EFFECT OF THE GEOGRAPHIC FACTORS ON THE CROSS COUNTRY MOVEMENT

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ABSTRACT

The goal of this paper is to identify the military geographic factors that affect the cross-country mobility (trafficability of the terrain) and to cite some standardised procedures for establishing of these factors. Classification of the cross-country movement levels. Influence of the slope, vegetation, water, soil, weather, urban area, transportation, and another features on the cross-country movement.

Keywords: Cross Country Mobility; Terrain Analyses; GO, SLOW GO, NO GO Terrain.

1. GENERAL CONSIDERATIONS

In practice, we usually analyse the cross-country mobility and establish conditions for movement as an integral part of complex analyses of conditions for operations in which we use data of geographic information systems (GIS).

These analyses are as follows:
- analysis of deployment of troops and military equipment in the combat area;
- analysis of possibilities of observation, search for concealed areas, conditions for camouflaging and use of smoke;
- analysis of communication and accomplishment of task connected with an analysis of electromagnetic waves propagation;
- analysis of possibilities of conduct of fire and protection against the enemy fire;
- analysis of threat of the NBC weapons employment in the area, analysis of conditions for epidemic and diseases dissemination;
- demographic analysis of population and urban areas;
- analysis of economic conditions in the regions;
- analysis of transportation conditions;
- analysis of terrain improvement, construction and destruction of objects;
- analysis of environmental factors and accomplishment of tasks related to natural disaster;
- analysis of conditions for logistic and medical support of troops.

It follows from the above analyses that we do not solve them in isolation, but completely by using various levels of GIS data that may differ in a level of detail, accuracy, quality, form, or even urgency.

2. CLASSIFICATION OF THE CROSS-COUNTRY MOVEMENT LEVELS

The cross-country mobility has a significant impact on the operations of troops both in time and costs. 3 basic levels of terrain when considering the cross-country movement:
- GO terrain;
- SLOW GO terrain;
- NO GO terrain.

From the viewpoint of used transport means for movement and from the respect of the cross-country mobility, we identify the following basic types of terrain:
- terrain suitable for tracked vehicles;
- terrain suitable for wheeled vehicles;
- terrain suitable for other types of transport means;
- terrain suitable for infantry.

At the combined units, in establishing the levels of the cross-country mobility, it is necessary to use a synthesis of the cross-country suitability and availability by means of all types of assets designed for movements.

3. MILITARY GEOGRAPHICAL FACTORS AFFECTING THE CROSS-COUNTRY MOBILITY

The factors affecting the cross-country mobility and selection of approach routes (in positive and also negative standpoints) are especially:

- slope of terrain relief;
- vegetation;
- surface water features;
- soil conditions;
- weather conditions;
- urban/built-up areas;
- lines of communication;
- other natural and man-made features.

The above-mentioned factors are closely related and as a result we can take their joint influence on the cross-country mobility as a time delay of movement of certain formation of troops expressed by a value 0 - 100 % against hypothetically established optimum conditions for movement.

3.1 Slope of terrain relief

In general, slopes of relief can be established from the topographical (final and plain) elementary areas that are generalised morphological picture of the earth surface that can be expressed by a continuous function

$$z = P_n(x, y) = \sum_{r=0}^{n} \sum_{s=0}^{n-r} a_{rs} x^r y^s \ ,$$

that is a polynomial of n-th level of variable coordinates x,y with coefficients a_{rs} determined by heights z .

Slopes of relief can also be determined from the matrix data (e.g. from data of digital models of relief in net of square net of points) where a limit criterion for the cross-country mobility is a maximum slope of elementary square of matrix calculated from 4 (6) level differences of the margin points. The cross-country mobility of larger territorial units is calculated from the level of accumulation of squares with certain values of maximum elevation. This cross-country mobility is also dependent on the direction of movement of troops, structure and width of columns during the movement, parameters of transport means available (maximum angle of gradient, heights of centre of gravity, etc.).

Selected NATO standards classify terrain by angles of slopes (moving upwards the slope) as follows:

- GO terrain slope < 30%;
- SLOW GO terrain 30% < slope < 50%;
- NO GO terrain slope > 50%.

3.2 Vegetation (plant-cover)

The cross-country mobility is influenced especially by the following factors:

- coverage of terrain by vegetation that can be expressed by relative number of wooded area of all vegetation against the total area of a given territory (specified in %);
- structure (relative position, size, form, orientation) of wooded sub-areas

Composition and specific characteristics of woody plants:

- *height of vegetation* that will influence the cross-country mobility in horizontal position of trees at the forced crossings and after windfalls and fallen trees (no NATO standards are specified),
- *tree stem diameter* measured at a height of 1.5 m above a terrain. NATO standards classify:
  GO terrain diameter < 5cm,
  SLOW GO terrain 5cm < diameter < 15cm,
  NO GO terrain diameter > 15cm,
- *tree spacing*, where standards specify:
  GO terrain 5m < spacing,
  SLOW GO terrain 3m < spacing < 5m,
  NO GO terrain spacing < 3m.
- *hardness, elasticity, nature of rooting and breadth of branching* (no NATO standards are specified).

The cross-country mobility of wooded area is in close correlation especially with the terrain slope since most of the wooded areas are located just on the slopes. Further, it is also closely related to the soil conditions. As the basis for establishing the cross-country mobility parameters in the wooded areas the GIS data, digital models of terrain and detailed forestry maps can be used.

3.3 Hydrology

The cross-country mobility is affected especially by the following factors:

- *location, size and form of surface water features* (rivers, streams, lakes, etc.);
- *bank conditions* (forms and gradient) of rivers and streams that are solved together with elements of slopes and another terrain features;
- *width of surface water features.* NATO standards classify rivers and streams and canals as follows:
  GO width < 1.5m,
  SLOW GO 1.5m < width < 18.0m,
  NO GO width > 18.0m;
- *depth of surface water features*. NATO standards classify surface water features as follows:
  GO depth < 0.6m,
  SLOW GO 0.6 < depth < 1.2m,
  NO GO depth > 1.2m,
  (except for classification at swimming combat equipment and equipment capable of deep fording);
- *bottom conditions*. In general, we distinguish muddy, slippery clay, sandy, gravel, rocky and paved bottom. At the bottom with no fair ground, on establishing the cross-country mobility it is necessary according to the depth of stream to add to the depth of stream the depth of this bottom (silt);
- *stream velocity*, where we identify the flowing water:
  GO velocity < 1.5m/s
  SLOW GO 1.5m/s < velocity < 2.5m/s
  NO GO velocity > 2.5m/s;
- *temperature* that will influence trafficability especially of the stagnant waters in winter season when ice cover can make the cross-country movement easier or it can make it difficult.
- *orientation of surface water features* (especially rivers and canals).

As a basis for establishing the cross-country mobility parameters of rivers and streams, the GIS data, digital models of terrain and detailed water supply and distribution maps can be used.

3.4 Soil conditions

In considering the cross-country mobility, there exist various types or groups of soil that to a various extent influence the troops mobility depending on a current structure of transport means and weather conditions given by total amount of precipitation in a given territory.

According to percentage content of clay particles in size less than 0.01 mm, the soil can be divided into the following groups:

- GO soils (sandy clay and clay sand on a firm ground and clayish soil with higher thickness during dry weather);
- SLOW GO soils (clayish soil during wet weather or silty clay, marl and powdered soil during dry weather);
- NO GO soils or soils with marginal trafficability during dry weather (mud, turf, gravel, rocky, stony).

Depending on the influence of the level of roughness of soil on mobility (average speed of movement) it is possible at individual types of transport means to identify the multiple coefficients of speed deteriorating, and they can have the following values:

$k_{PU} = 0.00$ at maximum effect;
$k_{PU} = 1.00$ at minimum effect of surface roughness on mobility.

For example, at the heavy and medium tanks, the multiple coefficients at the stony soils have a value $k_{pu} = 0.90$, it means that this soil hinders the tracked vehicle movement by 10 %.

To determine the degrees of trafficability, the geological maps and maps of soil groups can be applied.

3.5 Climate conditions

The most important weather factors that influence the cross-country mobility are as follows:

- *precipitation* that affect especially:
  - soil conditions (see Chapter 3.4) and consequently the slope passability,
  - roads and terrain trafficability especially in winter season (during slippery ice and deep snow),
  - rivers and streams passability (see Chapter 3.4) and especially the depth and velocity of currents.

Precipitations are measured in mm/time and they can have a long-term effect on the cross-country mobility.

Apart from the amount of rainfall or snowfall, this effect depends especially on drainage coefficients in individual river basins, on soil structure and temperatures.

Precipitations can be forecast to a certain extent from the weather maps by interpolation methods from z hypsometric overlay of total precipitations;

- *fogs, humidity and inversion* that affect visibility during movement;
- *clouds* that affect the air forces flight capabilities;
- *temperature* that affect:
  - soil and rock properties,
  - drainage coefficients and thus even the stream depth and velocity,
  - character of precipitations (rain, snow…), slippery ice creation,
  - rivers and streams fordability especially during winter weather,
  - mechanical properties of transport means.

Temperatures are measured in °C (°F) and can be forecast from the weather maps where the temperatures are interpolated mainly from January and July isotherms;
wind speed impairs the air forces and ground forces operations during movement. It is measured in m/s or km/h;
light conditions (time of sunrise and sunset and moonrise and moonset) that indirectly influence the cross-country mobility through to their effect on the decision making processes during movement.

3.6 Urban areas

Trafficability through the build-up areas is affected by the following factors:

- *land coverage (a number of towns, cities and villages) of the area involved,* i.e. a degree of urbanization which is expressed in %;
- *location, structure, form and orientation of the urban areas* to the direction of troops movement;
- *width of urban area,* i.e. diameter of an urban area. NATO standards identify:
  - GO urban areas (width of the urban area less than 500)
  - NO GO urban areas (width of the urban area 500 m or more);
- *width of passage through the built-up areas*. It is specified by:
  - width of the roads proper,
  - maximum width of potential passages through, incl. the central reservation and pavements (transversal distance between the blocks of buildings in the built-up area or between fencing in the villa-type area);
- *construction material* (concrete, metal, brick, wood,…) and building and object resistance;
- *building height* (it affects the flight capabilities and will represent obstacles after its destruction);
- *building fire resistance* (combustible, non-combustible buildings).

In determining the cross-country mobility parameters of the urban areas, the GIS data, digital models of terrain and detailed plans of towns and cities can be used.

3.7 Roads

Roads influence the cross-country mobility either as:

- *lines of communication*, when they are directed with the axes of movement;
- *objects of obstacles*, when they lead across the direction of movement and created on the embankments or dugouts. They have a similar effect on the cross-country mobility as line elements, i.e. features (see Chapter 3.8) or rivers and streams (see Chapter 3.3).

The cross-country mobility (trafficability) is greatly influenced by the road and railway network.

- *Railway* in terms of the cross-country mobility can be classified by:
  - number of tracks;
  - traction (type of drive);
  - track gauge;
  - transportation significance (railway capacity per period of time).

- *Roads* can be classified according to:
  - width;
  - quality of road surface;
  - transportation importance.

The NATO standards classify so called MLC categories of roads according to width and other parameters, such as:

Category	Total width of traffic lanes	Vehicle height (clearance height)	Curve radius
MLC 100	min. 9.0 m	min. 4.4 m	min. 21.4 m
MLC 70	min. 8.4 m	min. 4.0 m	-
MLC 30	min. 6.0 m	min. 3.5 m	-

According to a reinforcement of the road cover (surface) and according to weather, we identify so called AWHS, AWLS, FWHS and FWLS categories.

According to transportation significance, the influence of roads on the cross-country mobility can be expressed by a speed deteriorating coefficient k_{ko}, which corresponds to the density and quality of road network and which is specified in km/km^2 (or in km/100 km^2), where

$k_{ko} < 1.00$ for density and quality of road and railway network less than average;
$k_{ko} = 1.00$ for average density and quality of road and railway network;
$k_{ko} > 1.00$ for density and quality of road and railway network greater than average.

As a basis for determination of the cross-country mobility in vegetation, the GIS data, digital models of terrain, road database and road maps can be used.

3.8 Natural and man-made objects

The natural and man-made objects affecting the cross-country mobility are elements of spatial nature that usually cannot be expressed by continuous polynomial function as at the factor of slopes – see Chapter 3.1 and some polygon and line features. These features can be broken into hollowed out and elevated and from the resistance standpoint into reinforced and non-reinforced objects.

These types of objects are as follows:

- *embankments and dug-outs:*
  - GO: gradient < 100%, length < 1 km,
  - NO GO: gradient > 100%, length > 1 km;
- *gaps, craters:*
  - GO: width < 100 m, depth < 1.8 m,
  - NO GO: width > 100 m, depth > 1.8 m;
- *terrain levels:*
  - GO: height of reinforced level < 1.5 m,
    height of non-reinforced level < 2.0 m,
  - NO GO: height of reinforced level > 1.5 m,
    height of non-reinforced level > 2.0 m;
- *overhead piping* (gas pipe lines, oil pipe lines,…);
- *power transmission lines* (obstacle especially for helicopters);
- *protected areas* (national parks, protected areas and objects,…).

As a basis for establishing the cross-country mobility parameters in vegetation, it is possible to use GIS data, digital models of terrain and detailed maps of micro-relief forms.

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