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INVESTIGATING WORK TECHNOLOGY IN ROAD TRAFFIC

ABSTRACT

The study of the organisation and technology of work in traffic in general as well as in road traffic is conducted from different standpoints. Relevant scientific and expert literature deals with different approaches to the above study, which generates confusion among the experts who want the organisation and technology of work in road traffic to be based on the grounds of scientific organisation of work. The paper deals with the aspect of study which is based on the theory of scientific organisation and technology of work as well as its implementation in road traffic. The paper analysis especially the methods by which human work and influences upon it in road traffic are studied. The results of the said aspect of study show that it is possible to rationalise work, improve the exploitation indexes and, in general, improve the efficiency of existing organisation and technology of road traffic as a whole. Using the same aspect of study a new organisation and technology of road traffic can also be established and optimised.

KEY WORDS:

study of work, organisation and technology, road traffic, assessment of danger, human factor

1. INTRODUCTION

There are several definitions of the terms *organisation* and *technology* of work, which proves that they are mutually interrelated.

If an organisation wants to function efficiently, it should consider the characteristics of technologies. Technological changes are therefore the basis for the changes of organisation. However, this does not mean that *organisation* and *technology* have the same meaning.

The technology of road traffic like the technologies of the sea, rail, air and other branches of traffic is understood as the science and activity with interdisciplinary, traffic-technical, traffic-technological, traffic-organisational, traffic-economic, traffic-legal and other competences and skills of traffic technologists and traffic managers.

Traffic services are performed through several procedures or processes with various facilities. The procedures and processes of traffic services generation in road traffic are various, complicated and long-lasting, which depends on the kind of consignments, way of transport, characteristics of traffic means, characteristics and length of the road as well as the combination of the technologies of other related traffic branches.

Thus, the basic aim of the study of the organisation and technology of work in road traffic is to provide efficient functioning of the system as well as other dependent systems considering scientific findings of different scientific fields and disciplines.

This aim may be achieved only if the following is provided:

- co-ordinated interrelation of all organisational activities, as no individual part has its own aim;
- systematic study and improvement of the existing technological process and the method of work as well as the application of modern technologies and other achievements of scientific and technological progress in order to improve the efficiency of work;
- systematic study of psycho-physiological, sociological, ergonomic and other human aspects within the "man-machine" system;
- conditions for direct co-operation of all parties involved in organisation and technology;
- application of scientific and research methods in evaluating efficiency at all levels of organisation;
- introduction of favourable work conditions in the whole process of work, which are all harmonised with the human needs and limitations.

2. METHODS OF THE STUDY OF WORK IN ROAD TRAFFIC

In the relevant scientific literature various aspects of general organisation and technology study are dealt with, based on the standards of scientific organisation of work. From the standpoint of organisation and

technology of work the aspect of study of human work and impacts on this work are particularly acceptable.

The methods of this aspect are above all based on:

- direct observation of the functioning of the "man-machine" system from the viewpoint of the organisation and technology of road transport and its complex surroundings;
- measurement of the material factors of the work environment;
- measurement of time of work performed per its constituent element depending on the characteristics of the technological processes of work in road transport;
- assessment of micro and macro characteristics of workplaces of individual direct operators and above all in relation to the dimensional characteristics of manipulation fields,
- analysis of information flows between individual participants in road traffic as well as within the organisation structure;
- research into critical events, incidents and mistakes caused by human factors in road traffic;
- research into psychophysical and other characteristics of the operators in performing definite tasks in road traffic, and evaluation of their psycho-physical fatigue;
- analysis of the characteristics of road traffic facilities, depending on organisation and technology, natural and other complex influences of the macro environment on the functioning of the road traffic system.

In accordance with the selected aspect of study of the organisation and technology of work in road traffic only the following methods will be dealt with:

- methods of observation;
- methods of research and assessment of danger;
- methods of measurement and assessment of the degree of influence of the factors of the material environment of work;
- methods of research into critical events and errors;
- methods of assessment of physical and psychical fatigue;
- methods of research into the simplification of work.

1.1. Methods of observation

Observation of people-participants and performers of work in road traffic as well as observation of things and events is a subjective method in researching the reality. It is, however, frequently irreplaceable. Good results of its application depend above all on experience and competence of the observer as well as on the quality of the synthesis based on observation. The observation of factors and indexes "such as they are", as well as their integration into a logical whole of the process flow, which is determined by a series of causes and effects is not easy.

The essence of the method of observation is in providing the right proportions in the assessment of observed factors. Generally it can be concluded that the method of observation is adapted to the subject of research: either individual fragments of operators' work, transportation process, influence of natural and other conditions of work, etc.

This method is analogous to the observation through a microscope. If the magnifying is low, we see a general picture of the whole process observed. When we want to see the details, the picture of the whole disappears. It means that we have to observe, first, the general basis of all phenomena and the area of their manifestation and only then do we have to observe the details.

The observations with the aim of research into problems of the organisation and technology in road traffic are usually carried out in the longer period of time and they differ essentially from the operative and other regular and extra controls and inspections with which only serious failures can be detected. This method is oriented above all to finding out all essential digressions from the model, defined as basic, irrespective of the possibility of their deviation at a certain moment.

For a more qualitative application of this method, numerous general purpose check lists have been worked out. Their adaptation to the field of the organisation and technology of road traffic is presented in the literature (X).

2.2. Methods of research and assessment of danger

Research into the organisation and technology of work in road traffic from the standpoint of safety is based above all on investigation of danger for health and potential misfortunes. In investigating dangers at work it is very difficult to find out whether the subject of research should be only safety or should it be taken wider.

With this method dangers are detected which result in accidents, and which is the first step in the procedure of enhancing safety. In road traffic often the degree of danger is assessed of an individual workplace or conditions for all participants in traffic. Regarding stochastic aspects of all processes this problem is difficult to solve.

Although this method is subject to agreement for it is based on subjective assessment, it could nevertheless be applied above all to assessment of work conditions and qualification of workplaces as well as to defining priorities in an activity plan for enhancing safety.

Table 1 - Factors of danger

Human factors	Designation	Technical-technological factors	Designation	Organisational factors	Designation
Education, category of qualification	X_1	Technical-technological characteristics and the condition of transportation facilities	Y_1	Methods of work	Z_1
Adaptability to working conditions	X_2	Construction and technical condition of the macro workplace	Y_2	Supervision	Z_2
Psycho-physical capability, state of health, etc.	X_3	Technical-technological characteristics of the elements of road infrastructure and other elements of the macro workplace	Y_3	Organisational and technological systematisation of the workplace	Z_3
Attitude to work in road traffic	X_4	Material work environment	Y_4	Organisational level of technological process in road traffic	Z_4

In applying this method it is considered that three groups of danger factors affect each example of danger with their sub-factors, which is shown in Table 1.

2.2.1. Human factors

The qualification of operators or other participants in road traffic may influence the rate of danger risk depending on whether it is very good, good, sufficient, bad or very bad. Their adaptability to organisational, technical and technological characteristics of work is very typical, above all where it is essential.

Attitude to work of operators and all participants in traffic is shaped according to the level of their culture, either general, traffic or technical, according to their age, gender, experience, organisational and other characteristics. Inadequate attitude to work as a rule increases the risk of danger because of negligence and underestimation of essential safety measures, etc.

2.2.2. Technical and technological factors

Due to the simplification of the problem we can take an example of the construction together with the technical condition of road transportation means, elements of road infrastructure, etc. The construction and the technical condition can be either analysed separately or jointly. Thus, we might conclude that the means of transportation is well constructed, but its momentary technical condition is very bad, which may represent high risk of danger.

Similarly, definite elements of infrastructure may be well constructed, but their momentary condition may represent high risk of danger. On the other hand, there may be a situation where technical condition is good enough, but a constructional failure represents high risk of danger.

In evaluating danger risks of these factors also all other factors of material working environment should be taken into account, like noise, vibrations, elements of micro and macro climate, etc.

The condition of technical and technological factors is usually assessed by means of the following scale: very good, good, medium, insufficient, very insufficient and does not exist.

2.2.3. Organisational factors

Methods of work regarding safety in road transport may be bad or good, but the following scale is used in their assessment: very good, good, medium, insufficient and very insufficient. On the contrary, their influence on safety can be minimal, low, medium, great, very great.

The way of organisation of individual processes of work may directly influence the safety level. For example, the routine transportation process is usually less dangerous compared to the rhythm of work which changes often. Frequent replacements of operators of the transportation means because of work in several shifts usually increase the level of danger risk, as the individual responsibility of operators decreases in maintaining micro workplace.

2.2.4. Assessment of factors

As seen above, the influence of individual factors on the level of danger risk is assessed contrary to its real condition, i.e. if a factor is assessed as being very good its influence is minimal, at factor good the influence is little, etc.

Due to non-linear influence of factors on the level of danger risk only those factors are considered whose condition is medium or lower. General assessment of the danger risk level is, thus, based on an average rate of all, medium, insufficient and very insufficient assessments. Apart from that we distinguish also the so-called dominant factors and the factors of higher influence, which can be seen in Table 2

Such assessment enables control of definite activities to prevent accidents which may occur because of these analysed dangers. It should not be forgotten that

Table 2. Dominant factors for the assessment of danger risks

Condition of factors	Factors											
	X				Y				Z			
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Z_1	Z_2	Z_3	Z_4
1					*					*		
2	*						*		*			
3			*			*						*
4		*						*			*	
5				*								

on the same job several danger risks may exist and each of them needs to be analysed and assessed, e.g. a danger risk may be at the same time impending either from the vehicle, hazardous substance carried or the elements of infrastructure, etc.

2.3. Methods of measurement and assessment of factors rates of the material working environment

The measurement of various characteristics of the factors of material working environment is carried out with the aim of obtaining data enabling the assessment of influence of these factors on human beings with respect to:

- possibility of operative performance of definite tasks;
- danger risk of occupational diseases or accidents;
- improvement of working conditions on the job.

Measurement is carried out with special methods and instruments, e.g. measurement of noise, vibrations, concentration of gases and vapours in the air, temperature, moist, fast circulation of air, light force, etc. Methods of measurement are usually very simple. There are more problems regarding the choice of location, frequency and the time of measurement.

For example: the rate of exposure of an operator to the factor investigated is defined by the index of average measurements per each measuring day and then the arithmetic medium of all measurements within a longer period of time is calculated.

An average daily concentration (C_s) of one of the factors of the material environment can be obtained as follows:

$$C_s = \frac{C_1t_1 + C_2t_2 + C_3t_3 + \ldots + C_nt_n}{t_1 + t_2 + t_3 + \ldots + t_n}$$

where:

$C_1, C_2 \ldots C_n$ – denote measured concentrations at different locations in a definite period of time,

$t_1, t_2 \ldots t_n$ – stand for approximate time of exposure to the effect of the measured concentration.

The average periodical concentration (C_{sp}) can be obtained as follows:

$$C_{sp} = \frac{C_{s1} + C_{s2} + C_{s3} + \ldots + C_{sn}}{n}$$

The index of the level of danger risk can be obtained by calculation as to relation of concentration obtained by measurement and the permitted concentration (C_d).

$$C_n = \frac{C_{sp}}{C_d}$$

For example: if we wish to realise the third aim of measurement, i.e. improvement of working conditions, where concentration is below the permitted level, then the results may be used for further measurements in the most favourable conditions. These results show "weak points" of the formation of the material working environment which should be eliminated to reduce useless differences. As unfavourable conditions may appear at different locations and at different periods of time, also the number of measurements should be increased.

The measurement of power of the factors of material environment gives us the basis for their assessment. The assessment is made by comparison of the measured rate of concentrations and those standardised. The methods of measurement and the assessment of definite factors relevant for road traffic, e.g. the factors of micro and macro climate, noise, vibrations, air pollutants, etc. are numerous and will be dealt with in more detail.

2.4. Methods of research into critical events and errors

Research into critical events is usually very complicated because, apart from competence of the researcher, high inventiveness is needed along with patience and capability of deductive reasoning.

The methods of research into accidents at work and particularly traffic accidents are very specific and should include collecting and analysing documentary evidence, interrogating witnesses, analysing conditions prior to accidents, etc., which calls for special sci-

entific discipline with its own methodology, which, however, will not be dealt with here.

Besides, research should be done of errors in the methods and working conditions, above all considering regularity and possibility of the occurrence of accidents. Methods used may be as follows: analysis of documentation, questionnaires, interviews, etc. Errors at work may be best discovered by the method of observation. Here, simultaneously, a comparison is carried out of the existing instructions and procedures as well as comparison of recommended methods with those already implemented.

In research into causes of errors at work a hypothesis is put forward that the improvement of working conditions, decrease of tiredness, improvement of psycho-physical condition, ergonomic adaptation of facilities to human characteristics and limitations essentially reduce the possibility of errors and accidents.

2.5. Methods of assessment of physical and psychical efforts

Physical and psychical effort of operators and also other participants in road traffic can be assessed on the basis of detailed psychological and physiologic research.

There is also the possibility to assess physical and psychical effort on the basis of average demands of individual workplaces. Such assessments can be made by the so-called approximate methods oriented with regard to the rate of workload, regardless of working conditions. Therefore, the assessments of efforts should be analysed considering the working environment factors.

2.5.1. Assessment of physical effort

The assessment of physical effort in its essence consists of average assessments referring to:
- human energy consumption on the job in the individual workplace;
- static effort, depending on the body position;
- monotony or monotype movements.

The energy consumption of operators is assessed by comparing calculated daily consumption and standard rates according to the assessment criteria (Table 3). The calculation of daily energy consumption is made on the basis of the measurement of duration of individual operations and movements by means of measurement units which are conformed to a definite average rate of energy consumption. In the following phase rates of energy consumption for the whole operation are summed up, and finally rates are calculated for all operations performed within one day. The rates of energy consumption for individual working operations and their assessment can be found in abundant specialised literature.

Table 3. The assessment of energy consumption of an operator

Energy consumption for 8 hours working time in KJ	Assessment	
	Descriptive	Scoring
< 1254	Very low	0
1254 - 3344	Low	1 - 25
3345 - 6270	Medium	26 - 50
6271 - 8360	High	51 - 75
> 8360	Very high	76 - 100

The assessment of static effort is also carried out on the basis of standard evaluation criteria with respect to the body position on the job, which also exists in specialised literature. In the work which consists of several operations performed in different positions of operators, that position is assessed which is mostly exposed to static load, under condition that this load lasts for a minimum of 3 hours. In order to precisely define the rate of unfavourableness of static effort, elements of work where bulky cargo is handled should be considered. For example: if heavy loads are to be lifted with both hands, and if this is often repeated, the category of assessments which is defined on the basis of the body position increases by one degree.

Discomfort at work because of monotype movements is the result of repeated working operations engaging always the same group of muscles (Table 4). Monotype movements have definite relation to the monotony of work which refers particularly to psychical stress. If so, the number of movements has to be calculated which are repeated in a certain working operation or at least approximate evaluation of forces should be defined which act at that time. It is recommended to consider a marginal force of 100 N.

Table 4. The assessment of the rate of discomfort at work due to monotype movements

Number of repeated stereotype movements		Assessment of the rate of discomfort	
Force >100 N	Force < 100 N	Descriptive	Scoring
< 300	< 800	Low	1 - 30
300 - 800	800 - 1600	Medium	31 - 60
> 800	> 1600	High	61 - 100

2.5.2. Assessment of psychological effort

The assessment of psychological effort is also descriptive and scored. Like the assessment of physical effort three categories are considered:
- reception of information;
- decision-making;
- conduct of procedures.

Table 5. The total assessment of psychical effort of an operator

Rating	
General	Scoring
Minimal	0
Low	1 - 15
Medium	16 - 30
High	31 - 45
Very low	46 - 60

The assessment includes analysis of the following: information, decision-making, executive processes and particularly factors causing increase and decrease of psychical effort. Total assessment of psychical effort is based upon the amount of three individual scores (Table 5). Apart from that, a dominant phase of work should be determined where psychical effort is the highest.

Apart from the analysed total psychical effort of operators discomfort should also be defined deriving from monotony also contributing to psychical fatigue. The monotony of work has special importance in road traffic in assessing of the total psychical effort and has the following characteristics:

- unchangeability and low changeability in the work process;
- unchangeability and low changeability of micro and macro environment;
- ease of work, which reduces the need for intellectual processes;
- necessity of constant attentiveness without possibility of thinking about things not related to work, etc.

Total psychical effort assessed by consideration of both, the rate of psychical effort and monotony of work is equal to the rate of effort if the rate of monotony is lower than the rate of effort. If the latter two are the same or if the rate of monotony is higher than the assessment of total psychical effort is raised by a definite value.

2.6. Method of research into rationalisation of work

The methods of research into rationalisation of work from the viewpoint of the study of the organisation of technology of road traffic include a group of methods with which human work is examined and all influences on his work in order to simplify work, to set the time when it should be carried out, to increase safety, to reduce costs, etc.

With definite methods in the research into rationalisation of work the following can be achieved:

- formation of optimal way of work;
- reasonable duration of work needed.

The study of the organisation and technology of work requires its division in constituent parts and can be limited to two basic areas of activity:

- simplification of work;
- analysis of duration of work.

A task includes the whole process of work to be followed to meet a definite requirement or the set goal, e.g. transportation process of goods, a road vehicle ride in liner service, etc.

The phases of task include various kinds of work, carried out on different locations, e.g. loading, ride, discharge of goods.

The receiving is a constituent part of operation, e.g. loading of goods on a vehicle with handling facilities, receiving of goods with a particular loading facility, its lifting to a definite height and stowage on a vehicle, etc.

The movements are a constituent part of receiving, e.g. movements of a handling facility from its neutral position to the position of receiving goods, movements while receiving goods, etc.

The *micro movements* or basic movements are a constituent part of movements, e.g. movements of arms and legs of an operator operating the said facility.

2.6.1. Simplification of work

The simplification of work represents a systematic ascertaining, research and analysis of existing and proposed methods to carry out definite tasks as well as making up and application of simplified and more effective methods of work.

The basic phases in the process of simplification are:

- defining of the problem of work to be simplified;
- ascertaining of the existing way of work;
- analysis of the ascertained situation and defining a better way of work;
- implementation of the simplified way of work and its standardisation.

Defining the problem of work to be simplified

Before deciding which parts of work should be simplified, we have to consider all factors. In practice either the part of work which we are most familiar with can be taken into consideration or the one which we think is the most important. In road traffic those parts have to be simplified which reduce reliability, safety, regularity, timeliness, economy and effectiveness of functioning.

The definition of problems for the simplification of work in road traffic can be carried out through the following basic common factors:

- organisational;
- technical and technological;

- ergonomic;
- economic.

Ascertaining of the existing way of work

After having defined the problem, the existing condition of the workplace to be simplified should be ascertained. Various methods are used to collect data, which depends particularly on the type of work. In road traffic standardised methods, generally used in production, may be applied, like:

- succession of events;
- pace measurement;
- description of work performance;
- overall picture taken of a workplace;
- overall picture taken of operator's work;
- overall picture taken of man-machine system;
- overall picture taken of crew work on the transportation means, etc.

Analysis of the ascertained condition and the definition of a better way of work

Due to verification of condition and defining the possibilities of changing methods for the simplification of work the obtained data through ascertaining should be verified.

The critical analysis of all data obtained is possible only by accurate solutions to all issues referring to the object of work, to direct operators as well as to the location, time and the way of work. All solutions should be scientifically backed. An accurate analysis often shows that in some parts something should be omitted, combined, simplified or sophisticated.

Implementation of simplifications and standardisation

On the completion of the analysis, the ascertained condition and definition of the improvements, implementation follows by:

- ascertaining new methods of work;
- testing their "suitability";
- making arrangements for their introduction;
- controlling their implementation;
- standardising new methods.

2.6.2. Study and analysis of work duration

The aim of the study and analysis of work duration in road traffic is to find out the necessary time needed to perform a definite work. This time represents the amount of work and serves to:

- define standards of manning levels;
- plan the load to which transportation and handling facilities are exposed;
- plan deadlines for the performance of work;
- make up operative work plans;
- evaluate work and analyse losses;
- determine work costs;
- encourage better work by merit awards;
- compare new and old methods of work;
- plan and project a new work process;
- apply criteria for the simplification of work process, etc.

Duration of any work as well as the work in road traffic includes the following basic time elements:

- arrangements-final time;
- technological time;
- auxiliary time;
- additional time.

There are several methods for defining and analysing duration of work, but every method is not applicable for each type of work. For defining and analysing duration of work in road traffic the following basic methods may be used:

- method of assessment of duration of work;
- method of taking a picture of duration of work;
- method of defining time of work according to the system of predicted duration of time;
- method of taking an overall picture of a working day;
- method of momentary observations.

There are plenty of methods of the study and analysis of the duration of work, which is covered by specialised literature.

Regarding the problems of the organisation and technology of road traffic the method of momentary observations (MMO) is recommended by the author, based on a definite pattern of the work process for defining duration or frequency of definite working elements. The results are obtained on the basis of relevant proportion of elements with the freely chosen accuracy and statistical safety of 95%. The MMO method enables two basic procedures which differ only in the technique of implementation, but the principles and the elements of mathematical statistics and stochastic theory are the same:

MMO as a calculation procedure which measures the absolute and the missing frequency of the individual elements of work;

MMO as a procedure of finding out the duration of individual elements of work.

3. CONCLUSION

The selected aspect of the study of the organisation and technology of work in road traffic is in essence based on scientific organisation of work where the man, as a link in organisation and an executor of technological processes, is brought forward. The acquaintance with the essence of the "man-machine" system, organisation and technological processes, their interrelations, operation of individual elements

of this system as well as the problems of the forming of conditions for its optimal functioning is a prerequisite for the definition of problems, setting aims and defining research methods.

This aspect of the study includes research into human activities, i.e. of an operator or the participant in road traffic in accordance with the set aims, in connection with the simultaneous research into organisation and technology. Such research may be complex or specific.

The methods dealt with represent only a part of the methods compatible for the research into road traffic. These are above all methods of observation, research and assessment of danger risk, measurement and assessment of the rate of effect of the factors of material working environment, research into critical events and errors, assessment of physical and psychical effort as well as research into the simplification of work.

POVZETEK

Preučevanje organizacije in tehnologije dela v prometu nasplošno, kot tudi v cestnem prometu se opravlja z različnih stališč. V znanstveni in strokovni literaturi iz tega področja obstajajo zelo različni aspekti preučevanja, kar prinaša precej zmede med strokovnjake, ki si prizadevajo, da organizacijo in tehnologijo dela v cestnem prometu bazirajo na temeljih znanstvene organizacije dela. V referatu se obdeluje aspekt preučevanja, ki se temelji na teoriji znanstvene organizacije in tehnologije dela ter njegovi implementaciji v organizaciji in tehnologiji dela v cestnem prometu. Pri tem se posebej analizirajo metode, s katerimi se preučuje delo človeka in vplive na njegovo delo v cestnem prometu. Kot rezultat takšnega aspekta preučevanja organizacije in tehnologije cestnega prometa se lahko po obdelani metodologiji racionalizira delo, izboljšajo eksploatacijski kazalci in izboljša v celoti učinkovitost obstoječe organizacije in tehnologije cestnega prometa. Po istem aspektu preučevanja se lahko pristopi organiziranju ter optimiziranju tudi nove organizacije in tehnologije cestnega prometa.

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