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TELEMATIC SYSTEM OF HIGHWAY TRANSPORT

Structure of telematic system of highway transport was described. Twelve consisting systems were distinguished. A formal description of system was made, including applied facilities and methods. Using of application graph to describe telematic highway facilities together with its matrix representation was proposed.

SYSTEM TELEMATYKI TRANSPORTU AUTOSTRADOWEGO

Przedstawiono budowę systemu telematyki transportu autostradowego. Wyróżniono w nim dwanaście systemów składowych. Dokonano opisu formalnego systemu, który zawiera stosowane środki i metody. Zaproponowano zastosowanie grafu aplikacji w opisie wyposażenia telematycznego autostrady wraz z jego macierzową reprezentacją.

1. FORMAL DESCRIPTION

In [1,2] *transport system* is described as an ordered four in the following form:

$$ST = \langle G, F, P, O \rangle \tag{1}$$

where:

G – structure graph,
F – set of function determined at the nodes and/or arcs of structure graph,
P – traffic stream representing the movement of loads and/or people in the system,
O – organization i.e. allocation of traffic stream in the transport system.

A representation of transport system structure is a structure graph. This structure graph is representing highway structure placed in a concrete geographic site:

$$G = \langle W, L \rangle \tag{2}$$

where: W – set of graph nodes,
L – set of graph arcs.

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If the nodes and/or arcs of the graph (2) define the attribution of certain means of transport telematics used in people and loads movement process, then the graph describes telematic transport network. Therefore, the *telematic network of highway transport* is:

$$TST = \langle G, K \rangle \tag{3}$$

where: G – structure graph described in (2),

K- set of means of highway transport telematics attributed to certain nodes and arcs of the structure graph.

Let's have a cartesian product of measures and methods of highway transport telematics $K \times M$. In this product a representation e is given, which assigns the elements of the cartesian product to the elements from a $\{0,1\}$ set in this way:

$$e : K \times M \rightarrow \{0,1\} \tag{4}$$

while $e(k,m)=1$ only when the means with number k apply methods with number m. In opposite case $e(k,m)=0$.

Let's define RT set by the following elements:

$$RT = \{(k,m) : e(k,m) = 1\} \tag{5}$$

RT set is a two-partial relation named *telematic relation*:

$$RT \subset K \times M \tag{6}$$

Basing on [3,4] we can specify the *telematic system of highway transport* as:

$$T = \langle S, RT \rangle \tag{7}$$

where: S – transport network defined as: $S = \langle G, F \rangle$. It is clear that $F = F_W \cup F_L$, where F_W – is the set of functions defined on vertexes of structure graph, F_L – is the set of functions defined on arcs of structure graph. Functions from the set F represent transport network characteristics, for example technical (throughput, capacity), economic (movement cost, travel time) or mathematical (probability of moving from one node to the next) or others, which characterise the transport network in required way. RT – telematic relation as in (6).

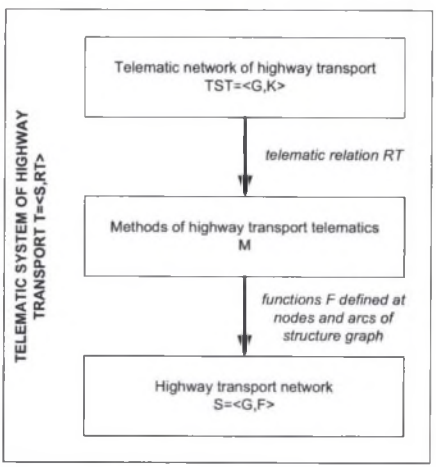

Fig.1. Illustration of a formal description of telematic highway transport system

The illustration of a formal description of telematic highway transport system is Fig.1.

2. CONSISTING AND COOPERATIVE SYSTEMS

Telematic system of highway transport is the set of telecommunication and informatics equipment and the electronic facilities connected together with relations of transferring and processing information. These equipment and facilities are located on the highway and its nearest surrounding and they are acting in a proper purpose. The aim of this system operation is reaching the concrete level of traffic safety and required effectiveness of transport process realized using highway as a land-based route.

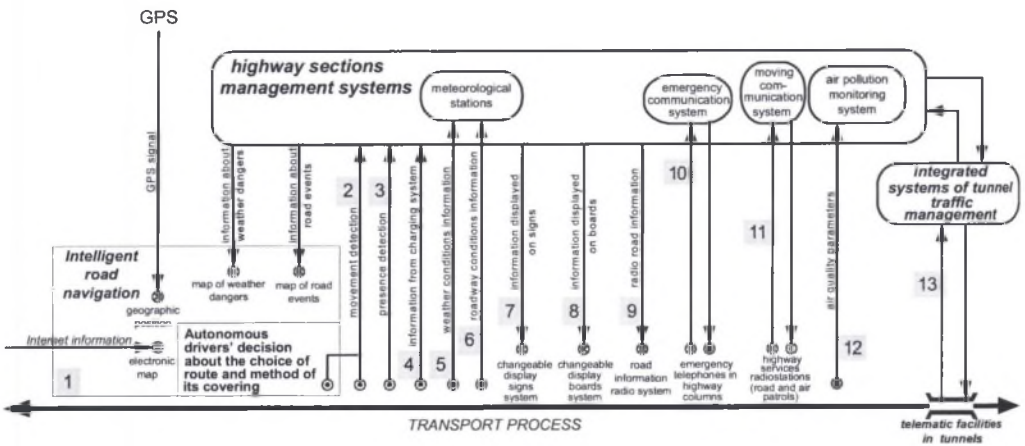

Fig.2 Construction of highway transport telematic system (over system) with marked elements of 12 consisting and cooperative systems (13); ⊙- sensors, ⊗- activators

Figure 2 shows telematic system of highway transport as an over system with noted elements of twelve consisting systems and cooperative systems. The telematic system of highway transport can consist of:

1. intelligent road navigation system,
2. movement detection system,
3. presence detection system,
4. charging system,
5. weather information gathering system,
6. system of gathering information about roadway conditions,
7. changeable display signs system,
8. changeable display boards system,
9. road information radio system,
10. emergency communication system,
11. moving communication system,
12. environment monitoring system.

On some highways, especially in the mountainous area, where there is a need of using tunnels, it is essential to use special telematic systems intended to supervise, manage and monitor traffic conditions in this terrain type. These are usually solutions, which are integrated telematic systems enabling monitoring many important movement and surrounding parameters at one time.

3. MEANS AND METHODS

Connection between the means used by twelve highway transport telematic systems previously mentioned and the methods used by these systems may be formally described using a form of an application graph.

Application graph of highway telematics is described as follows:

$$G_{ATA} = \langle K, M ; RT \rangle \tag{7}$$

where: K – set of highway transport telematic means used in 12 systems mentioned before, M – set of highway transport telematic methods, RT- telematic relation.

Application graph G_{ATA} is a split graph, because the set of its vertexes is decomposed into two disjoint subsets i.e. $K=\{k_i\}$ i $M=\{m_j\}$. Every application graph arc connects a vertex from set M with a vertex or vertexes in set K. Illustration 3 shows a general example of an application graph.

We can define a matrix characterising the application graph as:

$$\mathbb{D} = [\sigma_{ij}]_{12\times n} \qquad \sigma_{ij} = \begin{cases} 1 & \text{when the vertaxes i, j are connected with an arc} \\ 0 & \text{in the opposite case} \end{cases} \tag{8}$$

where: number 12 is the number of elements of the set of facilities used in highway telematic systems in systems presented in illustration 2 and n is the number of elements of the set of highway transport telematics methods used in these systems.

This matrix enables a formal description of highway equipment with transport telematic facilities and used methods that are aimed for reach proper traffic parameters on the chosen part of the road.

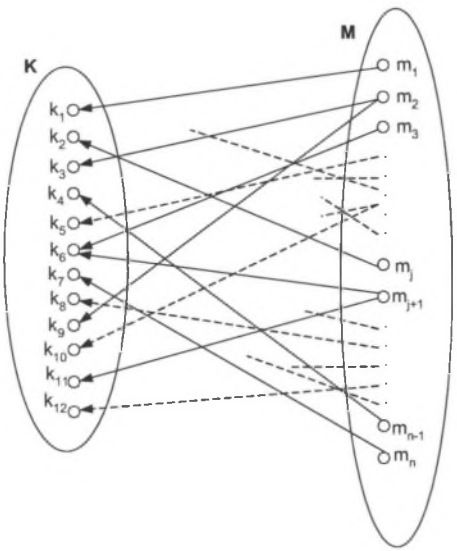

Fig.3. Application graph of highway telematics G_{ATA}

4. CONCLUSION

The proper usage of methods and means of highway telematics supports existence of formal description of transport system, which considers the characteristics of telematic applications. It is especially important while planning a gradual introduction of certain solutions with simultaneous observation of its application results. Equipment of highway transport telematics is very expensive. In case of taking ill-considered decisions about investing in this matter, there is a possibility of not having the requested effect, despite investing large sums of money.

The existence of a formal apparatus enables a proper description and, in consequence, simulation of the results of each decision. It gives us the basis to rationalize expenses on this matter. Presented methodology enables identification of the essential consisting systems of highway telematics and differentiation of means and methods used to realize steering a transport process.

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