QUALITY MANAGEMENT IN RAILWAY TRANSPORT - TRAFFIC CAPACITY VS. INFRASTRUCTURE CAPACITY

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ABSTRACT: In order to be able to adopt the best measures in any field, the main need is to know and differentiate between the different phrases and notions specific to the respective system. The purpose of this paper is to broaden the horizon of knowledge, to clarify the aspect considered non-compliant and to explain the correct form supported by examples of the notion of traffic capacity vs. infrastructure capacity and correlation with quality in the field of transport. In various specialized studies, in railway regulations and including in the laws of the European Union and national, only the idea of infrastructure capacity is incorporated, which is an inconsistent and erroneous expression. The actions of the quality management in the railway transport are included in both the strategic and the operative management, the particularity consists in the application of some measures of great technical and financial scope and with long durations of accomplishment. Therefore, the solutions to increase the quality of this service also consist in the ability to respond to new challenges, transport demand (allocation of traffic capacity) and limiting the effects of particularities in this sector.

KEYWORDS: railway transport, quality management, transport quality, capacity, correlation

1. INTRODUCTION

In recent decades, the railway transport sector has become an increasingly discussed topic, both at national and European level. The desire and aspiration to create a single European railway network has led to a multitude of common directives, decisions and regulations that transpose the legislation adopted at European level in each state, in order to achieve a European legislative homogeneity.

The management of the railway transport system is also found in different forms and models, with the aim and conviction of having adopted the optimal measures to manage the transition to a unique railway space. Several countries have adopted either a vertically separate management model or vertically integrated models, trying to introduce and regulate competition, allowing non-discriminatory access for several transport operators, so as to achieve the liberalization of the railway transport market.

However, few countries have so far managed to create efficient and transparent processes for allocating capacity to different transport operators, and state-owned operators still have a monopoly on the national transport market. The main subject of this paper is to clarify the main notions in the railway field regarding the allocation of traffic capacity and their erroneous exposure in some specialized studies, as well as in the framework laws that establish the regulations of the European Union in this field.

If we follow ad litteram the text of laws or regulations, the notion of infrastructure capacity, which is in the foreground, leads us to a wrong applicability of the capacity allocation precedent and does not represent what is actually,, sold'' to operators transport.

The analysis and description of the railway capacity is a rather complex procedure that should be sufficiently understood for a responsible management and to cope with the growing transport demand (this generating an increase in traffic).

Traffic capacity involves several complex systems, such as infrastructure, rolling stock, travel times and the human factor. Also other factors that influence capacity are:

- The number of current lines (the portion of the line between two input signals from opposite directions of two neighboring stations);
- Arrangement of lines in stations;

- Signaling system;
- The type of train and its performance;
- The characteristics of the location of the lines and the rolling resistances;
- Traffic organization;
- Reliability.

Therefore, it is important that the right actions are taken at the right time which requires a good understanding of how the railway system works and responds to the adaptation of new challenges.

There is no simple way to determine capacity, as it depends to such a high degree on several variables, which can be defined as a balance between the number of trains, average speed, stability and heterogeneity or a compromise between quantity and quality, more precisely between the number of trains (of operators) and the sum of the delays generated by them.

Increased traffic can cause a greater sensitivity to delays, which spread from train to train.

This sensitivity creates a conflict of interest between the allocation of new routes to certain transport operators (from a qualitatively weaker point of view) and the maintenance of the quality of trains already scheduled (or of higher quality), although access to the railway market must be non-discriminatory and equal by all railway operators.

The need to accurately resolve this conflict increases when the railway market is regulated and transport operators are denied route allocation due to capacity constraints. The relationship between capacity allocation and service quality is important to determine when the system is saturated, more precisely when the consequence of adding more routes outweighs the benefits [1].

2. CIRCULATION CAPACITY VS. INFRASTRUCTURE CAPACITY IN THE CURRENT CONTEXT

The basis of this paper was the idea that some specialized studies, railway instructions and even some laws, make a mistake when using the phrase ,,infrastructure capacity''.

The most relevant examples in this regard are: Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 on the establishment of the single European railway network and Law no. 202/2016 on the integration of the Romanian railway system in the single European railway network.

In several passages of the respective documents, only the notion of infrastructure capacity is conveyed and a procedure for obtaining train path by the railway transport operators is exposed, which several times considers that the infrastructure manager ,,sells'' the infrastructure capacity.

The very juxtaposition of the idea of train path with that of infrastructure capacity is erroneous.

According to the definition, the train path is a share of the traffic capacity made available to an operator to carry out its production process.

The following are some significant paragraphs of Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 on the establishment of the single European railway network in which the law makes errors of expression:

,,Art. 3:

[...]

18. „allocation'' means the allocation of railway infrastructure capacity by the infrastructure manager;

[…]

20. „congested'' infrastructure' means an element of infrastructure for which requests for infrastructure capacity cannot be fully met during certain periods, even after coordination of the various requests for the reservation of such capacities;

[…]

24. „infrastructure capacity'' means the possibility of scheduling train paths required for an infrastructure segment over a given period;

[…]

27. „train path'' means the infrastructure capacity necessary to allow a train to run between two points on the network during a given period;

[…]'' [2].

According to Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 on the establishment of the single European Railway Network, of which several passages have been presented, it follows that the Railway Infrastructure Manager allocates capacity to considered from their point of view infrastructure capacity.

The railway transport system can be defined as a network with regulated access which, unlike the road one where the traffic is self-regulated, the latter can be used only in certain time intervals, access being possible only through certain points well determined by the network administrator (nodes, terminals, stations, sectioning points), the access being regulated both in time and in space and for the determination of the capacity of such a network the principle of impenetrability is used [3].

The desire to deepen in this regard is determined by the fact that, according to studies in the field of rail transport, what the infrastructure manager „sells'' to transport operators, is traffic capacity.

According to the literature, traffic capacity (or transit) of a railway (or section of railway) means the maximum number of trains that can transit through a unit of time (usually one day) on the railway (or section).

As it is known, any railway is divided, by means of sectioning points (stations, stops, etc.) into several sections, and for reasons related to traffic safety, on such a section at a given time, there can only be one train.

Therefore, the number of trains that can run daily on a railway section is the higher the shorter the distances (or intervals) of tracking trains moving on the same line in the same direction, respectively the crossing distances of trains running in the opposite direction (also on the same line). In other words, the circulation capacity of a railway section varies in direct proportion to the number of section points located on it, because at a given moment the number of trains in circulation per section is always only one unit less than the number of points sectioning.

Whereas when it comes to the circulation capacity of a railway section we have in mind the trains that cross it in its entirety, from one end to the other, and how the time in which a train occupies the portion of the line between two consecutive section points is variable depending on a number of objective factors (distance between these points, terrain inclination, frequency of curves), it results that the size of the section's traffic capacity can be at most equal to the maximum number of trains that can travel daily on the most difficult portion (distance) of traffic located between two consecutive sectioning points on that section.

This is why such a line portion is called a limiting distance.

The above finding leads us to the conclusion that, in fact, the traffic capacity of a railway section is equal to the traffic capacity corresponding to the limiting distance, just as the traffic capacity of the rail corridor is equal to the traffic capacity of the section limiting its contents.

This does not mean that, in the organization of train traffic, it can be neglected that on the other sections, or sections, of the railway the circulation capacity is higher [4].

In conclusion, the capacity delivered to the operation is different from the capacity considered by the infrastructure manager.

A simplistic example is presented in support of these arguments: According to the general relation of the circulation capacity [5], without having interruptions in the train circulation, ie Aa = 0, the circulation capacity N can be determined with the relation:

$$N = \frac{1440}{\frac{T_P}{k}} = \frac{1440k}{T_P} \qquad (1)$$

On the traffic section, with double line, Predeal - Brasov, the infrastructure administrator, can consider that he delivered to the operation 2 lines, each with a capacity of:

$$N = \frac{1440k}{T_P} = \frac{1440}{10} = 144 \quad \text{trains/direction/day;}$$

$$N_T = 288 \text{ trains/day.}$$

We consider:

- K, the number of trains (or pairs of trains) in a period. In the case represented above, K=1;
- T_P is the period of the graph.

But the real capacity allocated to operation differs, as customer requirements are manifested in both directions and therefore, most likely, for most of the day of operation one of the lines must be used for the movement of trains in the other direction. In this logic the situation described above offers 144 trains in the odd direction:

$$N = \frac{1440k}{T_P} = \frac{1440}{10} = 144 \text{ trains/odd direction/day;}$$

And only 36 trains per direction seem:

$$N = \frac{1440k}{T_P} = \frac{1440}{40} = 36 \text{ trains/seem direction/day.}$$

Considering, T_P = 10 min, the direction of traffic on the slope and T_P = 40 min the direction of traffic on the ramp.

In conclusion, the traffic capacity allocated to the operation is:

N_T = 180 trains/day, compared to the 288 previously compared.

The inconsistency appears even more relevant by going through the articles in which it is circulated in the law of saturated capacity. If we follow ad litteram the text of the law, the transport operators could request the passage of the infrastructure as saturated only after exceeding the value 288, when in fact the capacity becomes saturated when it exceeds the value 180.

If the saturation is reached, the administrator may request increased fares, so the calculated traffic capacity helps the infrastructure manager, because if he waited to reach the infrastructure capacity, the saturation would appear much later (at 288 trains, compared to the 180 trains).

In conclusion, the infrastructure capacity is circulated, but when it is saturated, it is considered the circulation capacity.

As an example are mentioned some passages from the Reference Document of the CFR 2021 Network, Annex 17 - Infrastructure sections with saturated capacity:

„[...]

Reason for declaring infrastructure with saturated capacity: Decreased circulation capacity due to rehabilitation works.

[...]'' [6].

In this passage from the Reference Document of the CFR 2021 network, it is demonstrated the fact presented above, namely the non-conformity according to which at the moment of saturation, the infrastructure capacity is considered traffic capacity.

We can say that although the laws, regulations and studies only talk about the infrastructure capacity, what is actually given to the operation is the circulation capacity.

3. METHODS TO INCREASE TRAFFIC CAPACITY – CORRELATION WITH QUALITY IN THE FIELD OF TRANSPORT

The quality of the transport system can be interpreted as the result of the interaction between the satisfaction of the requirements addressed to the system (transport demand) and the possibility of allocating technological resources (supply).

The dynamic correlation „demand-supply'', but also the way in which the demand is satisfied determines the quality of the transport system.

The useful effect of the transport system in society can be defined as a production process, but the difference is that the effect of the system is inseparable from the transport process. The result of the production process that the system performs is the movement of goods or people in space and can only be consumed during the transport process.

Transport is a service that cannot be stored or preserved, which has to deal with top situations and which involves the existence of complex technical infrastructures.

The quality management of the transport system must take into account the equation of the three basic components, transport system-social and economic environment.

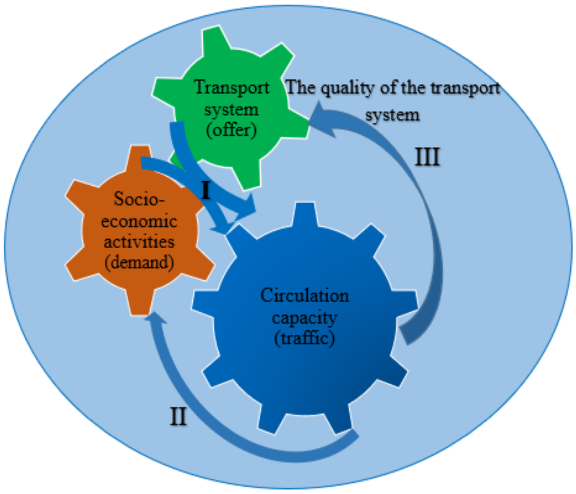

Figure 1. The set of relations of the quality management of the railway transport system

The quality management of the transport system consists in the synergy of all the subsystems and processes necessary for the development of the transport relationship.

Between the three subsystems, according to figure no. 1, three types of relationships are established that influence the quality of the system:

The quality of the transport system is becoming more and more comprehensive and in a close connection with the socio-economic and natural environment, due to the amplification of the requirements of sustainable development and quality of life, reflected in the increase of customer satisfaction. The aspects of transport quality that make up strategic and operational management lie in the fact that they can determine a multitude of essential measures for the system whose effects directly influence the level of satisfaction of user requirements, service delivery and limiting external effects [7]. The broad goals of quality aspects are in connection with the quality design examined both in terms of the customer and the resources of the service provider, but also in terms of the natural environment and quality of life (Fig. 2). The six levels of the quality aspects of the transport system are presented in a hierarchical structure and gradually propagate from an isolated transport service, to the company (society), to the transport mode and to the national transport system, continental or planetary [8]. This architecture in overlapping steps (systems/subsystems) highlights the need for a global treatment of the problem of the quality of transport services, given the "demand-supply" correlation in the conditions of multiple restrictions that the socio-economic environment imposes on the transport system [9].

The peculiarity of the total quality management in transports consists in differentiating the quality attributes of a service from that of the products.

The actions necessary to increase the quality in transports must be oriented towards limiting the effects of the particularities of the system, these being:

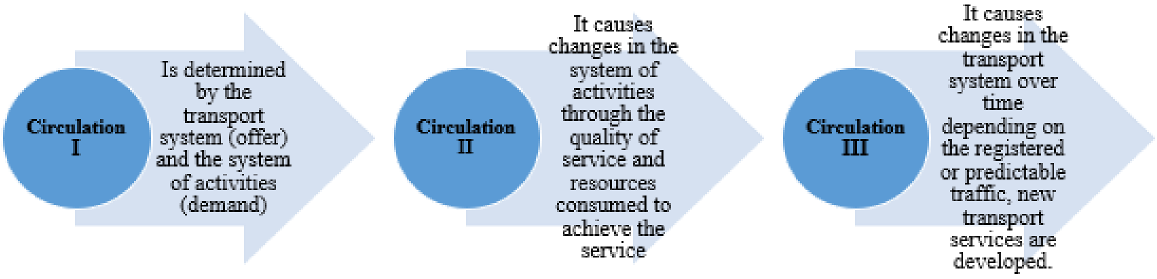

Figure 2. Increasing the quality in transport

- Intangibility of the service;
- Inseparability of the service;
- Limiting the variability of the services offered;
- Perishability of transport loads;
- Compensating for the lack of property on the transport service.

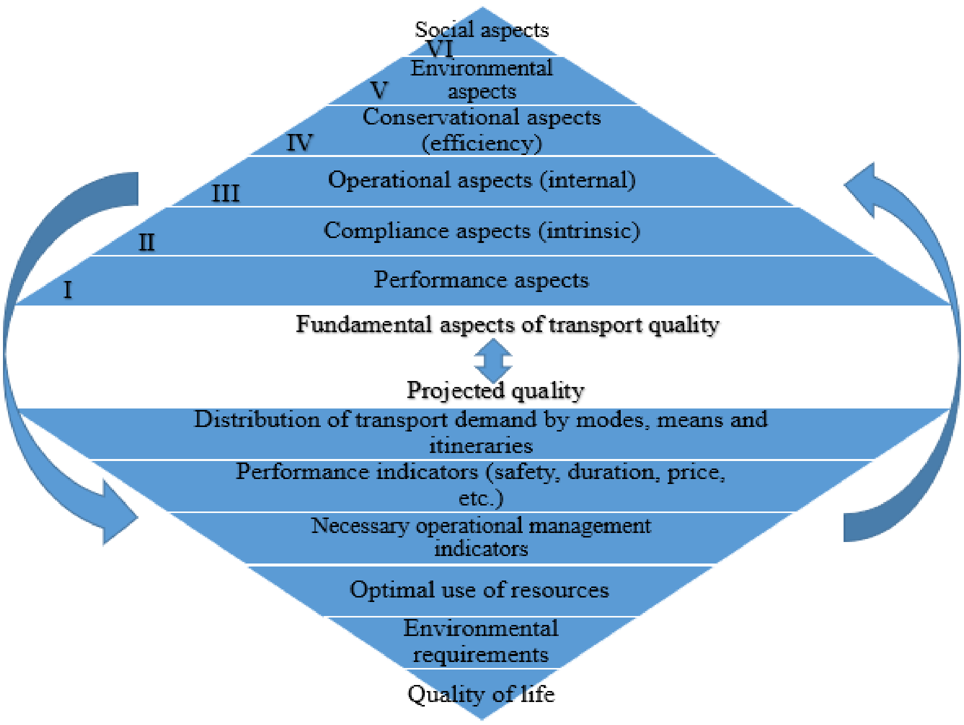

Figure 3. Quality aspects in the transport system [9]

As the liberalization of the railway transport market takes place, consequently there is also an increase in the transport volume due to the increasing demand, which can lead to a saturated circulation capacity on some sections. The problem of capacity allocation due to the increase in the number of railway transport operators in a national market, leads us to think that the simplest solution would be to increase the number of operating lines, which means changing the railway infrastructure. However, investments in infrastructure are very large and the expansion of infrastructure in some areas may be impossible. Therefore, solutions must be found to increase traffic capacity that limit or avoid the development or reconstruction of existing infrastructure. Consequently, several actions have been identified to increase traffic capacity, without changing the infrastructure components. The railway system consists of three main components (figure no. 4): infrastructure, rolling stock and organizational traffic control management. In order to optimize the railway transport system, the interaction of the three components must be taken into account [10]. The main connection between the quality of the offered service and the circulation capacity, consists in the variation of the offer quality with the load degree of the network, represented by the „speed-flow" curve [11].

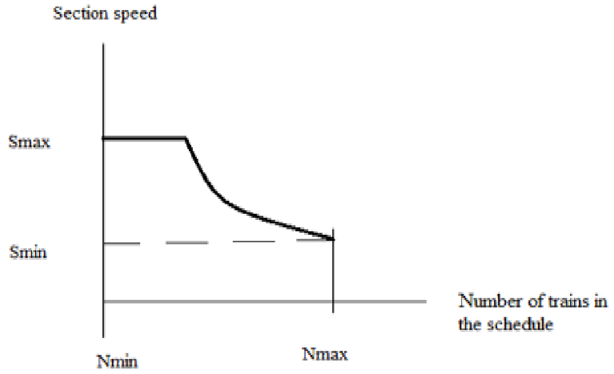

Figure 4. Dependence between the speed of a section and the number of trains in the schedule

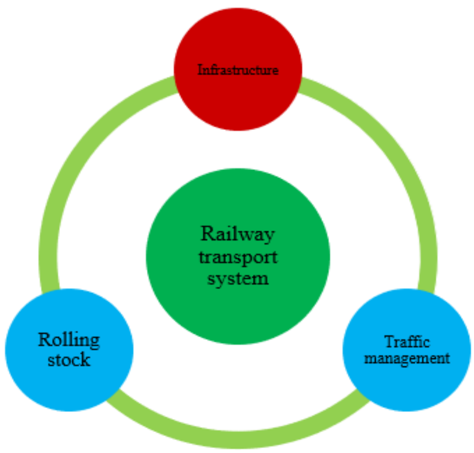

Figure 5. The interaction of the components of the railway transport system

The main actions proposed to increase the traffic capacity in the railway system, without bringing changes to the existing transport infrastructure, are:

1) Increasing the traction force of locomotives in operation:

Increasing the traction force of traction locomotives can be achieved in two ways:

a) by increasing the coefficient of friction at adhesion;

The traction force on the wheel of the locomotive, being given by the known relation $F_O = \mu_a x G_a$ (2), can be increased both by increasing the adherent weight and by increasing the coefficient of friction at adhesion.

The coefficient depends not only on the type of locomotive, but also on the speed of the terrain; at higher speeds the coefficient of friction at adhesion decreases.

b) by multiple traction.

Multiple traction means the use of two or more locomotives to tow a train. Locomotives towing a train can be operated by pulling or pushing.

Multiple traction is used for the purpose of:

- increasing the train's tonnage by keeping the same running times;
- keeping the core tonnage of the train unchanged on heavy sections;
- increasing the running speed of the train without increasing its tonnage, but obtaining an increase in the circulation capacity of the lines.

The normal and general way used in towing trains is to pull; pushing is used exceptionally. The use of multiple traction should only be done on the basis of savings calculations.

2) Increasing the number of trains and passing them without stopping, in the loaded direction, through the stations that limit the critical distance:

Increasing the number of trains and passing them without stopping, in the loaded direction, through stations that limit the critical distance can be achieved in the case of a simple railway line:

- by using the unpaired schedule in groups or in packages, increasing the number of trains in the loaded direction;
- using the false line on double railway in the loaded direction especially when the line is trivialized;
- by passing without stopping freight trains in the loaded direction through the stations that limit the critical distance; this is a measure that is practiced, but it is done with difficulty, but substantial increases in train tonnages can be made.

Emphasis will be placed on passes without stopping through stations that limit the critical distance.

We assume that at a critical distance AB in Figure no. 5, the running times of freight trains and crossing intervals are:

$t_1 = 20min;\ t_2 = 15min;\ t_{sd} = 3min;\ t_{sf} = 1min;$

$a_1 = a_2 = 3min;$

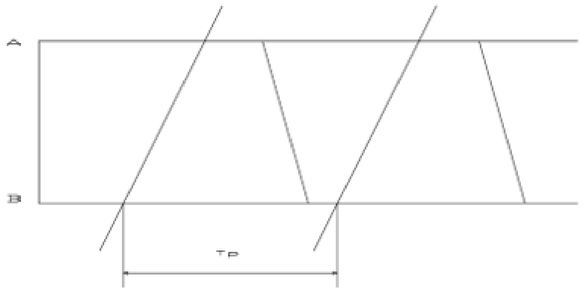

Figure 6. Scheme of the passage of trains without stopping, in the loaded direction, through the stations that delimit the critical distance

The loaded direction is from B-A.

If trains in both directions stop at stations A and B, we have:

- schedule period:

$$T_P = t_1 + t_2 + 2t_{sd} + 2t_{sf} + a_1 + a_2 = \\ = 20 + 15 + 2x3 + 2x1 + 3 + 3 = 49min; \quad (3)$$

- circulation capacity:

$$C_C = \frac{1440}{T_P} = \frac{1440}{49} = 29 trains / day \quad (4)$$

If the trains in the loaded direction would pass without stopping through stations A and B, according to the diagram in figure no. 5, it will be obtained:

$$T_P = t_1 + t_2 + 2t_{sd} + 2t_{sf} + a_1 + a_2 = \\ = 20 + 15 + 3 + 1 + 3 + 3 = 45min; \quad (5)$$

- circulation capacity:

$$C_C = \frac{1440}{T_P} = \frac{1440}{45} = 32 trains / day; \quad (6)$$

Circulation capacity of the section will increase with:

$$\Delta C_C = \frac{32 - 29}{29} x100 = 10\% \quad (7)$$

3) Modernization and adaptation of telecommunications means:

The restructuring of the telecommunications means in the sense of their modernization is done both from the point of view of traffic safety and that of increasing capacity.

The operating efficiency of the centralization installations, as a result of the new signaling technique, influences the transit and processing capacity of the station.

4) Crossing trains in stations on a simple railway:

The crossing of two trains on a simple railway at the station is carried out by stopping the first train during the passage of the second train. Such crossings are of no particular importance if one of the trains is stopped for technical and commercial reasons; however, in addition to the net stopping time, the time consumed with braking and starting it is also lost, which is an addition to the running time in case the train could pass through the station without stopping.

Also, to stop at a station, it is ideal for the braking process to take place as late as possible. When braking starts too early, time is lost. The greater the speed limiting distance, the greater the time losses [12].

In addition, additional fuel is consumed to overcome the starting resistance which, in the case of passage without stopping of the train, is non-existent.

A crossroads, in a railway station on the simple railway line, can bring a substantial improvement to the traffic schedule.

This network problem occurs because the railway distances are often relatively long and because the railway system has a high degree of interdependence, as trains cannot cross each other everywhere in the network [13].

5) Increasing the ciculation speed of trains on critical distance:

Increasing the speed of trains on critical distances can be achieved:

- by increasing the demand of the locomotive.
- by multiple traction, keeping the same tonnage.

Increased traffic speed leads to a shorter travel time and, finally, to a number greater of trains [14].

4. CONCLUSIONS

The need for scientific research lies in the need to provide justifications for a number of concrete and current topics that can contribute to a better interpretation of these topics of interest.

From the analysis carried out in this study, a series of conclusions were drawn which, although not fully covering the field and the problems it faces, try to summarize an important part of the aspects that characterize the differences between circulation capacity and infrastructure capacity and the correlation with quality in the field of transport.

Although in recent years there has been a slight change in the number of passengers transported by train, the poor condition of an important part of the railway infrastructure, which causes speed restrictions, and the fact that about 40% of the railway is electrified , do not allow the operation in quality conditions, which would generate an obvious increase in the demand for these services or, at least, the maintenance at a relatively constant level and consequently the circulation capacity being a low one.

The structure of the railway market is determined by the regulations in the field, both in terms of access to infrastructure and in terms of operating conditions established by the public service contract, which gives the state intervention levers to increase competitiveness.

In this sense, an attempt was made to present methods applicable to increase traffic capacity on railway infrastructure.

Efficient use of existing railway infrastructure is an essential component of a quality transport system and has become an essential objective for railway infrastructure managers.

Although infrastructure managers are responsible for allocating traffic capacity, railway operators are responsible for the rolling stock, so it is necessary to look for ways, rules and solutions for the interaction between the two parties to be effective as good as possible and the service offered to be as high quality as possible.

Optimizing the use of railway infrastructure and allocating traffic capacity is a complex and difficult issue.

Therefore, numerous capacity studies need to be conducted to determine what part of the additional traffic can be absorbed by the existing infrastructure and how much investment will be required for a new infrastructure [12].

Also, an efficient quality management system plays a key role in improving performance because, through it, better understand customer demands, identify ways to meet these demands and formulate methods of organization, management and control for minimizing errors in activity.

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