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## APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM FOR DETERMINATION VEHICLES FROM THE “SHADOWING” ZONE SUITABLE FOR STAFF USE

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**Key words:** landmark, “shadowing” zone, zone of direct visibility.

### Stating of a problem

During control of subunits' vehicles and staff tasks' fulfillment, each vehicle has an important meaning for subunits' commander. The vehicles, which have been already received the staff task, are temporary excluded from the list of the suitable ones for the task fulfillment. Situation and available quantity of landmarks can lead to the deficiency of appropriate vehicles for the work with landmarks. At the same time, the part of vehicles wholly suitable for operation may be located in the “shadowing” zone to the landmark conforming to the ground features' conditions.

It is actual to determine among them the ones, which are suitable for the accepted time (which satisfies the demands of durability of cycle of the staff algorithm of control) [1] to move to the line of the direct visibility with the landmark, and, owing to it, to diminish the deficiency of vehicles suitable for operation, and increase the efficiency of their use in the staff conditions.

### Analysis of the last researches and publications concerned the solving of this problem

From the analysis of publications [2,3], concerning the staff use of vehicles, the systems are known that give information about their own coordinates and location of the subordinate vehicles to the subunit commander, but they don't give information about areas of terrain where the “shadowing” zone concerning the landmark is observed.

In the work [4], for the solving of the staff task concerning the landmark, among the vehicles located in the “shadowing” zone concerning the landmark, the whole list of vehicles is considered, and not only those of them, which are located on the areas of “shadowing” zone that are the nearest to the line of direct visibility, and are capable to move into the zone of direct visibility to the landmark in the accepted time.

It is known from the source [5], mainly the authors consider the parameters of distance to the landmark, the remainder of the equipment by types, technical condition of vehicles, conditions of direct visibility, etc, when tasks to the vehicles concerning the staff work are determined.

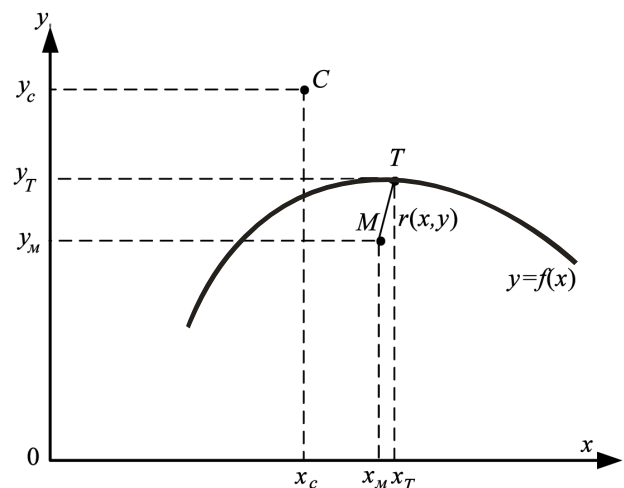
At the same time, in a staff circumstance, the situation may appear when the vehicle suitable for the staff work by the majority of indices, is “shaded” under the ground features' conditions. And the time, that is necessary for its moving to the line of direct visibility, doesn't exceed  $\tau_k$   $\tau_k$  of critical. The period of time  $\tau_k$  can be determined from the analysis of a budget of time [1], which is necessary for moving the vehicle to the line of direct visibility to the landmark. And if such vehicle, within limits of the mentioned time, is able to move from the “shadowing” zone to the line of direct visibility, so it can be included into the list of those which are suitable for the staff use.

### Stating of a task

The facts described above are taken into consideration, thus, the article is dedicated to the solving of a task, that consists in determination of vehicles from the “shadowing” zone by the means of the geographic information system (GIS), which are suitable for the staff use and are able to move to the line of direct visibility to the landmark in a time lesser than  $\tau_k$  of critical.

### Summary of the main material of the problem

On the base of information from GIS [6], we determine the “shadowing” zone from the point  $C$  of the landmark's location with coordinates  $(x_c, y_c)$  (see scheme 1).



Scheme 1. Variant of mutual location of  
landmark  $C$  and vehicle  $M$  relatively to terminator

For this aim, we build the functional relation  $y = f(x)$  that describes the bounds of the “shadowing” zone, in the sequel – terminator.

Foresee that the relation  $y = f(x)$  is a function which differentiates. For it, at the receiving of relation  $y = f(x)$ , we will apply the appropriate mathematical apparatus.

In the sequel, we will work with the vehicles suitable for the staff work concerning technical readiness and are located in the “shadowing” zone [1].

For the determination  $r(x, y)$  of distance from vehicle to terminator, apply the following correlation

$$r(x, y) = \sqrt{(f(x) - y_m)^2 + (x - x_m)^2} . \quad (1)$$

Analyze the conditions at which minimum takes place. From [7] it is known, that in a point of existence of extremum of a function of plenty of variables (which is  $r(x, y)$ ) partial derivatives are equal to zero, namely:

$$\begin{cases} \frac{\partial r(x, y)}{\partial x} + \frac{\partial r(x, y)}{\partial y} \cdot \frac{dy}{dx} = 0 \\ \frac{\partial r(x, y)}{\partial y} \cdot \frac{dy}{dx} = 0 \end{cases} . \quad (2)$$

Apply (2) to (1) and receive:

$$\begin{cases} \frac{1}{\sqrt{(y - y_m)^2 + (f(x) - x_m)^2}} \times \\ \times \left[ (x - x_m) + (f(x) - y_m) \cdot \frac{df(x)}{dx} \right] = 0 \\ \frac{1}{\sqrt{(y - y_m)^2 + (f(x) - x_m)^2}} \cdot (f(x) - y_m) \cdot \frac{df(x)}{dx} = 0. \end{cases} . \quad (3)$$

From the point of physical considerations, at any location of landmark  $C$  and vehicle  $M$ , the minimum distance between them exists. Thus, conditions (3) can be considered as those at which extremum realizes in this point.

From the solution of system (3) we will receive the value  $(x_T, y_T)$  of coordinates of terminator’s point that meet minimum  $r(x, y)$ .

Substituting value  $(x_T, y_T)$  into (1) we will receive  $r_m$  of a value of the minimum distance from combat vehicle to terminator.

Time  $\tau_{eux}$  of vehicle’s moving into the point  $(x_T, y_T)$  we will get from the correlation:

$$\tau_{eux} = \frac{r_m}{V} , \quad (4)$$

where  $V$  – middle velocity of vehicle’s moving during the process of the staff use.

Applying the correlation (4), conduct the timing  $\tau_{eux}$  for all shaded vehicles.

If the condition is complied  $\tau_{eux} < \tau_k$ , where  $\tau_k$  – critical time of vehicle’s moving, is determined from [1] according to the duration of cycle of its control in accordance with the staff algorithm, then such vehicles we include into the list of the suitable ones for the staff use.

### Conclusions

It is shown, that in case of application of GIS, the list of vehicles in subunits, suitable for the staff use concerning the landmark, can be additionally extended for the given moment of situation. This list is composed by those, which are in the “shadowing” zone.

The analytical correlation is received, which allows calculating the time of moving out of vehicle, which is located in the “shadowing” zone, to the line of direct visibility to the landmark.

Further researches are planned to devote to the elaboration of mathematical model of estimation of an error of determination  $\Delta t$  of time of moving out of the “shaded” vehicle to the line of direct visibility to the landmark.

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**Застосування геоінформаційної системи  
для визначення машин із зони “затінення”,  
придатних для штатного використання**

В. Корольов, Я. Заець, Р. Савчук

Здійснено формалізоване обґрунтування визначення функціональних машин у підрозділі, придатних для штатного використання, за допомогою геоінформаційної системи, серед тих, які перебувають у зоні “затінення”. Отримано аналітичне співвідношення, яке дає змогу обчислити час виходу машини, що розміщена в зоні “затінення”, на лінію прямої видимості до орієнтира.

**Применение геоинформационной системы  
для определения машин из зоны “затенения”,  
пригодных для штатного применения**

В. Корольов, Я. Заец, Р. Савчук

Стаття посвящена формалізованому обґрунтуванню визначення функціональних машин в підрозділі,


пригодных для штатного использования, с помощью геоинформационной системы, среди тех, которые находятся в зоне “затенения”. Получено аналитическое соотношение, которое позволяет вычислить время выхода машины, находящейся в зоне “затенения”, на линию прямой видимости к ориентиру.

**Application of geographic information system  
for determination vehicles from the “shadowing”  
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V. Korolov, Y. Zaiets, R. Savchuk


The article is devoted to the formalized determination of functional vehicles in subunits suitable for the staff use by the means of geographic information system, among those, which are located in the “shadowing” zone. It also offers the method of determination of “shaded” vehicles, which are capable to move out of the “shadowing” zone to the line of direct visibility to the landmark in the accepted time.

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