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The relation of pro-exploitation attributes with product development process of public transport vehicles manufacturing

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Abstract. The paper presents the influence of product development process and manufacturing of public transport vehicles on its pro-exploitation attributes. Moreover, it describes the expert method of inferring about future states of public transport vehicles (exploitation and service phases as well as elimination and utilization phases) based on earlier process of product development and manufacturing. A numerical formalization of the expert intuition of twenty specialists is a starting point of the method. The examined dependency regards the relation between pro-exploitation attributes of vehicle with the individual stages of the engineering design associated with product development process of vehicles. Hypothesis about the essential relation of the individual stages of product development process with pro-exploitation attributes of vehicle was verified with the method of progressive inference.

1. Introduction

The goal of this paper is to present research results concerning the influence of product development process and manufacturing of public transport vehicles on its pro-exploitation attributes. Public transport vehicles were ranked among the group of transport vehicles within the notional category: (figure 1). The analysis involves three large enterprises producing buses, trams and local metropolitan coaches.

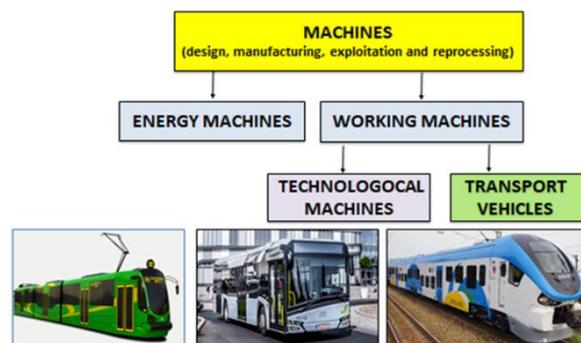


Figure 1. The group of transport vehicles as the element of the notional category: machines [1].



The problem-related presented in the paper has the character of a relation linking attributes of the pro-exploitation of a given group of public transport vehicles with the technical preparation and implementation of the processes of their creation. The processes of creating public transport vehicles were related to the structural, technological and organizational preparation and implementation of their production. The pro-exploitation approach in the processes of creating public transport vehicles is related to the existence of the life cycle of the production phase of the vehicle development process and the life cycle of vehicles as a usable result of implementing this production process.

Literature studies [2, 3] and practical experience show that a large part of the life cycle costs of public transport vehicles is a consequence of decisions made in the pre-production phases of their creation. Technical preparation of vehicle production turns out to be an area particularly susceptible to pre-production reduction of operating costs. According to literature studies, this phase determines up to seventy per cent of costs, which later can hardly be reduced [4–6]. Low operating costs of public transport vehicles translate, in the conditions of urban agglomerations, into lowering the costs of local transport in the individual (e.g. tram and city bus passengers) and socio-economic dimension of a metropolis.

2. Selected exploitation problems and meaning of pro-exploitation

Exploitation definition involves the stage of using and operating the vehicle; in addition, in the system of his use the use is a basic process [8]. However, functional features are providing about directing at improving manufacturing processes, according to the current state of technology. Generally, the contemporary problems of the exploitation concern five thematic areas: [7, 9]:

- the description, the modelling and improving objects and systems of the exploitation;
- strategy of the reconstruction and reconstructions of the exploitation systems;
- predicting the permanence and reliabilities;
- providing the efficient productive maintenance;
- economic of the exploitation and services.

Based on the exploitation meaning, next, the definition of the pro-exploitation approach to improving the processes of public transport vehicles creation was specified as: a set of purposeful construction, organizational, technological and economic activities undertaken in relation to the production process of minibuses, buses, trams and passenger rolling stock of regional railways (including its conception, maturing and stabilization) in order to make the most efficient and appropriate (from the point of view of the customer) use of manufactured vehicles at the stages of their use, servicing, liquidation and disposal after the end of operation.

On the basis of thirteen so-called good exploitation practices [10, 11], it was assumed that a public transport vehicle as an object of operation is characterized by the following features:

- functional (which is usually included in the technical specifications of a vehicle);
- structural (describing the principle of work and interaction of vehicle components);
- service (defined by instructions for use, adjustment and maintenance of a vehicle);
- diagnostic (controlled during vehicle maintenance inspections).

The assessment of the above four characteristics of the exploitation of public transport vehicles and adherence to good exploitation practices were brought down to the following seven attributes of exploitation of minibuses, buses, trams and passenger rolling stock of regional railways:

- effectiveness and functional efficiency (including the ease of starting exploitation) and economical use and maintenance (exploitation proper);
- reliability and durability, resistance to atmospheric conditions and damage;
- exploitation safety (including elimination of accidental start-ups, unauthorized use, maintenance and possible intentional damage);
- ergonomics (including general aesthetics of a vehicle, configuration and ease of operation, resistance to operating errors and instantaneous overloading);
- ecological operation.

- diagnostic and service susceptibility; reparability and audit control susceptibility;
- recycling and disposal susceptibility.

The first three attributes are covered by the common term: functional (technical-economical and usable) susceptibility of public transport vehicles. Similarly, the common term of adapting the construction and use of public transport vehicles to natural limitations and human capabilities was used to specify two other attributes: ergonomics and environmental exploitation of public transport vehicles. The other two pro-exploitation attributes were defined as diagnostic (inspections, repairs and audits), service susceptibility of public transport vehicles as well as recycling, and disposal susceptibility of these vehicles.

3. Pro-exploitation attributes and product development process of public transport vehicles — research characteristic

From the point of view of the attributes of operation of public transport vehicles the construction assumptions (prospective constructional preparation of production), connected with their technical characteristics and exploitation principles, related to all seven areas of exploitation of these vehicles. In order to check the above relational hypothesis based on the Delphi method, an expert method for predicting the dependence of specific attributes of the pro-exploitation of public transport vehicles on selected stages of technical preparation for their creation was developed. It was assumed that the inference about later conditions of minibuses, buses, trams and passenger rolling stock of regional railways (the phase of use and operation as well as liquidation and disposal) based on the earlier (within the life cycle of the product) technical preparation and implementation of the process of their creation is a future-predicting relationship.

The author's concept of this method took as a starting point the attempt of numerical formalization of expert intuition of the following twenty specialists: constructors, technologists, organizers of production and operation of public transport vehicles, an organizer of sales of these vehicles, a supplier of components and media in manufacturing processes, suppliers of components and operating media for vehicle users, users driving transport vehicles, users carrying out inspections and repairs, users — passengers of these transport vehicles and a liquidator of a worn-out vehicle.

The essence of the developed method was to 'force' moving experts who are undecided and do not have the right arguments to the group constituting the majority, that is the group of experts whose answers were in the so-called interquartile range of the median.

The presentation of the numerical results of the use of the above-mentioned expert method was limited to the study of relations linking the first and fifth stage of designing construction assumptions of the transport vehicle with three following attributes of its pro-exploitation: vehicle reliability and durability, exploitation resistance, ergonomics of the vehicle and its recycling and disposal susceptibility.

The conclusions obtained from the research on the prospective structural preparation of production of vehicles used in the future can be presented here as verbal interpretation (important from a cognitive and utilitarian point of view) and are formulated as follows:

- As part of the construction assumptions of public transport vehicles, both technical and economical as well as usability susceptibility and the adaptation of their construction and use to natural limitations and human capabilities (ergonomic aspects and ecological requirements) are specified. The prospective structural preparation of production also determines the diagnostic and repair service susceptibility of these vehicles associated with inspections, repairs and audits.
- Within the technical characteristics of public transport vehicles and the principles of their exploitation and use, recycling and usability premises of the last phase of life of minibuses, buses, trams and passenger rolling stock of regional railways are formulated.
- It seems that the structural similarity contained in the construction assumptions of public transport vehicles with other products of the company as well as the interchangeability and normalization unification of parts and components of public transport vehicles directly affect

this attribute of their operation which is associated with diagnostic and repair service susceptibility of a vehicle.

- Structural assumptions specifying the indicators and requirements as well as technical and operational processes and activities of public transport vehicles determine both their diagnostic and repair pro-operation as well as the functional, technical, economical and usability pro-operation.
- The size of the production programme and approximate investment outlays and, associated with it, the price of minibuses, buses, trams and passenger rolling stock of regional railways also formulated within the framework of construction design assumptions indirectly refer to the technical-utility and economic attribute of their operation.

4. Closing remarks

Analysing it is interesting to note that full confirmation in numerical expert opinions was obtained by another hypothesis stating that the development of technical and operational requirements, construction assumptions and preparation of the preliminary design followed by the technical and working design is the area of proper structural preparation of public transport vehicles, in which all attributes of their pro-exploitation are formed covering both functional and diagnostic-repair, recycling and disposal susceptibility as well as adapting the construction and use of the vehicle to the requirements of ergonomics and ecology. The conducted research undermined the intuitive belief that the same is the question of the stages of proper construction preparation of production, which include the execution (or computer simulation) of a public transport vehicle prototype, checking its compliance with the construction documentation and assumptions, and then performing the information series and the test vehicle series. The numerical values of expert opinions exceeded the level of significant dependence accepted for the method, but in a few cases there were problems with such clarification of interquartile ranges which would place their lower values above this level. The research also attempts to justify the next hypothesis about a significant link between the three stages of prospective technological production preparation (research regarding technological progress, scientific and research work on the concept of a technological process and design development of this process concept) with seven attributes of the pro-exploitation of a public transport vehicle. The numerical results of these studies led to the conclusion that the median value along with the lower limit of the interquartile range in twenty cases of relationship testing exceeded the lower level of significant dependence. Only in one case of the relationship between research in the area of technological progress and recycling and disposal susceptibility, the numerical value of the median was identified at the level of a small dependence.

Today's technical preparation of production must take into account the fact that the volatility and unpredictability of the environment of a manufacturing company is growing and there is no indication that this trend will reverse. Contemporary enterprises producing public transport vehicles based on the so-called rigid technology, which assumes the stability of the environment, are doomed to failure. Enterprises of this type may, however, continue and even develop in the conditions of changeability and unpredictability of the environment if they take prompt actions known as strategic intelligence, consisting in giving more importance to knowledge about new markets and new technologies (in line with the concept of the knowledge-based economy) and financial resources to acquire these technologies rather than material wealth. Such an approach will be the subject of undertaken research of the author in the nearest future.

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