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ERGONOMIC SYSTEM ANALYSIS OF ROAD TRANSPORTATION

ABSTRACT

The paper presents decomposition analysis of road transportation system using the ergonomic system analysis. The analysis is performed by its "Man-Vehicle", "Man-Road" and "Man-Operation" subsystems treated as systems with their own subsystems.

Since the ergonomic factors within road transportation system with its subsystems or elements are very complex and comprehensive, only the implications of the "Driver-Vehicle" system are analysed.

KEY WORDS

ergonomics, human, vehicles, roads, environment

1. INTRODUCTION

From the ergonomic point of view, the road transportation system's main feature is characterised by a large number of distinctive differences in terms of users, vehicles, human abilities and road conditions. Moreover, the road transportation assumes different weather and/or time conditions. It is being operated, managed and controlled using advanced methods and techniques entirely undetermined under the circumstances.

From the ergonomic point of view, the road transportation system investigation is based on the "Man-Machine" basic system approach. A micro ergonomic subsystem analysis at the lowest level enables transfer to the upper level until the required level is reached.

Relations within the system are extremely complex because of the interactive implications such as bio-technical, psycho-physiological, technological and/or operational features.

In order to comprehend a problem system, an ergonomic decomposition of the road transportation system using the subsystems "Man-Vehicle", "Man-Road" and "Man-Operation" is performed. The "Driver-Vehicle" ergonomic system analysis is particularly emphasised.

2. ERGONOMIC ASPECT OF THE ROAD TRANSPORTATION SYSTEM STRUCTURE (RTSS)

RTSS is presented in Figure 1, by decomposing the "Man-Vehicle-Road-Operation-Environment" basic subsystem.

As presented in Figure 1, there is no doubt that the system has a very complex open dynamic structure. Regarding the possibilities of its subsystems influencing the quality of function, several observations can be made:

- the Man-Operation subsystem has the most elastic structure;
- the Man-Vehicle subsystem has an average elastic structure;
- the Man-Road subsystem has low elasticity;
- the Man-Environment subsystem has the lowest elasticity with an entirely non-elastic structure

Particular subsystems in the MVROE system (Figure 1) receive input elements (x) and transmit output elements (y). Input elements (x) for each level of the system or subsystem could represent a substance, energy and information. Output elements (y) are to be as of transformed substance, energy or information.

The transformation process between input (x) and output (y) elements occurs in a determined time interval of (t). The whole process depends on the systems and subsystems features . This can be expressed by:

$$y = f(x, t, r)$$

For instance, the MV system treated as a subsystem of MVROE system being a subsystem of the RTS has its own very complex systems on its lower level such as: Driver-Vehicle (D-V), Passenger-Vehicle (P-V), Pedestrian-Vehicle (Pd-V), Designer-Vehicle

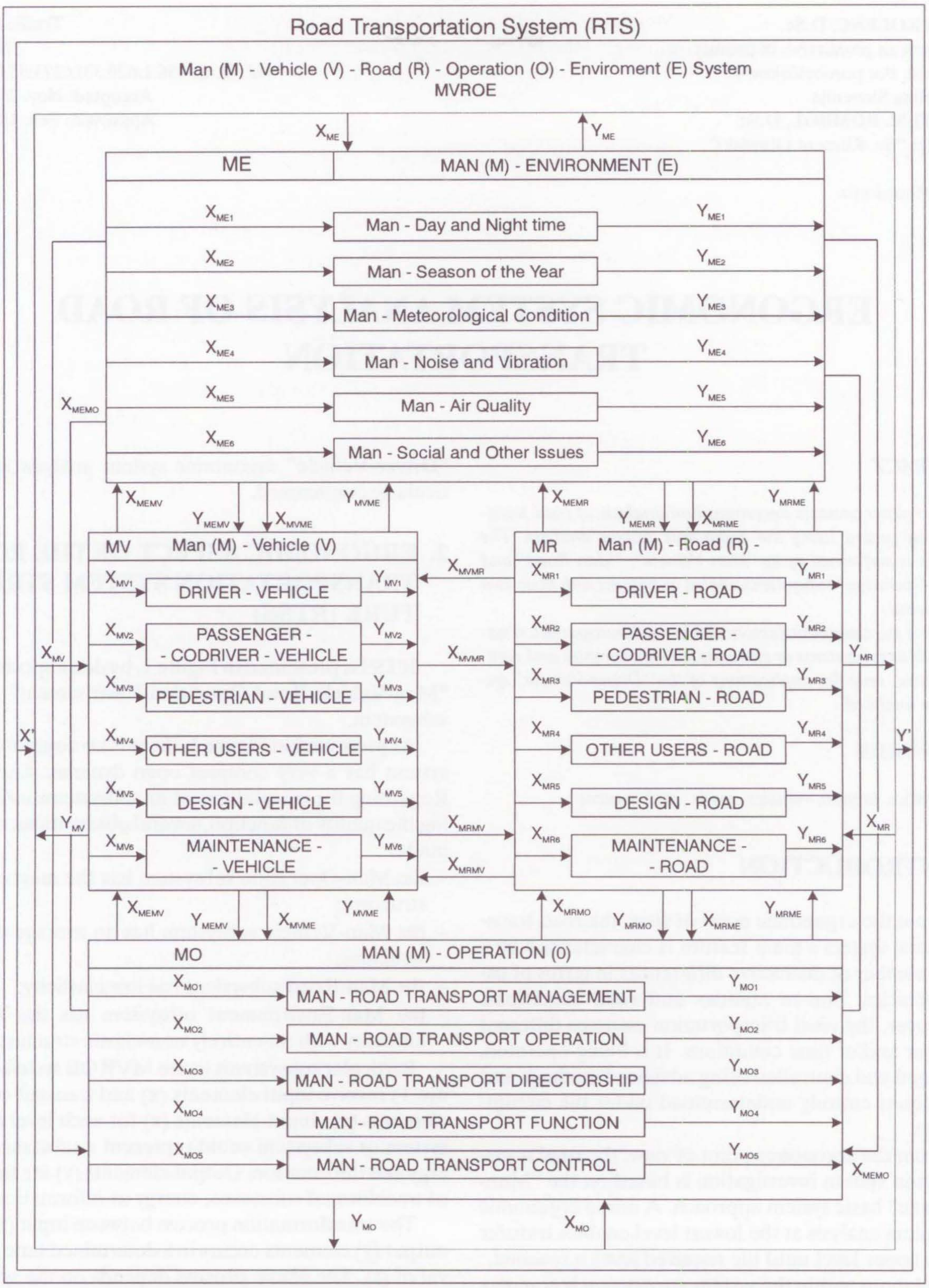

Figure 1 - Road Transportation System Decomposition from the Ergonomic Point of View

(Ds-V), Producer-Vehicle (Pr-V), Maintenance-Vehicle (M-V) system, etc. Within themselves, these systems are complex.

By analogy the MR system has its own subsystems at the lower level such as: Driver-Road (D-R), Passenger-Road (P-R), Pedestrian-Road (Pd-R), Designer-Road (Des-R), Constructor-Road (C-R), Maintenance-Road (M-R) subsystems.

As a subsystem of the upper level system, the ME system has its own subsystems at the lower level such as: Man-Time of the day/night, Man-Meteorological conditions, Man-Micro environment conditions, Man-Society subsystems, etc.

The MO system as a subsystem to the upper level system has its own subsystems on the lower level such as: Man-Management, Man-Operation, Man-Directorship, Man-Control, etc.

It is to be assumed that in all of the systems and/or subsystems the MAN subsystem is always present. Its roles, interests and features are different, various and often very contradictory.

3. ERGONOMIC ANALYSIS OF A CHOSEN SUBSYSTEM

Since the road transportation ergonomic analysis is extremely complex for further analysis, only the "Driver-Vehicle" (DV) system is to be chosen.

The DV system as a subsystem of the "Man-Vehicle" system (Figure 1), has its own bio-technical characteristics. The "Driver" subsystem has to be analysed as a new biological system with its own subsystems, whereas the "Vehicle" subsystem as a new technical system with its own subsystems as well.

At the same time, the DV system has to be analysed as a unified system whose characteristics differ when treated separately. For instance, in the role of a pedestrian, the driver, as a biological system, has entirely different ergonomic features compared with being only the driver himself.

The relations within the DV subsystem are very complex and dependent on its characteristics. There are interactions among other subsystems within the system observed. Thus, the real comprehension of functioning and ergonomic compatibility could be set.

The ergonomic in depth analysis of the DV system shows that the input elements come from the upper level MD system (Figure 1), such as the output parameters related to the co-driver passengers, and to other transportation users, vehicle designers, etc.

Apart from the above mentioned input elements, the DV system is receiving other incoming elements directly from the upper level MV system such as:
- through the "M-R" entity with its separate subsystems;
- through the "M-E" entity with its separate subsystems;
- through the "M-O" entity separate subsystems.

Input elements transformation of the "M-V" system, depends on the input elements features, the time of transformation and system characteristics.

The transformation process is stochastic due to the bio-technical characteristics of the system. Input elements transformation time of the "Driver" subsystem is not in accordance with the "Vehicle" subsystem. This is primarily due to the sc."off-set".driver behaviour phenomenon.

Thus the system characteristics impact on the output parameters (y) is dominant. Due to the ergonomic conformity level, output parameters form a linkup between the "Driver" as a biological system and the "Vehicle" as a technical system.

According to the input elements transformation, the "D-V" system transmits output elements (y) to the upper level of the "M-V" system and its separate subsystems relating to the co-driver, passengers, other users, constructors, service-managers, etc.

Besides the output components transmitted by the "M-V" system, there are some other elements transmitted directly toward:
- "Man-Road" system as an entity and its separate subsystems;
- "Man-Operation" system as an entity and its separate subsystems;
- "Man-Environment" system as an entity and its separate subsystems.

By performing further ergonomic analysis of the "Driver-Vehicle" system, a decomposition and analysis of the "Driver" and the "Vehicle" subsystem is required. The latter could be treated as a new system with its own subsystems.

The "Driver" system acting as a biological chain in the "Driver-Vehicle" system has its leading role in the system functioning. It receives input elements (x) from the vehicle such as: visual, audio and other indications such as acceleration, deceleration, vibrations, etc.

At the same time, the input elements for the "Driver" system are all the input elements related to the driver and coming from a co-driver, a passenger, a pedestrian and other transportation users.

There are some indirect input elements that a driver receives from the "Man-Road", "Man-Operation" and "Man-Environment" systems, as well as from its separate subsystems.

Input-output elements transformation depends on the features of input element for the driver (x), time of transformation (t), and the driver's characteristics .

Driver's transformation time is expressed by "off set" driver behaviour phenomenon with its direct implication to the upper level systems.

Driver features influence the output elements by their psycho-physiological characteristics, age, sex, level of knowledge, skills and attitudes, alcohol, drugs, etc.

Thus, the output elements coming from the driver out toward the vehicle form action forces on the vehicle control board, its weight, etc.

The driver transmits the output elements directly or indirectly to all the other subsystems in the "Man-Vehicle" system, such as to the co-driver, to the passengers, pedestrians, other transportation users, constructors, maintenance personnel, etc.

At the same time, input elements are directly transmitted via "Driver-Vehicle" system to the "Man-Road", "Man-Operation", and "Man-Environment" systems and all their subsystems.

The same analogy applies when ergonomic analysis for the "Vehicle" subsystem from the "Driver-Vehicle" system with all its subsystems until the lowest level, is required and performed.

4. CONCLUSION

Ergonomic system analysis of the road transportation entails particular problem complexity, understanding and interdisciplinary approach when road transportation system and its subsystem function are studied. Since it is not possible to cover all the system levels and its subsystems, only the ergonomic analysis of the "Driver-Vehicle" system is performed. The conclusion made is that the input elements characteristics, the input-output transformation time and the system characteristics have a major impact on the system function and performance.

The chosen subsystem ergonomic analysis has also shown that besides the ergonomic conformity between the "driver" and "vehicle" subsystems, a significant ergonomic relationship with other elements related to the road and its objects, to the complex environmental conditions, road transportation operation and technology, is to be observed. The main starting point made is of the ergonomic conformity to be primarily assumed as a function of man's characteristics and abilities when being a transportation user.

The analysis presented above has a significant role in road transportation system performance analysis, particularly in the area of traffic safety. It is to say that sc. "disguised" or "indirect" traffic accidents causes are very often treated with lacking consideration.

SAŽETAK

SUSTAVNA ERGONOMSKA ANALIZA CESTOVNOG PROMETA

U radu je putem sustavne ergonomske analize obavljena raščlamba sustava cestovnog prometa. Analiza je izvršena putem podsustava "čovjek-vozilo", "čovjek-cesta", "čovjek-organizacija" i "čovjek-okolina", koji su nadalje analizirani kao sustavi sa svojim podsustavima.

Zbog obimnosti i složenosti ergonomskih faktora sustava cestovnoga prometa, njegovih podsustava i elemenata, posebice je analiziran samo sustav "vozač-vozilo", kao podsustav sustava "čovjek-vozilo" s međusobnim utjecajima drugih podsustava cestovnoga prometa.

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