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Rail Infrastructure Access tariffs

Contribution for the formulation of a charging system based in operational cost modulation

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Abstract

The European legislation associated to the principles of fares regarding the access and use of the railroad infrastructure, which has in the 2001/14/EU directive and, later on, in the 2012/34/CE directive and also in the 909/2015 Regulation the main guidelines regarding the definition of future strategies concerning this issue, including the calculation of the marginal cost, has originated the constant study by investigators witch intend to better comprehend the best practices that should be adopted in order to revitalise a sector that struggles against others means of transportation.

Nowadays, there are a number of different criteria regarding the fares implemented for the access and use of the infrastructure in several European member states. This only reveals the lack of homogeneity and the absence of harmonized criteria's within the common area, which leads to the underdevelopment of the railroad market since it does not stimulate competiveness, nor regards and defends the interests of the several players, including society as a whole.

When we acknowledge this problem, it becomes clear that there is a strong motivation to start addressing the issue of developing a system that reflects the good practises already in use in other European countries, while in full consideration of European directives and regulations.

Therefore, the present work aims to deliver an analysis concerning the different policies and strategies already in use in other member states (specially does in western Europe), characterizing their fare systems and giving a clearer image on the major qualitative and quantitative differences of the different levels of fares implemented.

Furthermore, it was also an objective to present a new proposal for the implementation of a new charging system based in operational costs, aligned with the best practices available and also based on the concept of the operator willingness to pay since it's necessary to ensure competiveness within the various market segments.

Keywords**:** Willingness to pay; marginal cost; total cost; market segments

1 Introduction

This papers intent is to present a set of recommendations for the formulation of a charging system based in operational cost modulation for different market segments, aligned with the best practices available and also based on the concept of the operator willingness to pay.

This is to be obtained through the analyses of current practises within Western European member State Countries (Spain, France, Germany, Italy, Netherlands, Belgium and Portugal) in order to come to some conclusions concerning best practises in accordance to the EU Directives and Regulations, billing system structure and variables considered for the establishment of the fees charged to operators, while developing a method for the modulation of the different direct costs involving train operation.

Finally it presents a proposal based on the operational cost modulation as the basis for implementing a new tariff system.

2 State of the Art

Since its creation in 1950's, one of the main goals of the EEC was to establish a set of common policies within the European area.

Such intents are seen through the implementation of regulations and directives in order, for example, to address the public transportation services provided by the different member states.

Such measures were intended to improve the rail efficiency in order to compete with other modes of transportation.

The big first step, after a period of reforms undertaken by the EEC, was the adoption of the EEC Directive 91/440/EEC that would encourage states to proceed with structural reforms within the rail sector, mainly regarding the separation of accounts between the rail sector and the state, and also promoting the separation between network providers and train operators through the vertical separation of the two managements.

It was predicted that network managers would impose a tariff regime to operators for the use of the infrastructure in order for them to be compensated for the services provided.

However, such tariffs were only detailed in a later on in 2001. With what was known as the 1st Railway Package, came Directive 2001/14/EC that set down the rules for the establishment of the tariff regimes while defining the train access tariffs, and also set the basis for the creation of the trans-European corridors for the passenger and freight market, defined the parameters regarding licensing of train drivers.

Since this package, 3 more other were launched by the EU. They addressed issues regarding interoperability and safety within the European area (2nd Rail Package), crew certification and freight market opening to competition (3rd Rail Package). The 4th Railway Package allowed for the creation of the European Railway Agency and opened the passenger market within each member state to competition.

In 2012, the EU was "forced" to issue a recast od the 2001/12/EU Directive, known has the 2012/34/EU Directive, due to the need of better clarifying the issues regarding network management criteria and transportation activities and also to address the problem of the access charges for the use of the rail infrastructure.

When we deeper our analyses on the 2012/34/EU Directive,

From an economic perspective, there are two main principles regarding the establishment of the rail access tariffs: Full Cost (FC) and Marginal Cost (MC). While the first one (FC) tends to ensure that the Infrastructure Manager has full recovery of the cost incurred regarding the use of the infrastructure by the operators, the second one (MC) has the objective to define a fee that only reflects the actual cost of another train using the network.

When we deepen our analyses on the 2012/34/EU Directive, it becomes clear that the legislator intents that the infrastructure manager should only be reimbursed for the part regarding the costs directly resulting from the use of the infrastructure by a train. As such, we are induced to adopt marginal cost pricing theories has the pillar for establishing access tariffs since the basis of this methodology is the same as the legislators.

As such, the difference resulting from the direct cost and the full cost should be addressed by the state budget or, with some restrictions, imposed to operators throughout the adoption of additional fees above direct cost – mark-up's or other levy's – as long as those additional costs won't compromise the operators results creating a deficit situation.

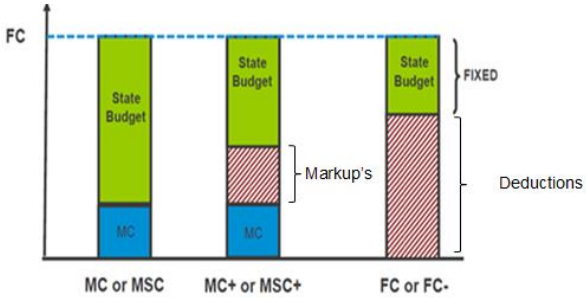

Figure 1 – Type of costs[1]

With this in mind, the EU in 2015 brings to light Regulation 909/2015 in order to more clearly define the rules for determining direct costs regarding train operation, excluding the type of costs as referred in article 4 of the regulation (non eligible costs – financial fees, costs regarding the maintenance of lines not in use,

[1] Image extracted from presentation made by Prodan, A. & P.F. Teixeira (2015)

salaries or other fees relation to the network system as a hole).

According to the regulation, the average direct costs resulting should be reflected in for the use of the entire network and billed in regards to the km.train or tonnes.km reserved or used by trains.

Also, if the network provider aims to practise cost above marginal cost, for example, in order to impose restrictions for the use of lines already congested, it is necessary that he determines the effective operators Willingness to Pay (WTP) in order to ensure that the market can bear such fees.

In order to ensure competiveness, in accordance to Directive 2012/34/EU, it is also necessary to ensure market segmentation. As such, the Ramsey-Boiteux principle is directly connected with WPT since its aim is to ensure that in an deficit economical context the price to pay by operators should reflect the social needs of society.

In this way, this model attends to market elasticity's which are different from between service segments (long distance, regional, urban): lower demand elasticity's are more favourable to higher prices, and vice versa. As such, in market segments that provide essential services without viable alternatives, setting higher tariffs will not have a big impact on the demand.

3 State of Practise

The tariff systems thought the European area doesn't follow normalised and harmonized rules since each country adopts different parameters for establishing their own access tariffs.

For instants, when we take the time to analyse Western European countries, which reality is closer to the Portuguese one from a social or development point of view, it becomes clearer that there are a number of different strategies and variables used in the formulation of the access tariffs.

As we can see from the table below (table 1), the cost theories by country tend to be different, reflecting the way that each member state looks at suck matters.

Table 1 – Types of cost theories by country [2]

Pricing theory	Countries
Marginal Cost (MC)	Netherlands (conventional lines)
Marginal Cost with Mark-up's (MC +)	Portugal, France, Spain
Full Cost deducted (FC -)	Germany, Italy, Belgium

As such, it is only fair to assume that the tariffs and variables used tend to be different from country to country.

As we can see from Table 2 to 4, there are a number of different aspects inherent to each tariff system that makes them unique and, as so, unable to consider that one is better than the other since all of them reflect the needs of each individual state and policies.

Table 2 – Types of variables by category

Groups	Variables
Infrastructure	Per line
	Axel load
	Speed
Capacity	Level of traffic
	Schedule
	Priority
	Access Reservation
Service	Type of service (passenger/freight)
	Tariffs by region
	Market segmentation
Rolling stock	Type of rolling stock
	Type of traction
	Maximum Speed
	Axel weight
	Total weight
	Number of pantographs
Line utilization	Per km.path
	Per train.km
	Per tonne.km
	Performance (delays)

From a value point of view, as it is shown in Figure 2, the medium values for access tariffs, in accordance to market segments, are very different amongst the countries analysed.

[2] Prodan & Teixeira (2015)

Table 3 – Types of variables used by country

Country	France	Portugal	Belgium	Spain	Germany	Netherlands	Italy
Pricing theory	MC +	MC	FC -	MC +	FC -	MC	FC -
€ in relation to:	km.train €/year	km.train	km.train tonnes.km	km.train seats.km	km.train	km.train	km.train minutes.train
Market segmentation	√	√	√	√	√	√	
Use (km)	√	√	√	√	√	√	√
Use of nodes							√
Service type	√		√	√	√	√	
Line type	√	√	√	√	√	√	√
Line technology			√				
Environmental impact			√				
Train weight			√			√	√
Train characteristics	√		√	√	√	√	√
Type of traction power		√					
Speed penalties					√		
Time of day	√		√	√			√

Table 4 – Types of tariffs used by country

Country	France	Portugal	Belgium	Spain	Germany	Netherlands	Italy
Minimum access tariff							
Use	√	√	√	√	√	√	√
Access	√			√			√
Capacity reservation	√			√			
Traffic				√			
Energy loss compensation	√						
Network Investments	√						
Congestion	√						
Delays					√		
Capacity efficiency					√		
Higher Speeds					√		
Noise					√		
Cancelations					√		
Optional routes					√		
New service discounts					√		
Parking						√	
Stops at stations			√			√	
Traction energy			√			√	
Administrative fees			√				
Operation fees			√				
Tourist fees			√				
Tests			√				
Shunting			√				
Penalties and incentives				*			
Reserved capacity not used		√	√			√	
Cancelations	√	√	√		**	√	√
Paths changed	√						
Performance							
Delays	√				**	√	√
Administrative process optimization	√						
Manifest declaration	√						
Reduction of wheel defects	√						
Use of reserved paths						√	
Environment							
Noise	√				**	√	

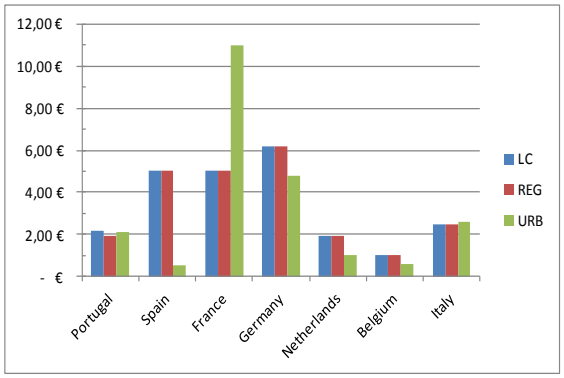

Figure 2 – Medium level of access tariffs in WE countries, by market segment

The correlation between access tariffs level values is very low between the same market segments which are consistent to the lack of harmonization in the European States regarding access tariffs.

With this in mind, it's only fair that the recommendations regarding the review of the tariff systems should reflect the best practises that different member states adopt in their own countries.

In accordance to the Directives and Regulations in hand, the use of km.train and or tonne.km will allow for infrastructure managers to be reimbursed according to the level of use or even the degree of wear resulting from train operation.

Regarding capacity, the introduction of scarcity charges by network managers could resolve some problems especially in rush hours when traffic volumes are higher in some elements of the lines in use.

On the other hand, fees reflecting environmental charges, like pollution produced by train operators, are also seen as a variable to take into account since it allows for the sharing of responsibility between the state and the polluters.

Finally, performance schemes can also be a viable option since they tend to induce a responsible behaviour by all of the parties – charges that reflect the delays caused cancelation fees or even fees regarding the non-utilisation of the paths reserved.

In order to have a clearer understanding on the level of access tariffs practised in the countries analysed and having in mind that there should be a separation between market segments, the next figure (figure 3) shows fees charged by km.train per country.

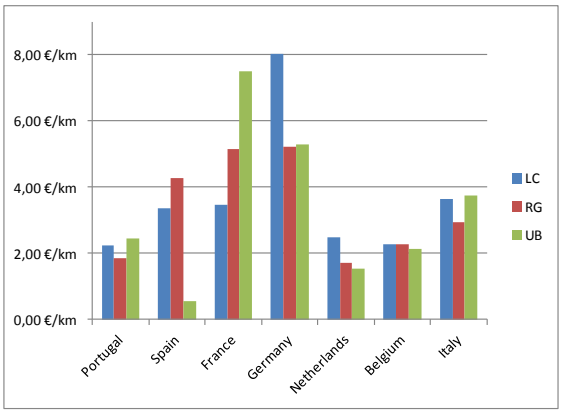

Figure 3 – Level of access tariffs in WE countries, by market segment[3]

Once again, these values tend to show the lack of correlation between the level of access charges practised by infrastructure managers and the market segments that they correspond. Even when we compare the access charges against the speeds, there is also a shortage of significance between these two variables.

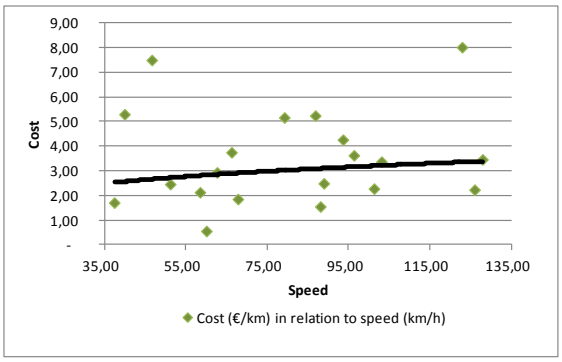

Figure 4 – Level of access charges relating to commercial speed

In respect to the Portuguese access tariff system, the network statement in use basis its pricing model on marginal cost theory. Charges over the direct cost are also considered, however, at the present, they are not yet implemented.

[3] For all matters concerned, it should be stated that these values were obtained in similar conditions, namely regarding the type of lines, market segments, rolling stock and time of day.

Regarding the 2012/34/EU Directive, the Portuguese scheme considers direct costs as the basis for the charges implemented. However, it also shows that the fees considered for LC/IC segments are the same as the Urban fees; regarding the Regional segment, the fees are lower than the other.

As such, we can state that the direct costs premise isn't being followed as stated in the EU Directive since it does not reflect the fact that there should be a differentiation between the two segments: in the Urban segment it is expected a higher number of stops in stations due to the type of service provided; the fact that the long course trains operate at higher speed also generates dynamic forces in the infrastructure, increasing the level of wear of the materials, and as such higher cost of maintenance.

As it was already stated before, the tariff system is divided by market segment, mark-up's are not yet in use and fees regarding the long term costs aren't also considered. There is also no discount system in place, neither incentives regarding interoperability or safety concerns.

However, the current network statement has included tariffs against reserved capacity not used, delays and capacity requests other than those planned.

4 Proposals for the implementation of a new access tariff system

The model adopted should be based on marginal cost.

It's structure, beside considering the direct costs incurred for the operation of the trains, considers mark-up's as a way to recover the costs of investment and maintenance, regarding that it does not compromise the operators competiveness and health.

These recommendations also emphasises the need to implement a fee that ensures the development of interoperability and safety concerns.

In addition, it should also be considered the need for:

- Access charges for the use of the stations;
- Capacity reservation;
- Discounts, namely due to traffic density;
- Environmental charges in relation to pollution and/or noise aspects;
- Performance schemes, to promote the better and more effective use of the infrastructure (delays, services changed or cancelled).

In Table 5 we present a series of variables that are to be considered in order to obtain the value of the access charge.

Table 5 – Variables to be considered in order to determine the value for the access charge

Marginal Cost relating to	Type of line	Maximum speed Maximum weight Traction infrastructure
	Type of rolling stock	Weight per axel Traction type

4.1 Direct Cost Modulation

In order to obtain the marginal cost and the WTP, it is essential that we first determine the direct costs resulting from the train operation.

In order to do so, it was developed a calculation methodology based on the model first developed by Alberto García Álvarez (2015), so that the different type of costs could be determined, specifically, the costs referring to capital, maintenance, cleaning, traction energy and operational staff.

All of these costs, for modulation purposes, are considered as dependent variables and speed is the independent variable. Therefore, the model created will show the different cost in relation to speed.

First, for modulation purposes, it is required to characterize the trains (length, number of seats, number of cabins, power, total weight, maximum speed) and the information regarding the services provided (distance, rotation times, maximum commercial speed).

Then, it's necessary to determine all of the variables that compose the total operating costs.

$$CT = CC + CM + CL + CE + CP \quad [1]$$

- **Capital costs – CC**

$$CC = \frac{TP - RV}{YR} + [r \times 0{,}5 \times TP] + i \times TP = TP \times \left[\left(\frac{1 - \frac{RV}{TP}}{YR}\right) + (0{,}5 \times r) + i\right] \quad [2]$$

Where:

- TP: Train cost (€)
- RV: Residual Value (€)
- YR: depreciation period (years)
- r – interest rate
- i – insurance costs

Since it's necessary to obtain the relative value of the capital function of the km.train:

$$OC = \frac{TP}{s \times RA} \quad [3]$$

Where:

- OC: Annual train possession cost (€/train.km)
- s: number of seats
- RA: Annual distance covered by a train while in service (km/year)

Then, in order to determine the cost of investment in the train we must first determine a series of parameters:

- Investment Costs

$$TP = 150.000 \times C + 26.500 \times M + 1{,}0 \times P + 25.000 \times NM + 6000 \times s \times CCF \quad [4]$$

Where:

- C: Number of cabins
- M: Empty weight (ton)
- P:Continuos Power (kW)
- NM: Number of engines
- CCF: Comfort coefficient

- Relation between power and speed

$$P = \frac{L - 15}{215} \times 4{,}46 \times S_{max}^{1{,}31} \quad [5]$$

- L: train length (m)
- Smax: train maximum speed (km/h)

- Relation between weight and speed

$$M = M_r + M_m = (1{,}6 \times L) + \frac{10 \times P}{1000} \quad [6]$$

Where:

- Mr: Non motorized weight (ton)
- Mm: Engine weight

- Number of engines needed:

$$NM = \frac{P}{2.000} \quad [7]$$

Where:

- NM: Number of engines

- Annual distance covered by a train while in service:

$$RA = (365 \times 60) \times \frac{S_{av} \times H_t \times D}{(R \times S_{av}) + (D \times 60)} \quad [8]$$

Where:

- Ht: Operational hours (hours)
- R: Rotation (minutes)
- D: Path distance (km)

- **Maintenance costs – CM**

$$CM = cf + cv = \left(\frac{CF \times L}{s \times RA}\right) + \left(\frac{CV \times L}{s}\right) \quad [9]$$

Where:

- CM: Maintenance cost (€/seat.km)
- cf: Fixed annual cost per seat (€/seat.km)
- cv: Variable annual cost per seat (€/seat.km)
- CF: Fixed maintenance cost per train linear metre (€/m.year)[4]
- CV: Variable maintenance cost per train linear metre (€/m.year)[4]

- **Cleaning costs – CL**

$$CL = \frac{(L \times cc)}{D \times s} \quad [10]$$

Where:

- CL: Cleaning costs per seat.km (€/seat.km)
- cc: Cleaning Cost per train linear metre (€/m)[4]
- D: Path lenght (km)

[4] CF, CV e cc according to Álvarez, A.G. (2015)

- **Energy Costs - CE**

$$CE = ec - rec + \alpha \times ec \quad [11]$$

Where:

- CE: Total energy cost (€/lugar.km)
- ec: Traction energy cost (€/seat.km)
- rec: Value of the energy returned to the network (€/seat.km)
- α: distribution coefficient (0,015)

➢ Traction energy cost

$$ec = \frac{EC_s}{s} = (E_{P_M} \times \pi \times EP_{S_M}) \times \frac{1}{s} \quad [12]$$

Where:

- EC_s: Energy cost supplied to the catenaries (€/train.km)
- EPM: Energy consumed by the pantographs (kWh/train.km)
- π: Ratio between ESM/EPM (for AC power - 1.03)
- EP_{SM}: Energy price per km (€/train.km)

➢ Energy supplied to the catenaries

$$EC_s = E_{S_M} \times EP_{S_M} = E_{PM} \times \pi \times EP_{S_M} \quad [13]$$

Where:

- E_{SM}: Energy absorbed by the catenaries (kWh/train.km)

➢ Value of the energy returned to the network

$$rec = -\left[E_{P_S} \times \frac{1}{\pi} \times (EP_{S_M} \times \beta)\right] \times \frac{1}{s} \quad [14]$$

Where:

- β: price ratio between consumed by the catenaries and returned energy to the network (1)

➢ Energy cost coefficient

$$ced = \alpha \times ec \quad [15]$$

Where:

- ced: energy cost distribution (€/seat.km)

- **Personnel Costs - CP**

$$CP = \left(\frac{LC_d}{J_d \times H_d \times S_{av}}\right) + \left(\frac{LC_a}{J_a \times H_a \times S_{av}}\right) \quad [16]$$

Where:

- CP: Personnel cost (€/seat.km)
- LC_d: Driver annual cost (€/person)
- LC_a: Train personnel annual cost (€/person)
- Jd : Driver annual working days (days/year)
- Ja : Train personnel annual working days (days/year)
- Ha: Driver service hours per day (h/days)
- Hd: Train personnel service hours per day (h/days)

Please note that personnel costs resulting from this methodology only reflects the operational staff within the train, therefore costs for any other personnel have to be determined separately in order for them to be considered.

4.2 Modulation Results

The results achieved are in direct relation with operational speed of the trains and for each of the market segments previously defined.

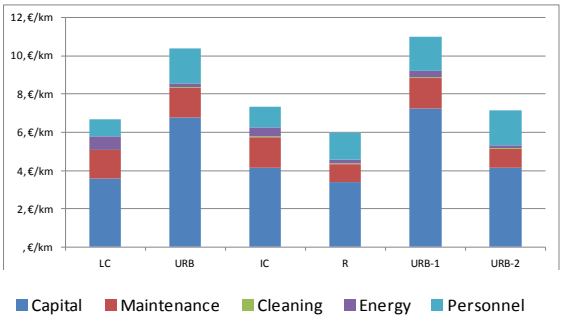

Figure 5 - Specific costs in relation to the commercial speed of the services provided

The results can also show us the cost variation in relation to the commercial speed of the train.

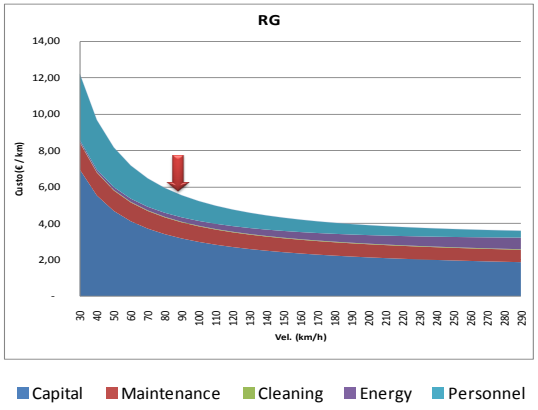

Figure 6 – Cost variation in relation to the commercial speed - the Regional segment

Analysing the results obtained, we come to the conclusion that while some of the costs tend to decrease while speed increases (personnel, capital), others behave just in the opposite direction when speed increases (energy and personnel).

One thing that we should have in mind when working with this modulation is that was initially design for the cost modulation at high speed; therefore, when working at lower speeds we should be aware of this limitation since the relative weight of the costs in relation to the km km covered by the train may result in a higher value.

4.3 Operational costs vs Willingness to Pay

When looking at the results from CP - Comboios de Portugal[5], mainly it's revenue by market segment and train.km covered in each market segment, we are able to determine whether the market segments economically viable.

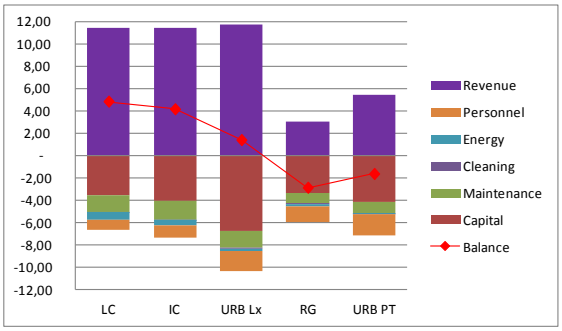

Figure 7 – Revenue vs Estimated Operacional Costs, by market segment

As we can see, the RG and Porto Urban trains are in a economic deficit; therefore, since these two segments are normally related to public service obligations, the regulators and the state should discuss the possibility of implementing public service contracts that could ensure account equilibrium.

It is also mandatory to remember that the methodology developed doesn't take into account the access tariffs imposed by the infrastructure manager since the objective of this line of thought is to determine the level of charges that each segment can sustain above marginal cost without compromising its economic health.

4.4 Surcharge just value

Finally, in order for the operator to be justly surcharged, there is the need to produce a formula that takes into account the various variables.

$$Surcharge = \frac{Estimated\ Revenue}{1 + Profit\ margin} - (Operational\ Costs_{estimates} + Marginal\ Cost) \quad [17]$$

In short, the formula takes into account all of the costs related to the train operation and the access tariffs imposed by the infrastructure manager. The surcharge that the operators must ensure in order to achieve financial health then has to consider the estimated revenue, without the profit margin, deducted by all of the costs.

5 Conclusions and further developments

As a result of this paper, we can clearly state that the formulation of a new tariff system should be based on the best practises in accordance to the EU Directives and Regulations.

Tariffs based on marginal cost pricing should be seen as the best choice at the moment since they allow form a better protection of either the operator or the final user, since it restricts the possibility of overpricing. These tariffs must be separated regarding to market segmentation.

Also, tariffs that take into account markup's, performance schemes, discounts, penalties/incentives and environmental charges must be considered since they will tend to reflect the reality of the activity developed. Nevertheless, these tariffs must not put at risk the market competiveness; therefore they must only be implemented if the market can bear it.

[5] Account report from CP – Comboios de Portugal EPE, 2015 e 2016

When formulating a charging system it is also recommended a operational cost modulation in order for the tariffs to be able to reflect the operators willingness to pay.

In the future, the development of charging models should also consider the modulation of the estimated revenue, and also a more comprehensive analysis on operational costs (determining costs by family of trains within market segments).

Also, there should also be taken into account the need for implement a formulation that establishes the just value of the surcharge imposed to the operator.

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