment Station. Technical report M-76-5)
   Prepared for U. S. Army Materiel Development and Readiness Command, Alexandria, Virginia, under Project 1G662601AH91, Task 01.
   Bibliographical footnotes.

   1. AMC-71 Mobility Model. 2. Mobility models. 3. Terrain 4. Vehicle performance. I. Willoughby, William E., joint author. II. U. S. Army Materiel Development and Readiness Command. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Technical report M-76-5)
   TA7.W34 no.M-76-5