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Terrain Trafficability in Modeling and Simulation

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ABSTRACT: *The term "terrain trafficability" is commonly used to denote the terrain component of the environment which affects ground vehicle mobility. This document describes the terrain trafficability representations used in four ground vehicle mobility models for virtual and constructive simulation: MosSAF/SIMNET, CCTT, WARSIM, and NRMM II. It is a "work in progress" and can be expected to evolve as the community becomes more familiar with the nature and use of ground vehicle mobility models and the capabilities of ground vehicle mobility models mature.*

1. Introduction

1.1 Defining a Ground Vehicle Mobility Model

By the narrowest definition, a ground vehicle mobility model is concerned only with the effects on the vehicle caused by the interaction of the vehicle with the environment (arrow #1 in Figure 1, below). In general, however the definition should also include the effects on the:

- environment caused by the interaction of the vehicle with the environment (arrow #2)
- driver caused by the interaction of the vehicle with the driver (arrow #3)
- vehicle caused by the interaction of the vehicle with the driver (arrow #4)

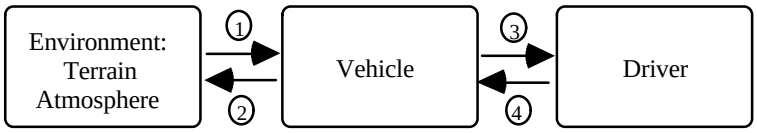

Figure 1: Vehicle Model Interactions

All subsequent usage of the term "mobility modeling" in this document is intended to refer to wheeled and tracked ground vehicles as they interact with the environment and the vehicle driver. This document does not consider issues in modeling the ground mobility of soldiers or ground effect vehicles dependent on air cushions and fans for movement.

Both the terrain and atmosphere contribute to the interaction of the vehicle with the environment. The term "terrain trafficability" is commonly used to denote the terrain component of the environment which affects ground vehicle mobility. This document describes the terrain trafficability representations used in several common ground vehicle mobility models.

1.2 Motivation and Purpose

Several DoD organizations are currently developing, or have recently developed, ground vehicle mobility models for use in modeling and simulation (M&S). These models are not clearly consistent with either each other or the current Army mobility modeling standard: the NATO Reference Mobility Model II (NRMM) for a variety of reasons. These inconsistencies result from differences in the functional requirements for each model, in particular issues in the resolution, accuracy, and performance required for specific M&S applications.

Recognizing that M&S requirements vary by functional usage, it is important that the DoD work to standardize a family of mobility models for use in M&S with well-understood characteristics and ranges of applicability. Critical to that standardization process is the ability to characterize and classify ground vehicle mobility models in a manner that ensures that they are not applied to inappropriate tasks, potentially resulting in the generation of misleading or inaccurate analytic representations or results.

An important goal of this document is to bring together the developers of ground vehicle mobility models and the developers of M&S systems using these models (and their customer, the warfighter) in order to more closely couple the capabilities of ground vehicle mobility models with user requirements. The requirements of both virtual and constructive simulations are addressed.

Fidelity and performance are the basic measures of a ground vehicle mobility model. Virtual simulations require ground vehicle mobility models of relatively high fidelity and real-time performance; computer-generated force (CGF) simulations (both aggregate-level[1] and platform-level[2]) require models of low to moderate fidelity but significantly better than real-time performance. Characterizing these differences in required fidelity is a significant challenge for the M&S community. The differences in performance are more easily characterized.

[1] Aggregate level simulations generally model ground vehicles in groups, such as a company-sized unit; typically these groups are heterogeneous and typical doctrine requires cohesion in the group during maneuver. As a result, the group generally moves based on the most-constrained vehicle (e.g., slowest).

[2] Platform-level simulations model ground vehicles as individual entities, although the effects of attached components such as a plow or trailer are often combined into the entity model, rather than being treated separately.

1.3 Organization

This document describes the terrain trafficability representations used in four ground vehicle mobility models for virtual and constructive simulation: ModSAF/SIMNET, CCTT, WARSIM, and NRMM II. For each it provides system background, an overview of the model, and a specification of its terrain slope and trafficability representations. This document is a "work in progress" and can be expected to evolve as the community becomes more familiar with the nature and use of ground vehicle mobility models.

1.4 Terrain Factors

The major terrain trafficability factors which influence ground vehicle mobility are as follows.

- **Slope**: Includes aspect with respect to direction of travel.
- **Obstacle descriptions**: Cross-sectional geometry; generic models acceptable.
- **Surface materials**: Categorized (by definition). Continuously valued (e.g., different concrete or asphalt compositions) desirable but probably excessive for other than the highest fidelity settings.
- **Soil Type**: The soil types in the Unified Soil Classification System (USCS) are composed of two letter (or four letters in the case of a borderline soil) connotative symbols composed of a prefix and a suffix. The prefix indicates the main soil type and the suffix indicates subdivisions of these main groups, as shown in Table 1.

Table 1: USCS Soil Type Connotative Symbols

Main Soil Type	**Symbol**
Gravel	G
Sand	S
Silt	M
Organic silts and clays	O
Peat	PT

Gradation	**Symbol**
Well-graded[3]	W
Poorly-graded[4]	P

Liquid limit	**Symbol**
Low LL (<= 50)	L
High LL (> 50)	H

These are combined to define 15 separate soil groupings, as shown in Table 2.

[3] Well-graded: soil materials characterized by a complete range of all representative grain sizes, and without excess or deficiency of any of these grain sizes.

[4] Poorly-graded: soil materials characterized by predominantly one graion size (these materials are commonly described as uniform graded) or a range of sizes with some intermediate sizes missing (these materials are sometimes described as gap-graded, skip-graded, or step-graded).

Table 2: USCS Soil Types

USCS Code	Description
GW	Well-graded gravels
GP	Poorly-graded gravels
GM	Silty gravels
GC	Clayey gravels
SW	Well-graded sands
SP	Poorly-graded sands
SM	Silty sands
SC	Clayey sands
ML	Inorganic silts and very fine sands
MH	Inorganic silts
CL	Inorganic clays of low to medium plasticity
CH	Inorganic clays of high plasticity
OL	Organic silts and organic silty clays of low plasticity
OH	Organic clays of medium to high plasticity, organic silts
PT	Peat and other highly organic soils

- **Soil strength**: Characterized by several inter-related factors:
  - RCI: Remolding Cone Index.
  - Cohesion: "C".
  - Internal friction angle: "Phi" – related to shear strength of soil and angle of repose/slump.
  - Density
  - Moisture content
- **Freeze/thaw depths**
- **Surface roughness**: Statistical in nature; classed into RMS groupings.
- **Surface slipperiness/wetness/ice**
- **Snow**:
  - Type: Used to map to density, age, and layering.
  - Depth
- **Non-woody vegetation**: Vegetation with stem diameter less than 1.0 inches. Includes brush and crops.
  - Type: Needs to be resolved to type of crop; e.g. millet (thick base clump with single stalk) *vs.* wheat (simple shoots).
  - Density: Stems per unit area (affect override and resistance)
  - Direction: Require angle of rows to nearest of 8 cardinal directions.
  - Height: Potentially affects driver visibility.
- **Woody vegetation**:
  - Type: Species can be used to derive stem spacing distribution assuming a non-managed mature forest. Different algorithms are required for managed forests and particular species (e.g., loblolly pine).
  - Diameter: Either discrete values and/or statistical distribution.
  - Spacing: Used only for statistical modeling.
- **Hydrology**:
  - Depth

- Velocity
- Direction: If vehicle is buoyant, need to determine direction of drift.

The primary determinants of terrain trafficability in most settings are slope, surface material (including soils) type/strength, and vegetation. The secondary determinants are hydrology and localized natural and man-made obstacles (including structures).

2. ModSAF/SIMNET Trafficability

2.1 Background

The Modular Semi-Automated Forces (ModSAF) environment provides a Distributed Interactive Simulation (DIS) system for simulating and controlling battlefield entities, such as vehicles, Dismounted Infantry (DI), missiles, and dynamic structures on a virtual battlefield. These entities interact with each other and with manned individual entity simulators, such as an M1 tank simulator, to support training, combat development experiments, tactics and doctrine studies, weapon and sensor evaluations, and man-machine interface issues. The ModSAF System functions in an established simulation system environment at the Aviation Test Bed (AVTB) at Ft. Rucker, Alabama, and the Mounted Warface Test Bed (MWTB) at Ft. Knox, Kentucky, among other locations.

ModSAF was initially developed by the Defense Advanced Research Projects Agency (DARPA) What If Simulation System for Advanced Research and Development (WISSARD) and "Seamless Simulation" programs. ModSAF restructures the SIMNET Semi-Automated Forces (SIMNET SAF 3.10.6 and ODIN SAF 4.3.6) baseline to make it more open, more modular, and DIS compliant. In addition to new functionality developed under WISSARD, ModSAF focused on providing better control, more flexibility, and extensions to higher echelons, and full documentation.

With ModSAF, the operator is able to organize forces according to task, transfer control to another operator, and regroup forces for new tasks. A single operator has the ability to command vehicles simulated by more than one SAF workstation. It is also possible to checkpoint and restart a mission without re-tasking forces. Command and control information is recorded along with exercise information. The system provides beyond visual range air-to-air combat behavior, and includes improved modeling of radar, indivisibility among entities, and detection probabilities. The operator can plan higher level and more flexible missions by including contingencies for known and expected agents. The resulting ModSAF initially ran under DIS 2.0.3 protocol standards, but has been subsequently upgraded to subsequent DIS protocol versions, and then ported to use the High Level Architecture (HLA) Run Time Infrastructure (RTI).

The ModSAF ground vehicle mobility model is unchanged from the SIMNET baseline. It serves as a good example of an emulated-driver vehicle model as used in platform-level CGF simulations. These have reduced fidelity requirements from human driver trainers, and are required to run at "faster than real time" speeds.

The model has been modified for use in the OneSAF Testbed (OTB; the designated successor to ModSAF) and the Joint SAF (JSAF), so the following descriptions may not exactly correspond to particular current implementations.

2.2 Model Overview

ModSAF uses a simple parametric formulation which characterizes vehicle performance according to vehicle type and 16 soil types. These six parameters are:

- Maximum speed forward (Kilometers/Hour)
- Maximum speed reverse (Kilometers/hour)
- Maximum acceleration (Meters/second^2)
- Maximum deceleration (Meters/second^2)
- Maximum turning rate (Arc Degrees/second)
- Maximum climb angle (Arc Degrees)

In addition, a fuel usage rate is specified for engine idle and maximum power.[5]

[5] E.g., 0.125 at engine idle, and 12.5 at maximum power; the units are undefined in the documentation.

For comparison purposes, Tables 3 through 8 list the parameters for six vehicles. These vehicles were chosen based on the CCTT vehicle classes (see Table 10) and their class-specific representative vehicles.

Table 3: Wheeled Low Mobility: US M977 model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	92.0	20.0	•1.42	•4.27	•30.0	35.0
SOIL_ROAD	92.0	20.0	•1.42	•4.27	•30.0	35.0
SOIL_RCI250	92.0	20.0	•1.42	•4.27	•30.0	35.0
SOIL_RCI050	10.0	5.0	•0.99	•4.27	•30.0	35.0
SOIL_SHALLOW_WATER	5.0	5.0	•0.44	•4.27	•30.0	•45.0
SOIL_DEEP_WATER	0.0	0.0	•0.0	•4.27	•30.0	•45.0

(•: generic to all wheeled vehicles)[6]

Table 4: Wheeled High Mobility: US HMMWV model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	88.0	47.0	•1.42	•4.27	•30.0	30.0
SOIL_ROAD	88.0	47.0	•1.42	•4.27	•30.0	30.0
SOIL_RCI250	88.0	47.0	•1.42	•4.27	•30.0	30.0
SOIL_RCI050	40.0	35.0	•0.99	•4.27	•30.0	30.0
SOIL_SHALLOW_WATER	20.0	20.0	•0.44	•4.27	•30.0	•45.0
SOIL_DEEP_WATER	0.0	0.0	•0.0	•4.27	•30.0	•45.0

(•: generic to all wheeled vehicles)[7]

Table 5: Tracked Low Mobility: US M88A1 model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	49.0	49.0	•1.42	•4.27	•30.0	30.0
SOIL_ROAD	49.0	49.0	•1.42	•4.27	•30.0	30.0
SOIL_RCI250	49.0	49.0	•1.42	•4.27	•30.0	30.0
SOIL_RCI050	30.0	30.0	•0.99	•4.27	•30.0	•45.0
SOIL_SHALLOW_WATER	20.0	20.0	•0.44	•4.27	•30.0	•45.0

[6] Source file in-line comments note: "Copied from generic tracked vehicles, need real data."
[7] Source file in-line comments note: "Copied from generic tracked vehicles, need real data."

SOIL_DEEP_WATER	0.0	0.0	•0.0	•4.27	•30.0	•45.0

(•: generic to all tracked vehicles)

Table 6: Tracked Moderate Mobility: US M981 model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	18.3	18.3	•1.42	•4.27	•30.0	•45.0
SOIL_ROAD	18.3	18.3	•1.42	•4.27	•30.0	•45.0
SOIL_RCI250	18.3	18.3	•1.42	•4.27	•30.0	•45.0
SOIL_RCI050	9.0	9.0	•0.99	•4.27	•30.0	•45.0
SOIL_SHALLOW_WATER	4.0	4.0	•0.44	•4.27	•30.0	•45.0
SOIL_DEEP_WATER	0.0	0.0	•0.0	•4.27	•30.0	•45.0

(•: generic to all tracked vehicles)

Table 7: Tracked Good Mobility: US M2 model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_ROAD	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_RCI250	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_RCI050	40.0	40.0	•0.99	8.0	•30.0	•45.0
SOIL_SHALLOW_WATER	20.0	20.0	•0.44	8.0	•30.0	•45.0
SOIL_DEEP_WATER	0.0	0.0	•0.0	8.0	•30.0	•45.0

(•: generic to all tracked vehicles)

Table 8: Tracked High Mobility: US M1 model parameters

Soil Type	**Max. Speed Forward (KPH)**	**Max. Speed Reverse (KPH)**	**Max. Accel. (MPS^2)**	**Max. Decel. (MPS^2)**	**Max. Turn Rate (DPS)**	**Max. Climb Angle (Degs)**
SOIL_DEFAULT	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_ROAD	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_RCI250	85.0	85.0	•1.42	8.0	•30.0	•45.0
SOIL_RCI050	40.0	40.0	•0.99	8.0	•30.0	•45.0
SOIL_SHALLOW_WATER	20.0	20.0	•0.44	8.0	•30.0	•45.0
SOIL_DEEP_WATER	0.0	0.0	•0.0	8.0	•30.0	•45.0

(•: generic to all tracked vehicles)

In summary, for these six specific cases:

- Of 16 soil types (see Section 2.4, below), only 6 are explicitly used. Of those, only 4 actually have differing effects on vehicle mobility: DEFAULT, RCI050, SHALLOW_WATER, and DEEP_WATER. The latter is always impassable. For passable soil types, there are essentially only 3 categories:

- Hard surface: always at maximum speed
- Soft surface: 60% or less of maximum speed
- Fordable: 40% or less of maximum speed

- Wheeled vehicle values have been copied from tracked vehicle values.
- Maximum rates of acceleration are constant across vehicle types.
- Maximum turn rates are constant across vehicle types.
- In all cases, maximum climb angle is as good or better in water than on dry land.

For specific analysis and training purposes it is not uncommon to edit vehicle-specific parameter files, including ensuring that important vehicles include parameters for important soil types. When appropriate soil types are not included in a vehicle parameter file, the values used are those of SOIL_DEFAULT.

The basic approach used to calculate the actual speed of a vehicle is as follows:

- The desired speed for this vehicle is determined by the driver model (*desired_speed*)
- The current speed is read from the vehicle model (*current_speed*)
- The maximum speed for the vehicle type on the current soil type is read (*max_mps*)
  - If the vehicle is towing another object, *max_mps* is set to a maximum towing speed
  - If the vehicle is on an uphill slope, a multiplier effect is calculated which degrades *max_mps*
- If the vehicle is crossing a bridge or breaching, *desired_speed* is degraded based on parameters associated with the bridge or type of breach
- If the *desired_speed* is greater than *max_mps*, the *desired_speed* is limited to *max_mps*
- If the *current_speed* is not equal to *desired_speed*, acceleration or deceleration is taken into consideration:
  - *desired_acceleration* is calculated as (*desired_speed* - *current_speed*) / *dt*.
  - If *desired_acceleration* is less than the *maximum_acceleration* on the current soil type
    - *current_speed* is set to *desired_speed*
  - Else
    - *current_speed* is calculated as *current_speed* + (*maximum_acceleration* * *dt*)

A similar approach is used for deceleration, and movement in reverse. Finally, there may then be further degradation of the vehicle speed, and the time it takes to complete the driver-specified path, due to presence of terrain obstacles that must be negotiated.

2.3 Slope

The ModSAF ground vehicle mobility model compares the slope value along the direction of vehicle travel, and if it exceeds a vehicle-specific maximum climb angle for the current soil type then the vehicle stops. Below the threshold, terrain slope has a multiplicative degradation effect on vehicle speed. High lateral slopes may cause tracked vehicles to “throw a track” and stop.

2.4 Trafficability

The ModSAF ground vehicle mobility model defines 16 surface types, called “soil types” (see Table 9) for modeling ground vehicle mobility. Each surface type denotes a qualitative surface strength, surface slipperiness, the presence of stemmed vegetation, the presence of overlying water, and the presence and depth of certain unique conditions.

Table 9: ModSAF Soil Types

Index	Soil Type	Description
0	SOIL_DEFAULT	Unknown type of soil
1	SOIL_ROAD	Asphalt or other hard surface
2	SOIL_RCI250	Packed soil or dirt road
3	SOIL_RCI050	Soft sandy soil
4	SOIL_DEEP_WATER	Impassable deep water
5	SOIL_SHALLOW_WATER	Passable shallow water

6	SOIL_MUD	Muddy soil
7	SOIL_MUDDY_ROAD	Wet dirt road
8	SOIL_ICE	Slick ice surface
9	SOIL_SWAMP	Very soft surface
10	SOIL_FORESTED	Canopy or forested area
11	SOIL_US_RAILROAD	Railroad w/ US specifications
12	SOIL_EURO_RAILROAD	Railroad w/ European specs.
13	SOIL_ROCKY	Small rocks <= 18 inches
14	SOIL_BOULDERS	Large boulders 6 ft. high
15	SOIL_FLIMSY	Indoor surface for dismounted infantry
15[8]	SOIL_NO_GO	Terrain that is not traversable

The ModSAF ground vehicle mobility model generally treats stemmed vegetation and localized terrain obstacles (e.g., anti-tank ditches) as discrete objects which are handled by either maneuvering (avoidance) or as a series of localized slopes. Snow does not currently affect ground vehicle movement in ModSAF.

3. CCTT Trafficability

3.1 Background

The Close Combat Tactical Trainer (CCTT) is the first system in the Combined Arms Tactical Trainer (CATT) family of training systems. CCTT utilizes the Distributed Interactive Simulation (DIS) network protocol to provide a virtual environment for training armor and mechanized infantry personnel. CCTT is composed of a variety of manned modules, an Operations Center (OC), Semi-Automated Forces (SAF), and several support workstations.

The manned module vehicles (MMV) are cabin simulations with virtual out-the-window views for training on vehicles such as the M1A1, M1A2, and M113. The CCTT manned modules, OC, and SAF use the same terrain model to support mobility modeling.

SAF and OC provide emulated vehicles to populate the battlefield; they share a common CGF architecture. SAF provides a wide range of both BLUFOR (friendly) and OPFOR (enemy) entities. OC provides BLUFOR entities to support battalion staff training and to add depth to the battlefield with entities which provide resupply, maintenance, combat engineering, and fire support capabilities. Both SAF and OC are controlled via user interfaces provided on the SAF Workstations and OC Workstations, respectively. The actual simulation of the SAF and OC entities is provided by separate CGF processors dedicated to entity simulation.

The CCTT manned modules and SAF use the same terrain model to support ground vehicle mobility modeling, however the manned modules require a higher level of fidelity in order to support crew training. In order to preserve interoperability between the manned modules and the SAF, a more complex model of ground vehicle mobility is used in the CGF architecture than might be otherwise warranted.

The CCTT SAF ground vehicle mobility model is an emulated-driver vehicle model which while having reduced fidelity requirements from the associated manned module human driver trainers uses the same model of terrain trafficability. It is only required to run at "real time" speeds, as is the manned module.

The model has been modified and enhanced subsequent to the initial fielding of CCTT, so the following descriptions may not exactly correspond to a particular implementation.

[8] Note that this index has two associated meanings, depending on the terrain database in which it appears.

3.2 Model Overview

The CCTT ground vehicle mobility model is based on a general first-principle dynamics model (see Figure 2).

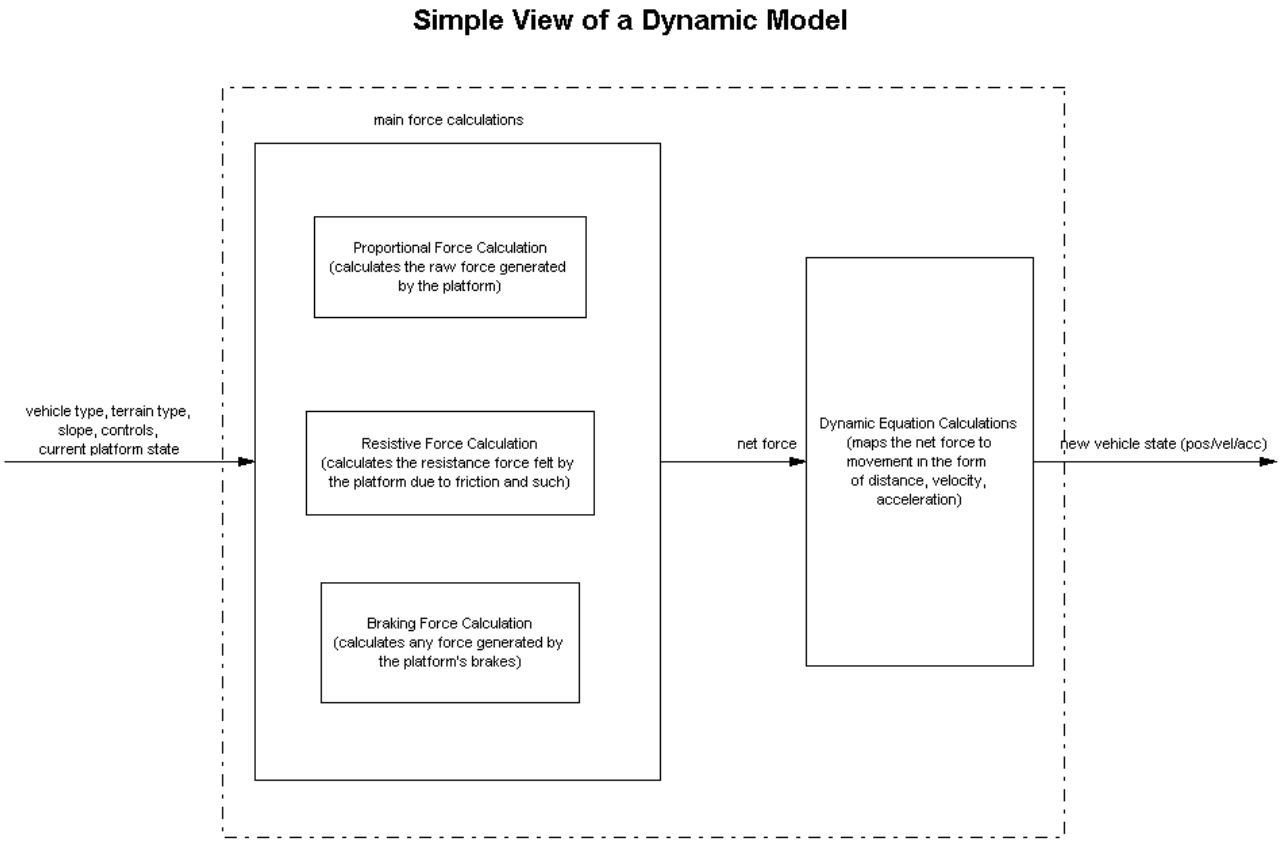

Figure 2: General Dynamics Model Formulation

The model integrates explicit driver inputs (e.g., throttle, brake) with vehicle class-specific velocity, resistance force, and deceleration pre-computed curves (see Figures 3 and 4).

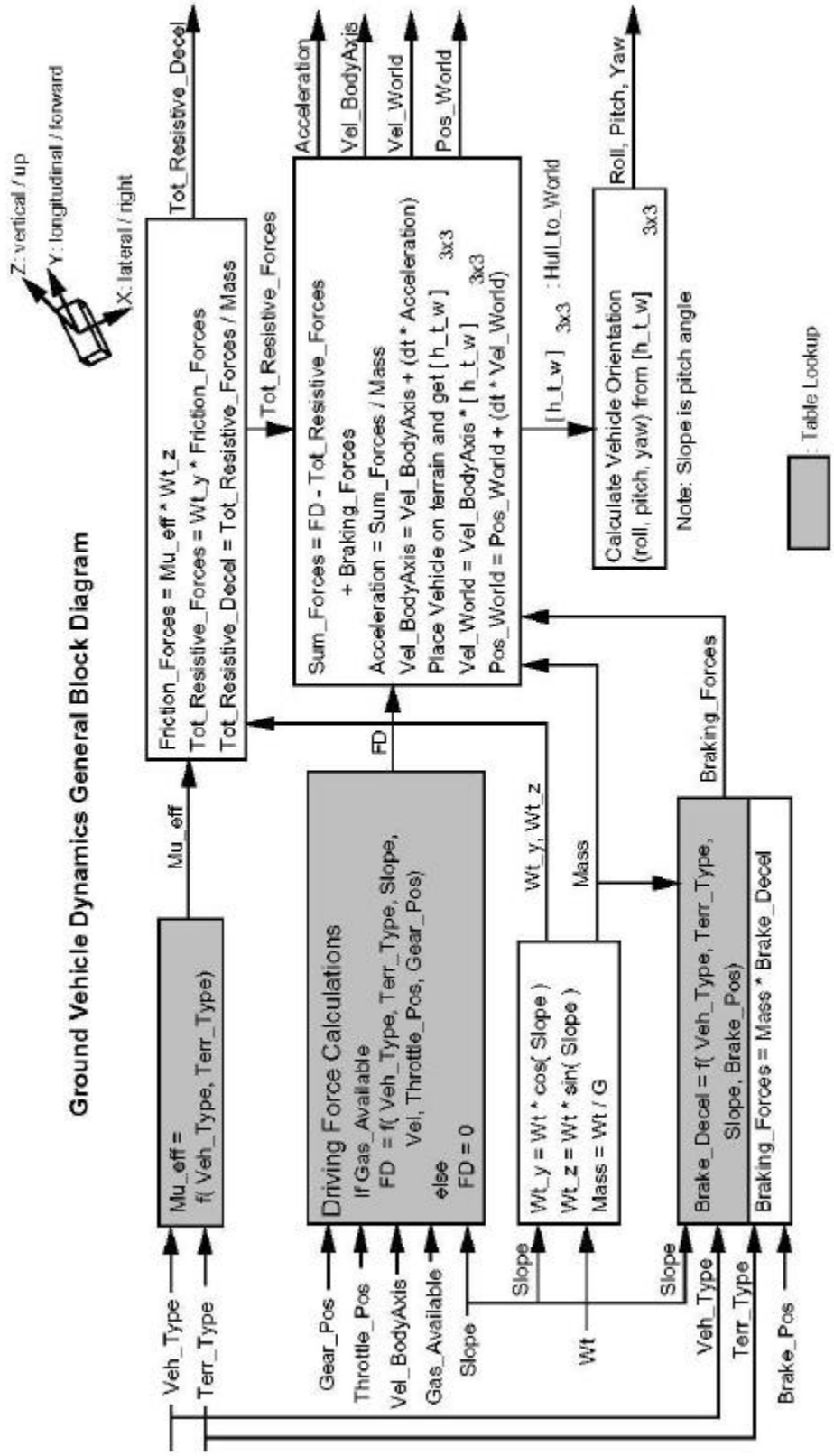

Figure 3: CCTT Vehicle Dynamics Block Diagram

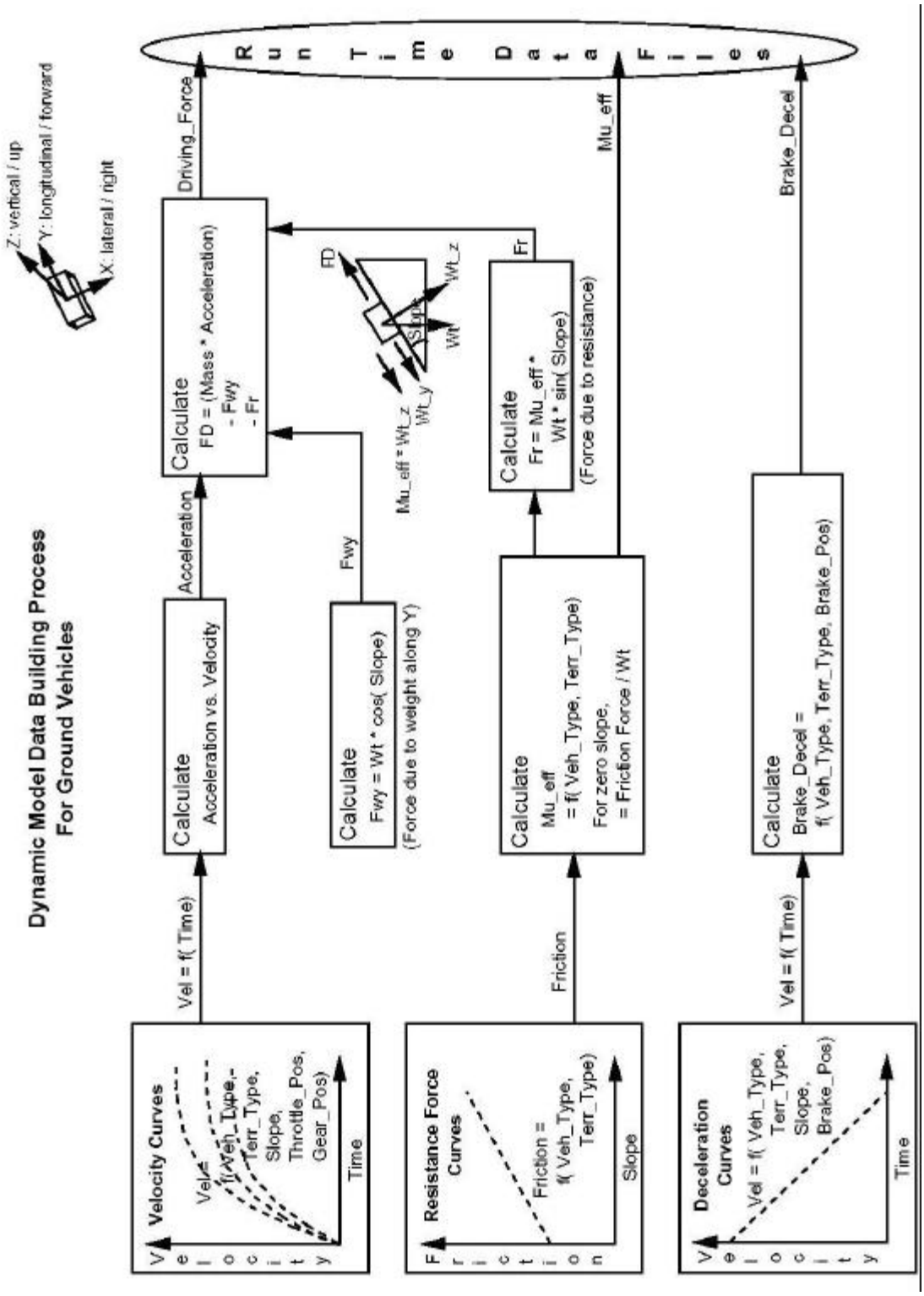

Figure 4: CCTT Use of Velocity, Resistance Force, and Deceleration Curves

The various types of CCTT manned module vehicles are binned into 6 classes based on the ground-contact system used and general mobility characteristics (see Table 10). For each class, the three (velocity, resistance force, and deceleration) curves are pre-computed using NRMM for each of the 30 terrain codes (see Section 3.4, below).

Table 10: CCTT Vehicle Classes

SAF Class	Representative Vehicle	Other Vehicles in Class
Wheeled: Low Mobility	M977 HEMTT (10 Ton Cargo Truck)	M978 HEMTT FS, M984E1 HEMTT Wrecker, M985 HEMTT (10 Ton Cargo Truck), BRDM2 ATGW with 4 AT5, 2S12 120mm Mortar, GAZ-66 Truck, KRAZ Truck
Wheeled: High Mobility	M1025 HMMWV	M93 NBC Recon Vehicle, M1043 HMMWV, M1044 HMMWV, M106A2, M1064, M998 HMMWV, BRDM2, BTR 60P, M1078 LMTV, M1079 LMTV, M1083 MTV, M1089 MTV Wrecker, M1091 MTV, HMMWV with TOW Launcher, MTR 80, UAZ469 Medium Truck, French AMX 10 RAC
Tracked: Low Mobility	M60 Series AVLB	M728 CEV, M9 ACE, M88A1 Tank Recovery Vehicle, T62 w/o Reactive Armor, British Challenger MBT, British Chieftain MBT, French AMX 30 MBT
Tracked: Moderate Mobility	M981 FISTV	M113A3 APC, M113A1 APC/Ambulance, M577A2 CP, GMZ Tracked Mine Layer, MTU-20 AVLB, MTK-2 Mine Clearer, BREM1 Recovery Vehicle, ZSU 23-4 Quad 23mm, 2S19 152mm Self-propelled Howitzer, 2S3 152mm Self-propelled Howitzer, 2S6 Quad 30mm 8 SA 19
Tracked: Good Mobility	M2A2 BFVS	M992 FAASV, M109A6 Self-propelled Howitzer, M270 MLRS, BMPIKsh, BMPIP, SA-13 Air Defense Missle Artillery, BAT-2 Route Clearing Vehicle, SA-15 Air Defense Missile Artillery, T64/T64B w/Reactive Armor, 2S1 122mm Self-propelled Howitzer
Tracked: High Mobility	M1A1 MBT	T80, BMPII, BMPIII, 9P149 (MTLB w/AT6), 1V12 MT-LB Variant (Jamming Variant), German Leopard II MBT, German Marder2, T72, French AMX 40 LeClerc MBT, Leopard IA4, British Warrior

3.3 Slope

The CCTT ground vehicle mobility model defines 11 slope classes (see Table 11). Each class represents a range of slope values along the direction of vehicle travel, and is treated as a single representative slope in the ground vehicle mobility model.

Table 11: CCTT Slope Classes

Slope Class	Slope Range (Percent)	Representative Slope (Percent)
1	<= (– 60)	– 60
2	– (40 - 60)	– 50
3	– (20 - 40)	– 30
4	– (5 - 20)	– 13
5	– (0 - 5)	– 3
6	0	0

7	0 - 5	3
8	5 - 20	13
9	20 - 40	30
10	40 - 60	50
11	>= 60	60

3.4 Trafficability

The CCTT ground vehicle mobility model defines 30 terrain codes (see Table 12) for modeling ground vehicle mobility and designates an associated correlation from the material codes used in the image generator for the manned modules. Each terrain code denotes a surface type (generally soil), both qualitative and quantitative surface strengths, surface slipperiness, the presence of non-stemmed vegetation, and the presence and depth of overlying water.

Table 12: CCTT Terrain Codes

Terrain Code	USCS Soil Type or Surface Type	Qualitative Soil Strength	CI / RCI
1	SP, SW	Soft	35
2	SP, SW	Average	100
3	SP, SW	Hard	130
4	SM, SC, ML, ML, CH, MH, OL, OH	Very Soft	25
5	GW, GP, GM, GC, SM, SC, CL, ML, CH, MH, OL, OH	Soft	35
6	SM, SC, CL, ML, CH, MH, OL, OH	Average - Soft	50
7	SM, SC, CL, ML, CH, MH, OL, OH	Average - Hard	80
8	SM, SC, CL, ML, MH, OL	Hard	130
9	GW, GP, GM, GC, SM, SC, CL, ML, MH, OL	Very Hard	280
10	SM, SC, CL, ML, MH, OL	Hard (Slippery)	130
11	SM, SC, CL, ML, MH, OL	Very Hard (Slippery)	280
12	CH, OH	Hard	130
13	CH, OH	Very Hard	280
14	CH, OH	Hard (Slippery)	130
15	CH, OH	Very Hard (Slippery)	280
16	PT	Dry Peat	40
17	GW, GP, GM, HC, Rock	Dry Loose Surface Road	300
18	GW, GP, GM, HC, Rock	Wet Loose Surface Road	300
19	NO-GO	Swamps, Bogs, Etc.	10
20	Concrete, Asphalt	Dry Pavement	600
21	Concrete, Asphalt	Wet Pavement	600
22	SM, SC, CL, ML, CH, MH, OL, OH	Brushland - Medium	80
23	SM, SC, CL, ML, CH, MH, OL, OH	Brushland - Hard	280
24	SM, SC, CL, ML, CH, MH, OL, OH	Brushland - Medium (Slippery)	80
25	SM, SC, CL, ML, CH, MH, OL, OH	Brushland - Hard (Slippery)	280

26	Water w/ (Silts and Clays) Bottom	Depth 16 inches	25
27	Water w/ (Silts and Clays) Bottom	Depth 33 inches	25
28	Water w/ (Silts and Clays) Bottom	Depth 60 inches	25
29	Water w/ (Bedrock, Gravel, Paved) Bottom	Depth 16 inches	300
30	Water w/ (Bedrock, Gravel, Paved) Bottom	Depth 33 incles	300

The CCTT ground vehicle mobility model treats stemmed vegetation and localized terrain obstacles (e.g., anti-tank ditches) as discrete objects which are handled by either maneuvering (avoidance) or an obstacle-specific movement algorithm. Snow is not currently modeled in CCTT.

4. WARSIM Trafficability

4.1 Background

WARSIM (Warfightering Simulation) is a simulation developed for the purpose of training U.S. Army commanders and their staffs from a battalion through a theater level war. The level of fidelity in modeling ground vehicle mobility considers platform-level issues, however a large amount of behavior will be aggregated to the platoon level. The reasons for the platform representation of movement are multiple. First, the mobile capability of individual platforms within a group must be considered (requiring explicit calculation) when deciding on a commanded speed for the group. In addition, platforms must appear “tactically” correct—moving platforms must keep a commanded speed, formation and avoid obstacles. Also, since targeting of individual platforms will occur, individual platforms may be lost from the parent unit due to attrition and casualties. Each moving platform must be accounted for within the WARSIM infrastructure with a specific location, and sensors must be able to track platform-specific information during the simulation. An abstract platoon object is used to direct the corresponding movement components of an “equipment group” and tasks common to all constituent platforms are handled by this object. An example is one platoon following another platoon on a route – a basic road march order.

The WARSIM ground vehicle mobility model is similar to emulated-driver vehicle models as used in platform-level CGF simulations (e.g., ModSAF). It has significantly reduced fidelity requirements from human driver trainers, and is specifically required to run at "faster than real time" speeds – a critical requirement for most aggregate-level simulations.

The model has been tweaked subsequent to its initial development, so the following descriptions may not exactly correspond to a particular implementation.

4.2 Model Overview

The WARSIM ground vehicle mobility model is derived from the NATO Reference Mobility Model II (NRMM II; see Section 5, below). Performance concerns resulted in a design based on table look-up. Many of the detailed inputs needed for the NRMM II are inferred, simplified, or aggregated to reduce the amount of data produced in the form of “speed reduction factors” or SRFs for the various representative mobility bundles within WARSIM. The overall design is as illustrated in Figure 5.

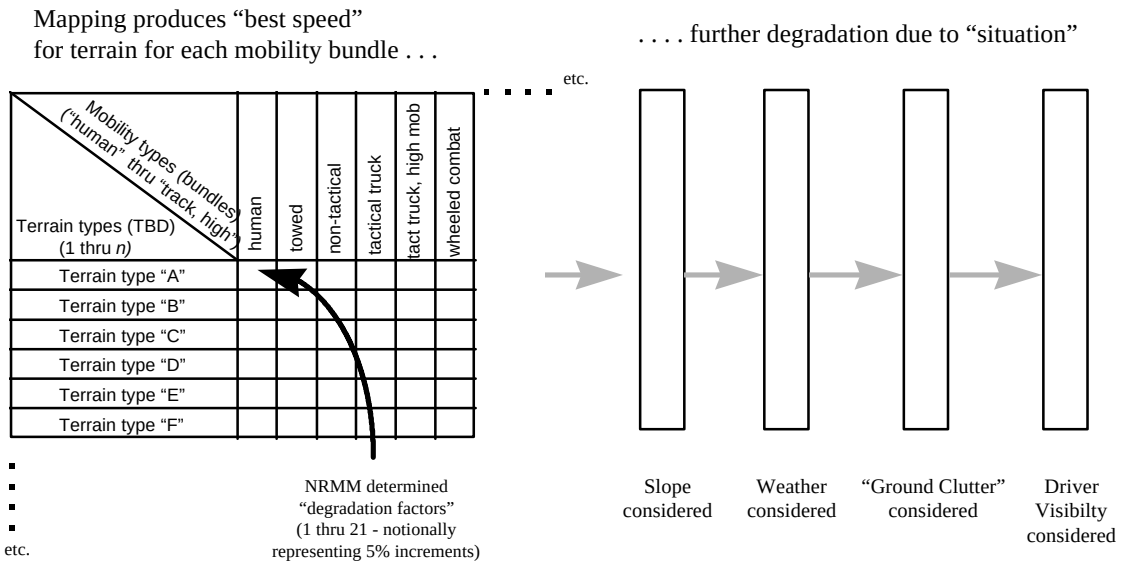

Figure 5: WARSIM mobility model data flow

WARSIM represents more than 200 towed, wheeled, or tracked ground mobility platforms. In order to define their ground mobility capabilities without obtaining a complete set of all the required inputs needed for the NRMM II for each platform, platforms with similar characteristics are grouped or categorized into nine bundles as listed in Table 13. A representative vehicle is used to representing the mobility capability of each bundle.

Table 13: WARSIM Mobility Bundles and associated Representative Vehicle

WARSIM Mobility Bundle	Representative Vehicle
Low-mobility Towed	M911 with M747 heavy equipment transporter (HET) trailer
Medium-mobility Towed	M923, 5-ton Truck towing an M1061, 1 ½ ton trailer
High-mobility Towed	Medium Tactical Vehicle (MTV, like the M1084) towing an M1061 trailer
Low-mobility Wheeled	M911 HET
Medium-mobility Wheeled	M923, 5-ton Truck
High-mobility Wheeled	MTV
Low-mobility Tracked	Armored Vehicle Launched Bridge
Medium-mobility Tracked	M113A3 Armored Personnel Carrier
High-mobility Tracked	M1A1 Main Battle Tank

The bundles are defined by the uniform application of the speed reduction factors (SRF) produced from running the NRMM II against a representative vehicle or representative combination of trailer and prime mover for the "towed" bundles. The appropriate SRF is applied to each platform's maximum road speed to determine the "best speed" which that platform could physically achieve in its current conditions. The "best speed" may vary between platforms belonging to the same mobility bundle, if their baseline maximum speeds are different.

The speed reduction factors (see Figure 1) are pre-computed using NRMM II for the representative vehicle for each mobility bundle under multiple conditions. These conditions are:

- Slope: 8 bands from "minus" (-)40% to "plus" (+)40 % including zero slope or level ground.
- Surface condition: 2 values – wet and dry.
- Obstacle spacing: 4 values – "no clutter", 30 feet, 25 feet, and 20 feet.

- Situational visibility: 4 values – unlimited, 100 feet, 50 feet, and 25 feet.

Figure 6 illustrates how the environmental conditions, the ground vehicle, and the commanded speed relate to each other.

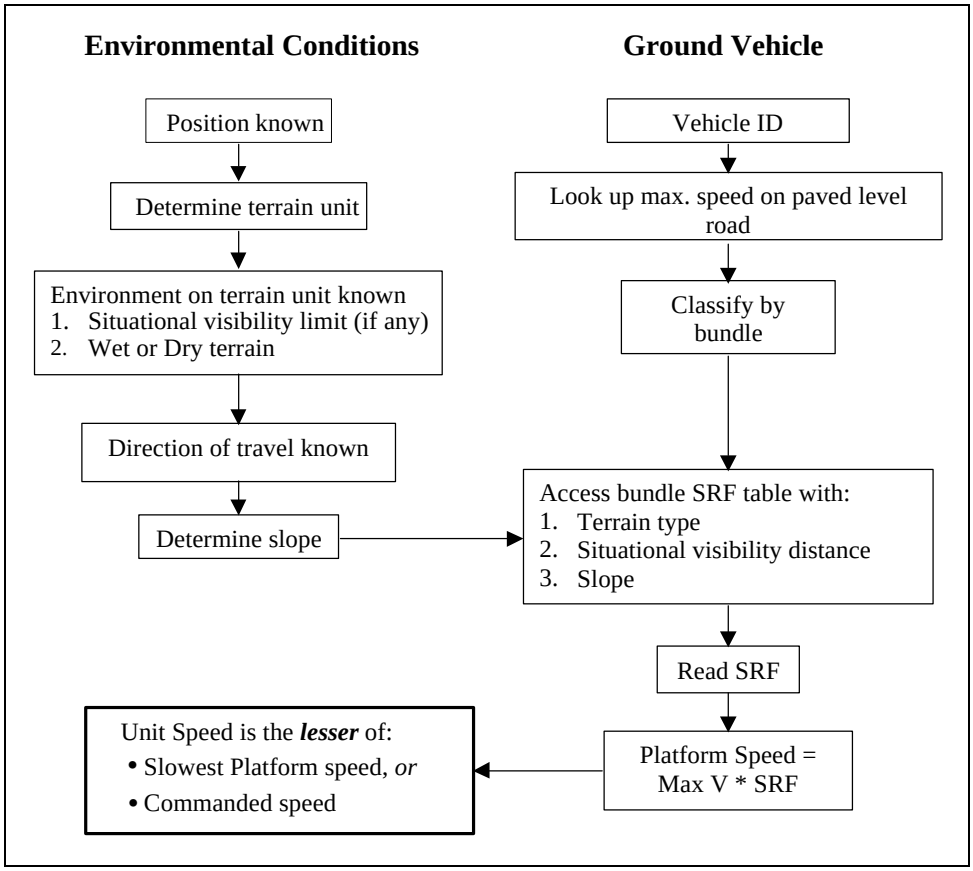

Figure 6: WARSIM Abstract Mobility Model Logic Diagram

The terrain type stored in the runtime terrain database is termed the "Surface Trafficability Group, JSIMS Mobility Model (STGJ)", and is defined as: "The index used by the US DoD Joint Simulation System (JSIMS) to describe the trafficability of a terrain unit with respect to ground forces. This value is used to index one or more lookup tables associated with the ground forces mobility model in order to predict or analyze ground force movements (e.g., units, vehicles, infantry)." There are 807 individual types recognized (see Section 4.4), however these are currently mapped to a smaller set of 255 types for use in indexing the SRF table.

Figure 7 summarizes the WARSIM system-level approach to ground vehicle mobility modeling using offline lookup table generation, runtime lookup, and multiplicative degradation for weather and soil moisture.

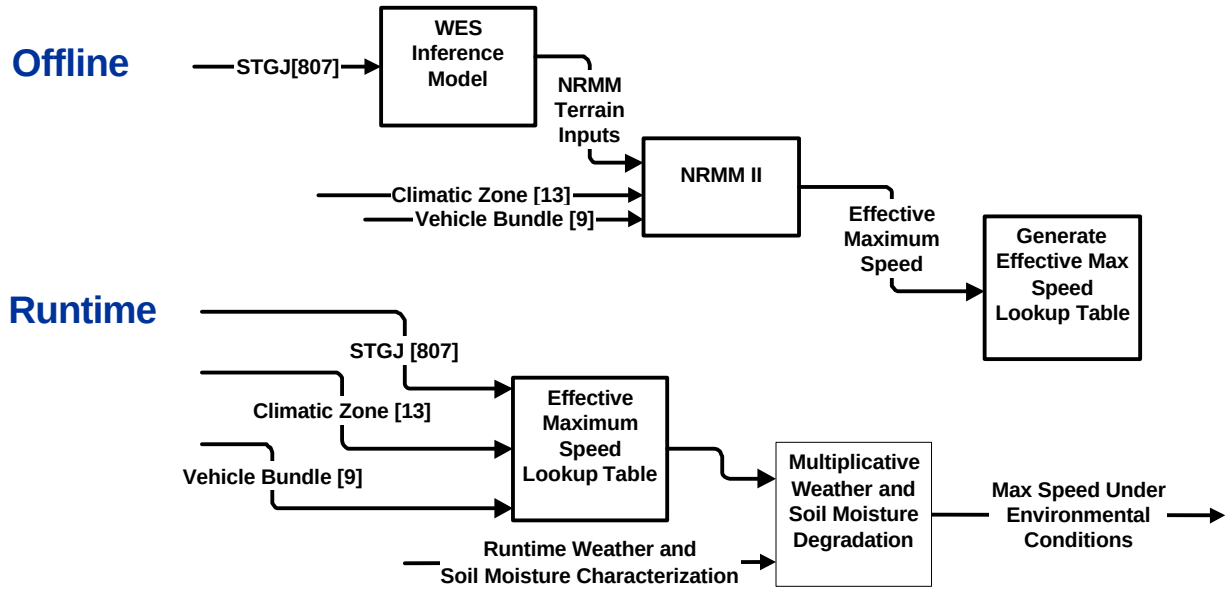

Figure 7: WARSIM System-Level Mobility Model Data Flow

4.3 Slope

The WaRSIM ground vehicle mobility model defines 8 slope classes (see Section 4.2). Each class represents a range of slope values along the direction of vehicle travel, and is treated as a single representative slope in the SRF table.

4.4 Trafficability

The WARSIM ground vehicle mobility model defines 807 terrain codes (see Table 14) for modeling ground vehicle mobility. Each terrain code denotes a unique combination of feature type (if applicable), surface type (generally soil), the presence and type of vegetation (including crops as well as brush/undergrowth), and the presence of unique landforms (e.g., sand dunes).

Table 14: WARSIM Terrain Codes

Code	Definition
0	Default
1	Areal Urban: MINE
2	Areal Urban: QUARRY
3	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: GW
4	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: GP
5	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: GM
6	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: GC
7	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: SW
8	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: SP
10	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: SC
11	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: ML
12	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: CL
13	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: OL
14	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: CH
15	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: MH
16	Areal Urban: OIL_OR_GAS_FIELD; SOIL_TYPE: OH
17	Areal Urban: PROCESSING_PLANT
18	Areal Urban: SETTLING_POND

19	Areal Urban: OIL_OR_GAS_FACILITIES
20	Areal Urban: POWER_PLANT
21	Areal Urban: SUBSTATION
27	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: SW
28	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: SP
29	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: SM
30	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: SC
31	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: ML
32	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: CL
33	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: OL
34	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: CH
35	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: MH
36	Areal Urban: AMUSEMENT_PARK; SOIL_TYPE: OH
37	Areal Urban: GRANDSTAND
38	Areal Urban:RACE_TRACK; SOIL_TYPE: GW
39	Areal Urban:RACE_TRACK; SOIL_TYPE: GP
40	Areal Urban:RACE_TRACK; SOIL_TYPE: GM
41	Areal Urban:RACE_TRACK; SOIL_TYPE: GC
42	Areal Urban:RACE_TRACK; SOIL_TYPE: SW
43	Areal Urban:RACE_TRACK; SOIL_TYPE: SP
44	Areal Urban:RACE_TRACK; SOIL_TYPE: SM
45	Areal Urban:RACE_TRACK; SOIL_TYPE: SC
46	Areal Urban:RACE_TRACK; SOIL_TYPE: ML
47	Areal Urban:RACE_TRACK; SOIL_TYPE: CL
48	Areal Urban:RACE_TRACK; SOIL_TYPE: OL
49	Areal Urban:RACE_TRACK; SOIL_TYPE: CH
50	Areal Urban:RACE_TRACK; SOIL_TYPE: MH
51	Areal Urban:RACE_TRACK; SOIL_TYPE: OH
52	Areal Urban: STADIUM_OR_AMPHITHEATRE
53	Areal Urban: BUILDING
54	Areal Urban: BUILT_UP_AREA
55	Areal Urban: SETTLEMENT; SOIL_TYPE: GW
56	Areal Urban: SETTLEMENT; SOIL_TYPE: GP
57	Areal Urban: SETTLEMENT; SOIL_TYPE: GM
58	Areal Urban: SETTLEMENT; SOIL_TYPE: GC
59	Areal Urban: SETTLEMENT; SOIL_TYPE: SW
60	Areal Urban: SETTLEMENT; SOIL_TYPE: SP
61	Areal Urban: SETTLEMENT; SOIL_TYPE: SM
62	Areal Urban: SETTLEMENT; SOIL_TYPE: SC
63	Areal Urban: SETTLEMENT; SOIL_TYPE: ML
64	Areal Urban: SETTLEMENT; SOIL_TYPE: CL
65	Areal Urban: SETTLEMENT; SOIL_TYPE: OL
66	Areal Urban: SETTLEMENT; SOIL_TYPE: CH
67	Areal Urban: SETTLEMENT; SOIL_TYPE: MH
68	Areal Urban: SETTLEMENT; SOIL_TYPE: OH
69	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: GW
70	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: GP
71	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: GM
72	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: GC
73	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: SW

74	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: SP
75	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: SM
76	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: SC
77	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: ML
78	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: CL
79	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: OL
80	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: CH
81	Areal Urban: NATIVE_SETTLEMENT; SOIL_TYPE: MH
100	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
101	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
102	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
103	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
104	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
105	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Bedrock
106	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Paved
107	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Peat
108	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
109	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
110	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Coral
111	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Slash
112	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Seamount
113	Areal Water: FORESHORE; BOTTOM_MATERIALS_COMPOSITION: Sand
114	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
115	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
116	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
117	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
118	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
119	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Bedrock
120	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Paved
121	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Peat
122	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
123	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
124	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Coral
125	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Slash
126	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Seamount
127	Areal Water: WATER_EXCEPT_INLAND; BOTTOM_MATERIALS_COMPOSITION: Sand
128	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
129	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
130	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
131	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
132	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
133	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Bedrock
134	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Paved
135	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Peat
136	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
137	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
138	Areal Water or Hydrography: AQUEDUCT; BOTTOM_MATERIALS_COMPOSITION: Sand

139	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
140	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
141	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
142	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
143	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
144	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Bedrock
145	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Paved
146	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Peat
147	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
148	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
149	Areal Water or Hydrography: CANAL; BOTTOM_MATERIALS_COMPOSITION: Sand
150	Areal Urban: FILTRATION_BEDS
151	Areal Water: FISH_HATCHERY
152	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
153	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
154	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
155	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
156	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
157	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Bedrock
158	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Paved
159	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Peat
160	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
161	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
162	Areal Water: LAKE_OR_POND; BOTTOM_MATERIALS_COMPOSITION: Sand
163	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: GW
164	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: GP
165	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: GM
166	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: GC
167	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: SW
168	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: SP
169	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: SM
170	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: SC
171	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: ML
172	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: CL
173	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: OL
174	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: CH
175	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: MH
176	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: OH

177	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: <= 25, SOIL_TYPE: PT
178	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: GW
179	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: GP
180	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: GM
181	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: GC
182	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: SW
183	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: SP
184	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: SM
185	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: SC
186	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: ML
187	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: CL
188	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: OL
189	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: CH
190	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: MH
191	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: OH
192	Areal Vegetation: MARSH_OR_SWAMP; DENSITY_MEASURE_PERCENT_OF_TREE_OR_CANOPY_COVER: >= 26, SOIL_TYPE: PT
193	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
194	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
195	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
196	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
197	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Bedrock
198	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Paved
199	Hydrography: RAPIDS; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
200	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
201	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
202	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
203	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
204	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
205	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Bedrock
206	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Paved
207	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Peat
208	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
209	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
210	Areal Water: RESERVOIR; BOTTOM_MATERIALS_COMPOSITION: Sand
211	Areal Vegetation: RICE_FIELD; SOIL_TYPE: GW
212	Areal Vegetation: RICE_FIELD; SOIL_TYPE: GP
213	Areal Vegetation: RICE_FIELD; SOIL_TYPE: GM

214	Areal Vegetation: RICE_FIELD; SOIL_TYPE: GC
215	Areal Vegetation: RICE_FIELD; SOIL_TYPE: SW
216	Areal Vegetation: RICE_FIELD; SOIL_TYPE: SP
264	Areal Vegetation: TUNDRA; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Tundra
265	Areal Vegetation: TUNDRA; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Tundra
266	Areal Vegetation: TUNDRA; SOIL_TYPE: PT, VEGETATION_CHARACTERISTIC: Tundra
267	Areal Physiography: SNOW_FIELD; SNOW_OR_ICE_CATEGORY: Snow
268	Areal Physiography: SNOW_FIELD; SNOW_OR_ICE_CATEGORY: Ice
269	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: GW
270	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: GP
271	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: GM
272	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: GC
273	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: SW
274	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: SP
275	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: SM
276	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: SC
277	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: ML
278	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: CL
279	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: OL
280	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: CH
281	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: MH
282	Areal Physiography: GROUND_SURFACE_ELEMENT; SOIL_TYPE: OH
283	Areal Physiography: ROCK_STRATA_OR_ROCK_FORMATION
284	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: GP
285	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: GM
286	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: GC
287	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: SW
288	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: SP
289	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: SM
290	Areal Physiography: SAND_DUNE_OR_HILLS; SOIL_TYPE: SC
291	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: GW
292	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: GW
293	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: GW
294	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: GW
295	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: GW
296	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: GW
297	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: GW
298	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: GW
299	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: GW
300	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: GW
301	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: GP
302	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: GP
303	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: GP
304	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: GP
305	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: GP
306	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern),

	SOIL_TYPE: GP
307	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: GP
308	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: GP
309	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: GP
310	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: GP
311	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: GM
312	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: GM
313	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: GM
314	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: GM
315	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: GM
316	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: GM
317	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: GM
318	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: GM
319	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: GM
320	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: GM
321	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: GC
322	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: GC
323	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: GC
324	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: GC
325	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: GC
326	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: GC
327	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: GC
328	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: GC
329	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: GC
330	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: GC
331	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: SW
332	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: SW
333	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: SW
334	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: SW
335	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: SW
336	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: SW
337	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: SW
338	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: SW
339	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: SW
340	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: SW
341	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: SP
342	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: SP
343	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: SP
344	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: SP

345	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: SP
346	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: SP
347	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: SP
348	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: SP
349	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: SP
350	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: SP
351	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: SM
352	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: SM
353	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: SM
354	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: SM
355	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: SM
356	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: SM
357	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: SM
358	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: SM
359	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: SM
360	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: SM
361	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: SC
362	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: SC
363	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: SC
364	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: SC
365	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: SC
366	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: SC
367	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: SC
368	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: SC
369	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: SC
370	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: SC
371	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: ML
372	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: ML
373	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: ML
374	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: ML
375	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: ML
376	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: ML
377	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: ML
378	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: ML
379	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: ML
380	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: ML
381	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: CL
382	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: CL

383	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: CL
384	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: CL
385	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: CL
386	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: CL
387	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: CL
388	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: CL
389	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: CL
390	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: CL
391	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: OL
392	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: OL
393	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: OL
394	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: OL
395	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: OL
396	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: OL
397	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: OL
398	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: OL
399	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: OL
400	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: OL
401	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: CH
402	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: CH
403	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: CH
404	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: CH
405	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: CH
406	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: CH
407	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: CH
408	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: CH
409	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: CH
410	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: CH
411	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: MH
412	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: MH
413	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: MH
414	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: MH
415	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: MH
416	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: MH
417	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: MH
418	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: MH
419	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: MH
420	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: MH
421	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Unknown, SOIL_TYPE: OH

422	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Slash and Burn-Shifting cultivation, SOIL_TYPE: OH
423	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Permanent field, SOIL_TYPE: OH
424	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Ditch Irrigation, SOIL_TYPE: OH
425	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Grazing, SOIL_TYPE: OH
426	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Regular (planting pattern), SOIL_TYPE: OH
427	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Linear (planting pattern), SOIL_TYPE: OH
428	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Not Applicable, SOIL_TYPE: OH
429	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Type of field Pattern, SOIL_TYPE: OH
430	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Other, SOIL_TYPE: OH
431	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: GW
432	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: GP
433	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: GM
434	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: GC
435	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: SW
436	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: SP
437	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: SM
438	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: SC
439	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: ML
440	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: CL
441	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: OL
442	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: CH
443	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: MH
444	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Terraced, SOIL_TYPE: OH
445	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: GW
446	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: GP
447	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: GM
448	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: GC
449	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: SW
450	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: SP
451	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: SM
452	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: SC
453	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: ML
454	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: CL
455	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: OL
456	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: CH
457	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: MH
458	Areal Vegetation: CROPLAND; FARMING_TYPE_CATEGORY: Crop Rotation, SOIL_TYPE: OH
459	Areal Vegetation: ORCHARD; SOIL_TYPE: GW
460	Areal Vegetation: ORCHARD; SOIL_TYPE: GP
461	Areal Vegetation: ORCHARD; SOIL_TYPE: GM
462	Areal Vegetation: ORCHARD; SOIL_TYPE: GC
463	Areal Vegetation: ORCHARD; SOIL_TYPE: SW
464	Areal Vegetation: ORCHARD; SOIL_TYPE: SP
465	Areal Vegetation: ORCHARD; SOIL_TYPE: SM
466	Areal Vegetation: ORCHARD; SOIL_TYPE: SC
467	Areal Vegetation: ORCHARD; SOIL_TYPE: ML
468	Areal Vegetation: ORCHARD; SOIL_TYPE: CL

469	Areal Vegetation: ORCHARD; SOIL_TYPE: OL
470	Areal Vegetation: ORCHARD; SOIL_TYPE: CH
471	Areal Vegetation: ORCHARD; SOIL_TYPE: MH
472	Areal Vegetation: ORCHARD; SOIL_TYPE: OH
473	Areal Vegetation: VINEYARD; SOIL_TYPE: GW
474	Areal Vegetation: VINEYARD; SOIL_TYPE: GP
475	Areal Vegetation: VINEYARD; SOIL_TYPE: GM
476	Areal Vegetation: VINEYARD; SOIL_TYPE: GC
477	Areal Vegetation: VINEYARD; SOIL_TYPE: SW
478	Areal Vegetation: VINEYARD; SOIL_TYPE: SP
479	Areal Vegetation: VINEYARD; SOIL_TYPE: SM
480	Areal Vegetation: VINEYARD; SOIL_TYPE: SC
481	Areal Vegetation: VINEYARD; SOIL_TYPE: ML
482	Areal Vegetation: VINEYARD; SOIL_TYPE: CL
483	Areal Vegetation: VINEYARD; SOIL_TYPE: OL
484	Areal Vegetation: VINEYARD; SOIL_TYPE: CH
485	Areal Vegetation: VINEYARD; SOIL_TYPE: MH
486	Areal Vegetation: VINEYARD; SOIL_TYPE: OH
487	Areal Vegetation: HOPS; SOIL_TYPE: GW
488	Areal Vegetation: HOPS; SOIL_TYPE: GP
489	Areal Vegetation: HOPS; SOIL_TYPE: GM
490	Areal Vegetation: HOPS; SOIL_TYPE: GC
491	Areal Vegetation: HOPS; SOIL_TYPE: SW
492	Areal Vegetation: HOPS; SOIL_TYPE: SP
493	Areal Vegetation: HOPS; SOIL_TYPE: SM
494	Areal Vegetation: HOPS; SOIL_TYPE: SC
495	Areal Vegetation: HOPS; SOIL_TYPE: ML
496	Areal Vegetation: HOPS; SOIL_TYPE: CL
497	Areal Vegetation: HOPS; SOIL_TYPE: OL
498	Areal Vegetation: HOPS; SOIL_TYPE: CH
499	Areal Vegetation: HOPS; SOIL_TYPE: MH
500	Areal Vegetation: HOPS; SOIL_TYPE: OH
501	Areal Vegetation: GRASSLAND; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
502	Areal Vegetation: GRASSLAND; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Tropical Grass
503	Areal Vegetation: GRASSLAND; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
504	Areal Vegetation: GRASSLAND; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Tropical Grass
505	Areal Vegetation: GRASSLAND; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
506	Areal Vegetation: GRASSLAND; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Tropical Grass
507	Areal Vegetation: GRASSLAND; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
508	Areal Vegetation: GRASSLAND; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Tropical Grass
509	Areal Vegetation: GRASSLAND; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
510	Areal Vegetation: GRASSLAND; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Tropical Grass

511	Areal Vegetation: GRASSLAND; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
512	Areal Vegetation: GRASSLAND; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Tropical Grass
513	Areal Vegetation: GRASSLAND; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
514	Areal Vegetation: GRASSLAND; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Tropical Grass
515	Areal Vegetation: GRASSLAND; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
516	Areal Vegetation: GRASSLAND; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Tropical Grass
517	Areal Vegetation: GRASSLAND; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
518	Areal Vegetation: GRASSLAND; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Tropical Grass
519	Areal Vegetation: GRASSLAND; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
520	Areal Vegetation: GRASSLAND; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Tropical Grass
521	Areal Vegetation: GRASSLAND; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
522	Areal Vegetation: GRASSLAND; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Tropical Grass
523	Areal Vegetation: GRASSLAND; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
524	Areal Vegetation: GRASSLAND; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Tropical Grass
525	Areal Vegetation: GRASSLAND; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
526	Areal Vegetation: GRASSLAND; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Tropical Grass
527	Areal Vegetation: GRASSLAND; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Pasture, meadow, steppe
528	Areal Vegetation: GRASSLAND; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Tropical Grass
529	Areal Vegetation: GRASSLAND; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
530	Areal Vegetation: GRASSLAND; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
531	Areal Vegetation: GRASSLAND; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
532	Areal Vegetation: GRASSLAND; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
533	Areal Vegetation: GRASSLAND; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
534	Areal Vegetation: GRASSLAND; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
535	Areal Vegetation: GRASSLAND; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
536	Areal Vegetation: GRASSLAND; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
537	Areal Vegetation: GRASSLAND; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
538	Areal Vegetation: GRASSLAND; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
539	Areal Vegetation: GRASSLAND; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Grassland

	with scattered trees
540	Areal Vegetation: GRASSLAND; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
541	Areal Vegetation: GRASSLAND; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
542	Areal Vegetation: GRASSLAND; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Grassland with scattered trees
543	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: GW
544	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: GW
545	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: GW
546	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: GP
547	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: GP
548	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: GP
549	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: GM
550	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: GM
551	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: GM
552	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: GC
553	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: GC
554	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: GC
555	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: SW
556	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: SW
557	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: SW
558	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: SP
559	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: SP
560	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: SP
561	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: SM
562	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: SM
563	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: SM
564	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: SC
565	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: SC
566	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: SC

567	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: ML
568	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: ML
569	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: ML
570	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: CL
571	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: CL
572	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: CL
573	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: OL
574	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: OL
575	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: OL
576	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: CH
577	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: CH
578	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: CH
579	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: MH
580	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: MH
581	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: MH
582	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Open (<=5%), SOIL_TYPE: OH
583	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Sparse (>5% and <=15%), SOIL_TYPE: OH
584	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Medium (>15% and <=50%), SOIL_TYPE: OH
585	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: GW
586	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: GP
587	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: GM
588	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: GC
589	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: SW
590	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: SP
591	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: SM
592	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: SC
593	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: ML
594	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH;

	BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: CL
595	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: OL
596	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: CH
597	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: MH
598	Areal Vegetation: SCRUB_OR_BRUSH_OR_BUSH; BRUSH_OR_UNDERGROWTH_DENSITY_CODE: Dense (>50%), SOIL_TYPE: OH
599	Areal Vegetation: BAMBOO; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Bamboo
600	Areal Vegetation: BAMBOO; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Bamboo
601	Areal Vegetation: BAMBOO; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Bamboo
602	Areal Vegetation: BAMBOO; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Bamboo
603	Areal Vegetation: BAMBOO; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Bamboo
604	Areal Vegetation: BAMBOO; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Bamboo
605	Areal Vegetation: BAMBOO; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Bamboo
606	Areal Vegetation: BAMBOO; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Bamboo
607	Areal Vegetation: BAMBOO; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Bamboo
608	Areal Vegetation: BAMBOO; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Bamboo
609	Areal Vegetation: BAMBOO; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Bamboo
610	Areal Vegetation: BAMBOO; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Bamboo
611	Areal Vegetation: BAMBOO; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Bamboo
612	Areal Vegetation: BAMBOO; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Bamboo
613	Areal Vegetation: TREES; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Coniferous
614	Areal Vegetation: TREES; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Coniferous
615	Areal Vegetation: TREES; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Coniferous
616	Areal Vegetation: TREES; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Coniferous
617	Areal Vegetation: TREES; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Coniferous
618	Areal Vegetation: TREES; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Coniferous
619	Areal Vegetation: TREES; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Coniferous
620	Areal Vegetation: TREES; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Coniferous
621	Areal Vegetation: TREES; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Coniferous
622	Areal Vegetation: TREES; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Coniferous
623	Areal Vegetation: TREES; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Coniferous
624	Areal Vegetation: TREES; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Coniferous
625	Areal Vegetation: TREES; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Coniferous
626	Areal Vegetation: TREES; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Coniferous
627	Areal Vegetation: TREES; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Deciduous
628	Areal Vegetation: TREES; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Deciduous
629	Areal Vegetation: TREES; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Deciduous
630	Areal Vegetation: TREES; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Deciduous
631	Areal Vegetation: TREES; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Deciduous
632	Areal Vegetation: TREES; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Deciduous
633	Areal Vegetation: TREES; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Deciduous
634	Areal Vegetation: TREES; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Deciduous
635	Areal Vegetation: TREES; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Deciduous
636	Areal Vegetation: TREES; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Deciduous
637	Areal Vegetation: TREES; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Deciduous
638	Areal Vegetation: TREES; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Deciduous
639	Areal Vegetation: TREES; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Deciduous
640	Areal Vegetation: TREES; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Deciduous

641	Areal Vegetation: TREES; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Mixed Trees
642	Areal Vegetation: TREES; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Mixed Trees
643	Areal Vegetation: TREES; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Mixed Trees
644	Areal Vegetation: TREES; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Mixed Trees
645	Areal Vegetation: TREES; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Mixed Trees
646	Areal Vegetation: TREES; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Mixed Trees
647	Areal Vegetation: TREES; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Mixed Trees
648	Areal Vegetation: TREES; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Mixed Trees
649	Areal Vegetation: TREES; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Mixed Trees
650	Areal Vegetation: TREES; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Mixed Trees
651	Areal Vegetation: TREES; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Mixed Trees
652	Areal Vegetation: TREES; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Mixed Trees
653	Areal Vegetation: TREES; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Mixed Trees
654	Areal Vegetation: TREES; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Mixed Trees
655	Areal Vegetation: TREES; SOIL_TYPE: GW, VEGETATION_CHARACTERISTIC: Mangrove
656	Areal Vegetation: TREES; SOIL_TYPE: GP, VEGETATION_CHARACTERISTIC: Mangrove
657	Areal Vegetation: TREES; SOIL_TYPE: GM, VEGETATION_CHARACTERISTIC: Mangrove
658	Areal Vegetation: TREES; SOIL_TYPE: GC, VEGETATION_CHARACTERISTIC: Mangrove
659	Areal Vegetation: TREES; SOIL_TYPE: SW, VEGETATION_CHARACTERISTIC: Mangrove
660	Areal Vegetation: TREES; SOIL_TYPE: SP, VEGETATION_CHARACTERISTIC: Mangrove
661	Areal Vegetation: TREES; SOIL_TYPE: SM, VEGETATION_CHARACTERISTIC: Mangrove
662	Areal Vegetation: TREES; SOIL_TYPE: SC, VEGETATION_CHARACTERISTIC: Mangrove
663	Areal Vegetation: TREES; SOIL_TYPE: ML, VEGETATION_CHARACTERISTIC: Mangrove
664	Areal Vegetation: TREES; SOIL_TYPE: CL, VEGETATION_CHARACTERISTIC: Mangrove
665	Areal Vegetation: TREES; SOIL_TYPE: OL, VEGETATION_CHARACTERISTIC: Mangrove
666	Areal Vegetation: TREES; SOIL_TYPE: CH, VEGETATION_CHARACTERISTIC: Mangrove
667	Areal Vegetation: TREES; SOIL_TYPE: MH, VEGETATION_CHARACTERISTIC: Mangrove
668	Areal Vegetation: TREES; SOIL_TYPE: OH, VEGETATION_CHARACTERISTIC: Mangrove
669	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: GW
670	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: GP
671	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: GM
672	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: GC
673	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: SW
674	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: SP
675	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: SM
676	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: SC
677	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: ML
678	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: CL
679	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: OL
680	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: CH
681	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: MH
682	Areal Vegetation: CLEARED_WAY_OR_CUT; SOIL_TYPE: OH
683	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: GW
684	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: GP
685	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: GM
686	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: GC
687	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: SW
688	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: SP
689	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: SM
690	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: SC

691	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: ML
692	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: CL
693	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: OL
694	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: CH
695	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: MH
696	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: OH
697	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: PT
698	Areal Urban: AIRPORT_OR_AIRFIELD; SOIL_TYPE: Evaporites
699	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Hard / Paved
700	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Unpaved
701	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Light
702	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Corduroy
703	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Grass / Sod (Soft)
704	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Natural
705	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Permanent
706	Areal Urban: APRON_OR_HARDSTAND; ROAD_OR_RUNWAY_SURFACE_TYPE: Temporary
707	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Hard / Paved
708	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Unpaved
709	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Light
710	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Corduroy
711	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Grass / Sod (Soft)
712	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Natural
713	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Permanent
714	Areal Urban: HELIPORT; ROAD_OR_RUNWAY_SURFACE_TYPE: Temporary
715	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Hard / Paved
716	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Unpaved
717	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Light
718	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Corduroy
719	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Grass / Sod (Soft)
720	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Natural
721	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Permanent
722	Areal Urban: TAXIWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Temporary
723	Areal Physiography: EXPOSED_BEDROCK
724	Transportation: RAILROAD
725	Transportation: RAILROAD_SIDING
726	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: GW
727	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: GP
728	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: GM
729	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: GC
730	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: SW
731	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: SP
732	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: SM
733	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: SC
734	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: ML
735	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: CL
736	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: OL
737	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: CH
738	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: MH
739	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: OH

740	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: PT
741	Transportation: CART_TRACK or TRAIL; SOIL_TYPE: Evaporites
742	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Hard / Paved
743	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Unpaved
744	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Light
745	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Corduroy
746	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Grass / Sod (Soft)
747	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Natural
748	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Permanent
749	Transportation: ROAD; ROAD_OR_RUNWAY_SURFACE_TYPE: Temporary
757	Maritime: BREAKWATER_OR_GROYNE
758	Maritime: MOLE
759	Maritime: JETTY
760	Maritime: PIER_WHARF
761	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Clay and Silt
762	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Silty Sands
763	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Sand and Gravel
764	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Gravel and Cobble
765	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Rocks and Boulders
766	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Bedrock
767	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Paved
768	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Peat
769	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Sand over mud
770	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Mixed qualities
771	Transportation: FORD; BOTTOM_MATERIALS_COMPOSITION: Sand
772	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Hard / Paved
773	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Unpaved
774	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Loose / Light
775	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Corduroy
776	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Grass / Sod (Soft)
777	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Natural
778	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Permanent
779	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Temporary
780	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Asphalt / Asphalt Mix
781	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Brick
782	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Concrete
783	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Composite Permanent
784	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Part Concrete and Part Asphalt
785	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Bituminous
786	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Clay
787	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Composite Non Permanent
788	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Coral
789	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Graded grass or Earth
790	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Ungraded Grass or Earth
791	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Gravel
792	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Ice
793	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Laterite
794	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Macadam
795	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Membrane
796	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Mix in Place

797	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Steel Planking
798	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Sand
799	Transportation: RUNWAY; ROAD_OR_RUNWAY_SURFACE_TYPE: Snow
800	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: GW
801	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: GP
802	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: GM
803	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: GC
804	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: SW
805	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: SP
806	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: SM
807	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: SC
808	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: ML
809	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: CL
810	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: OL
811	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: CH
812	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: MH
813	Areal Physiography: LAND_SUBJECT_TO_INUNDATION; SOIL_TYPE: OH

5. NATO Reference Mobility Model II

5.1 Background

The NATO Reference Mobility Model (NRMM) was developed in the early 1970's and combines many mobility related technologies into one comprehensive package designed to predict the physically constrained terrain/vehicle interaction of vehicles operating in on- and off-road terrain. Since its inception NRMM has been continually updated and expanded as a result of ongoing mobility research and is now in its second release (NRMM II). NRMM provides NATO members with a standard reference for mobility performance evaluations. NRMM is integrated into other automated models providing the mobility predictions for several tactical, analytical and wargaming models.

NRMM is an example of a "traditional" mobility model that ignores driver inputs (mostly) and assumes either maximum throttle or maximum braking in order to determine "maximum speed made good". Such models are often used in command and control decision aids where the objective is to predict general rates of movement rather than specific vehicle performance in the hands of a (skilled) human operator.

5.2 Model Overview

NRMM is a force balance model. A theoretical maximum tractive force versus speed relation is determined from characteristics of the vehicle power-train, the ground traction assemblies, and the terrain surface characteristics. Then various resisting factors which produce impediments to motion are determined. The sum of these resistances compared with the tractive-force versus speed relation provides a maximum possible force-controlled speed. Several non-force related speed limits are determined. The minimum of these speeds and the force controlled speed are compared to yield a final (steady state) maximum vehicle running speed. Then this vehicle running speed is considered in conjunction with the frequency of occurrence of individual terrain elements within a given area to provide a final “speed made good”.

NRMM is comprised of several sub-models each of which contributes to some aspect of ground mobility performance and, in many cases, has been developed as a result of scientific laboratory and field studies. Many of the sub-models are empirical while others are more theoretical. A study specifically designed to validate the comprehensive model resulting from the logical combining of these sub-models has been performed. Since its inception NRMM has been further validated by the continual ongoing vehicle mobility studies conducted at the U.S Army Waterways Experiment Station (WES) and other Army laboratories.

NRMM consists of the following major components:

- a sub-model to predict the power train performance,

- a vehicle/surface interface routine (soils & hard surfaces),
- a slope effects sub-model (lateral and longitudinal),
- an obstacle-geometry/vehicle interface sub-model (macro-geometry),
- a ride dynamics response sub-model (micro-geometry),
- a vehicle/vegetation interface sub-model,
- a braking performance sub-model, a curvature sub-model,
- a water crossing sub-model (currently disabled due to lack of acceptable input terrain data), and
- several other routines which have minor influence on the results.

There are several related mobility prediction models which are not part of the official NRMM family, but which are included in the related suite of analytical prediction programs:

- a swimming criteria prediction program (SWIMCRIT) provides dry and water-filled gap predictions. Does not predict speed; only GO / No-GO based on traction and resistance;
- a tracked vehicle steering (TVSTEER) model provides information about steering for tracked vehicles. This model is still under development and has not been fully validated; and
- a wheeled vehicle steering model is under development.

A full description of the NRMM ground vehicle mobility model is beyond the scope of this document. Additional documentation can be found in the following references:

1. B. G. Schreiner and W. E. Willoughby, "Validation of the AMC-71 Mobility Model", Technical Report M-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180, March 1976.
2. P. W. Haley, M. P. Jurkat, and P. M. Brady, Jr., "NATO Reference Mobility Model, Edition I, Users Guide, Volume I, Operational Modules", Technical Report 12503, (AD B047979L) US Army Tank-Automotive Research & Development Command, Warren, MI., 1979 (Oct).
3. P. W. Haley, M. P. Jurkat, and P. M. Brady, Jr., "NATO Reference Mobility Model, Edition I, Users Guide, Volume II, Obstacle Module", Technical Report 12503, (AD B047980L) US Army Tank-Automotive Research & Development Command, Warren, MI., 1979 (Oct).
4. M. P. Jurkat, C. J. Nuttall, and P. W. Haley, "The AMC '74 Mobility Model", Technical Report 11921 (LL-149), US Army Tank-Automotive Research & Development Command, Warren, MI., 1975 (May).
5. D. C. Creighton, "Revised Vehicle Dynamics Module: User's Guide for Computer Program VEHDYN II", Technical Report SL-86-9, US Army Engineer Waterways Experiment Station, Vicksburg, MS., 1986 (May).
6. R. B. Ahlvin, and P. W. Haley, "NATO Reference Mobility Model, Edition II, NRMM II User's Guide", Technical report GL-92-19, (AD 170301) US Army Engineer Waterways Experiment Station, Vicksburg, MS.
7. Farr, J. V., Rabalais, C. P., Underwood, R. B. III and Ahlvin, R. B., "Mobility and Plowing Capabilities of the Combat Mobility Vehicle", Technical report GL-91-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS., April 1991.

5.3 Slope

The NRMM ground vehicle mobility model uses continuously varying up and down slope values along the direction of vehicle travel. Lateral slope is generally ignored.

5.4 Trafficability

Table 14 lists the feature types and their associated attributes that are used as terrain trafficability inputs by NRMM II. A complete data model, including the domain range for each feature-attribute combination, is available.

Table 14: NRMM II Features and Associated Attributes

ANY_SURFACE_AREA (area)	- - -
Attribute Set	
AREA[9]	FROZEN_SOIL_LAYER_BOTTOM_DEPTH
FROZEN_SOIL_LAYER_TOP_DEPTH	FROZEN_WATER_TYPE
MAXIMUM_STANDING_WATER_DEPTH	MEAN_STEM_SPACING_QB_STEM_DIAMETER[10]
SNOW_DENSITY	SNOW_DEPTH
SOIL_CONE_INDEX_QB_MEASUREMENT_DEPTH	SOIL_DEPTH
SOIL_TYPE	SOIL_WATER_MASS
SOIL_WATER_VOLUME	SOIL_WETNESS
SURFACE_SLIPPERY	TERRAIN_ROUGHNESS_ROOT_MEAN_SQUARE
ROAD (line)	A <TERRAIN_TRANSPORTATION_ROUTE> maintained for <MOTOR_VEHICLE> use; a road.
Attribute Set	
FROZEN_SOIL_LAYER_BOTTOM_DEPTH	FROZEN_SOIL_LAYER_TOP_DEPTH
FROZEN_WATER_TYPE	MAXIMUM_STANDING_WATER_DEPTH
PATH_COUNT	ROAD_MINIMUM_TRAVELLED_WAY_WIDTH
SNOW_DENSITY	SNOW_DEPTH
SOIL_CONE_INDEX_QB_MEASUREMENT_DEPTH	SOIL_DEPTH
SOIL_TYPE	SOIL_WATER_MASS
SOIL_WATER_VOLUME	SOIL_WETNESS
SUPERELEVATION	SURFACE_MATERIAL_TYPE
SURFACE_SLIPPERY	TERRAIN_ROUGHNESS_ROOT_MEAN_SQUARE
TERRAIN_ROUTE_TYPE	TERRAIN_TRANSPORTATION_ROUTE_SURFACE_TYPE
TUNNEL (line)	A passage under the <TERRAIN>, open at both ends, and usually containing a <TERRAIN_TRANSPORTATION_ROUTE>; a tunnel.
Attribute Set	
BLOCKAGE_PRESENT	LENGTH
OVERHEAD_CLEARANCE	VEHICULAR_SPEED_LIMIT
BRIDGE (line)	A <STRUCTURE> that connects two <LOCATION>s and carries pedestrian or <VEHICLE> traffic over a <TERRAIN_OBSTACLE> such as a <WATER_BODY>, a declivity, or a <ROAD>; a bridge, an overpass.
Attribute Set	
BLOCKAGE_PRESENT	LOAD_CLASS_ONE_WAY_TRACKED
LOAD_CLASS_ONE_WAY_WHEELED	LOAD_CLASS_TWO_WAY_TRACKED
LOAD_CLASS_TWO_WAY_WHEELED	OVERHEAD_CLEARANCE
VEHICULAR_SPEED_LIMIT	
CROSS_COUNTRY_BARRIER (line)	A permanent or semi-permanent <BARRIER> placed across any <TERRAIN> to prevent <VEHICLE> or <PERSONNEL> traffic.

[9] Attributes (and Features) are denoted by their EDCS EA and EC Labels, respectively.

[10] EDCS label notation has been extended through use of the "qualified by" syntax ("QB") which composes two EDCS attributes such that the result is a primary attribute with multiple values indexed by the domain values of the second attribute; for example, MEAN_STEM_SPACING as a function of STEM_DIAMETER, and SOIL_CONE_INDEX as a function of MEASUREMENT_DEPTH.

Attribute Set	
DEPTH_BELOW_SURFACE_LEVEL	FROZEN_SOIL_LAYER_BOTTOM_DEPTH
FROZEN_SOIL_LAYER_TOP_DEPTH	FROZEN_WATER_TYPE
HEIGHT_ABOVE_SURFACE_LEVEL	MAXIMUM_STANDING_WATER_DEPTH
MEAN_OBJECT_SPACING	MEAN_STEM_SPACING_QB_STEM_DIAMETER
SNOW_DENSITY	SNOW_DEPTH
SOIL_CONE_INDEX_QB_MEASUREMENT_DEPTH	SOIL_DEPTH
SOIL_TYPE	SOIL_WATER_MASS
SOIL_WATER_VOLUME	SOIL_WETNESS
SURFACE_SLIPPERY	SURFACE_SLOPE
TERRAIN_OBSTACLE_TYPE	TERRAIN_ROUGHNESS_ROOT_MEAN_SQUARE
WIDTH	

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