Specification of basic operational/technical performances of new railway vehicle for suburban/urban transport

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Abstract

The new vehicles for suburban/urban transport, planned to be introduced on the network of electrified lines of Yugoslavia in the near future, should be maximally adapted to operational conditions they will operate in. For this reason a complex project was prepared, the purpose of which was the specification of these performances.

The paper will present the results of this investigation which included 11 towns of Yugoslavia.

The basic strategy of investigations was that vehicle performances can be defined only as a set of systematically investigated construction elements of the network of railway lines on which these vehicles are to operate, the established volume and characteristics of passenger flows, technology and organization of suburban/urban transport, new acquired knowledge, principles and solutions in building new similar vehicles in the most developed countries and economic abilities of towns where such vehicles are to be used.

By further investigations a method of multi-criterion evaluation known as the outranking methods can be applied in specifying the desired performances.

1. Introduction

The second half of this century is characterized by expansion of population into towns, the unbridled spreading of the most towns, as well as the economic development, resulting in significant transport problems therein. Different pace of living, standard, and level of services brought new requirements in respect of traffic organization. An additional
problem in the transport systems development in towns is the growing loading of central city zones as well as the growing environmental problems therein. All this aroused a need for new compatible suburban/urban systems which will be able to economically use the existing infrastructure and limited space resources within towns.

In FR Yugoslavia 34% of railway network is electrified, and that the most important lines with the highest traffic volume, connecting the major towns. It was for that reason that the group of experts from the University, the Yugoslav Railways and domestic industries placed a contract for the preparation of a project, the basic objective of which is to specify the vehicles for railway suburban/urban transport on the electrified railway network.

2. Methodology of Investigation

In view of the fact that vehicles for this type of transport have not been manufactured in Yugoslavia thus far, the project is to specify the vehicles which will, in the best possible way, accommodate and meet the customers', purchaser's (railway) and industries' requirements.

The customers' requirements are reflected through parameters related to the characteristics of routes on which they would travel (travelling time, comfort, putting aside of luggage, proper information to passengers on both the train and the station, regularity, punctuality). The railway's requirements are related to vehicle operation, i.e. meeting of specific local conditions. The industries' requirements are that the performances affecting the design solutions of all vehicle elements be as much as possible adjusted to the domestic industries' capacities.

The inter-relation and -dependence of all these factors with the environment elements and their further impact on specification of the new vehicle's performances are shown in Figure 1.

![Figure 1. The factors essential for specifying the methodology](image)
Based on all requirements and constraints, the investigation methodology has been specified, the basic algorithm of which is shown in Figure 2. The substance of the methodology is that the basic vehicle performances can be specified only by specifying the towns and railway network on which the vehicle in question will serve, technical, operational and technological elements of railway network, new technology of suburban/urban transport and basic traction calculations. The technical, operational and technological parameters of railway lines have been set out for a long period of time so that the vehicle specification has the most influence on a new proposed technology for this movement.

The basic assumptions of the new technology are: the characteristics of the quality of service and magnitude of passenger flows on different routes, as well as the socio-economic and environmental requirements.

The first step of the methodology implementation during the course of 1995 specifies, on the basis of all these assumptions, the possible variant of preliminary solutions of the new vehicles. The second step, which is underway, by means of the known methods of multi-criteria optimization (multi decision methods known as outranking methods) from the group of variant preliminary solutions, specifies the basic vehicle.

Figure 2. Basic algorithm of the investigation methodology
3. Results of the implemented methodology

On the basis of the specified methodology and investigation 18 criteria have been selected, divided into 36 sub-criteria, presented in Table 1. Each of the specified criteria has its place and quantification in hierarchy.

Basic technical/operational performances of vehicles (EMUs)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sub-criterion</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle capacity</td>
<td>Number of seats</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Total number of standing places</td>
<td>120</td>
<td>140</td>
</tr>
<tr>
<td>Interior of vehicle</td>
<td>Seat arrangement</td>
<td>2+1</td>
<td>2+2</td>
</tr>
<tr>
<td></td>
<td>Number of standing places</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Aisle width (m)</td>
<td></td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Inner vehicle width (m)</td>
<td></td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>Special purpose space</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Heating and ventilation system</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Design</td>
<td>Ratio of passengers entry/exit channel and vehicle capacity</td>
<td>1:35</td>
<td>1:37.5</td>
</tr>
<tr>
<td></td>
<td>Number and location of doors (at one side of the vehicle)</td>
<td>2-4</td>
<td>4-6</td>
</tr>
<tr>
<td>Design</td>
<td>Marking (on front and lateral sides) - displays and different colours</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loud-speaker system installed in whole train set</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Lighting system</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Sanitary facilities</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Main unit set</td>
<td>Possibility of coupling the sets</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Possibility of use for other categories</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Vehicle flexibility</td>
<td>Driving units (motor coach)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of coaches</td>
<td>Trailers (remolque)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of driver’s posts</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Basic dimensions</td>
<td>Width (m)</td>
<td>28</td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td>Length (m)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Length of individual vehicles in the set</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Traction motors</td>
<td>Asynchronous and power GTO inverters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>Projected</td>
<td>UIC</td>
<td>UIC</td>
</tr>
<tr>
<td></td>
<td>Operational</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max speed-max gradient (km/h)</td>
<td>80/26</td>
<td>120/10</td>
</tr>
<tr>
<td>Curve radius</td>
<td>in horizontal plane</td>
<td>80/250</td>
<td>800/</td>
</tr>
<tr>
<td></td>
<td>in vertical plane</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The vehicle capacity is defined on the basis of the planned new organization of operations according to the tact train schedule, with a 2-hour tact during the day (one hour in the peak period-rush hour). The factors influencing the specified capacities also are the magnitudes of passenger flows on each of 56 routes for 11 towns.

The total effects of this traffic can expected and obtained only if the number of departures during the day is not bellow 10, with the maximum punctuality, regularity and timely informing of passengers, which is a property of the quality of service of modern railway suburban/urban transport. The number of seats is obtained on the basis of the number of passengers travelling from farther stations, taking into consideration the social and age structures, as well as the sex of passengers.

The arrangement and appearance of seats is established from the ratio of the total number of seats and number of standing places, conditioned by ergonomic criteria and largeness of the communication space available to passengers through the train.

The ratio of entry/exit channels, number and location of doors, are obtained on the basis of the number of passengers getting on/off the vehicles on the most loaded stations in peak periods of the day and the scheduled train stopping times in them.

The length of individual train vehicle elements and the whole set is established in relation to the required capacity and dynamic analyses of train movement, whereas the width is in the function of vehicle length and the relevant UIC regulations.

The maximum speeds on the line and on gradients are established on the basis of current and future technical and operatonal line characteristics. The vehicle performances for horizontal and vertical curves are established in the same way.

The braking characteristics of the vehicle are specified in the function of the prescribed braking distances.

The vehicle floor height is established on the basis of the need to meet the requirements for safety and easy circulation of passengers at
entrance and exit, both on the station with low platforms and those which
already have high platforms. A special attention is attached to specifying
this height due to the fact that most stations have low platforms and
trend to avoid spending high amounts of money for their conversion into
high ones.

This project has not provided a solution for access of handicapped
persons, for which there are no financial means in 11 analysed towns.

The investigation established that the required capacity of about
240 passengers per set is satisfied with two or three unit set. Due to
increased passenger flows on some lines and in some periods of the day,
there should be a facility of coupling together up to three sets.

4. Conclusion

In accordance with the way of looking at the problem, the
customers’ requirements, a new concept of organization of operations, a
new trend of supplying the services and achieving the quality of service,
as well as the abilities of industries, the project specifies 5 variants of
preliminary solutions.

In specifying the performances of the suburban/urban vehicle for
electrified lines the important point to be considered is not the question
of improvement, promotion or modernization of the existing vehicle, but
the development of the completely new one. This new vehicle would be a
sort of a unificated vehicle which will meet the given requirements to the
greatest possible extent.

Contrary to the conventional presently used sets, the preliminary
solution of the new vehicle is characterized by the structure adjusted to
current transport requirements (modular construction), high running
performances making easier a successful integration with other
transport modes (acceleration, maximum speed, braking distance, power,
etc.), a new quality of service, environmental aspect, energy saving, as
well as the easier maintenance.

Out of the selected elements (criteria) important for defining this
vehicle, some are particular for this analysed network of railway lines
only. The characteristics obtained represent the required performances
which can be modified only to a small extent, without disturbing the basic
concept of the vehicle, in order to obtain the less costly, but more
optimal vehicle.

The overall work of this project demonstrates that for 11 analysed
towns in Yugoslavia, there is a need on 56 routes to have a modern
railway suburban/urban transport. It is found that the issue of choice of
the optimal vehicles characteristics is multi-disciplinary, and that one of
the most important roles is played by spatial and functional allocation of
the population’s activities in the suburban/urban areas where to the
directions and flows of passengers movements are directly related.
5. Reference


5. Faculty of transport and traffic engineering, Razvoj domaćeg vozila za prigradsko-gradski saobraćaj na mreži elektrificiranih pruga - (Development of domestic railway vehicle for suburban/urban transport on the electrified railway network), Beograd 1995.

Figure 3. Preliminary solution of two unit set (EMU)
Figure 4. Preliminary solution of three set (EMU)
Figure 5. Preliminary solution of two unit set (EMU)