CETRA²⁰¹²

2ⁿᵈ International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR

Proceedings of the
2nd International Conference on Road and Rail Infrastructures – CETRA 2012
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

ORGANISATION

CHAIRMEN

Prof. Željko Korlaet, University of Zagreb, Faculty of Civil Engineering
Prof. Stjepan Lakušić, University of Zagreb, Faculty of Civil Engineering

ORGANIZING COMMITTEE

Prof. Stjepan Lakušić
Prof. Željko Korlaet
Prof. Vesna Dragčević
Prof. Tatjana Rukavina
Maja Ahac
Ivo Haladin
Saša Ahac
Ivica Stančerić
Josipa Domitrović

All members of CETRA 2012 Conference Organizing Committee are professors and assistants of the Department of Transportation, Faculty of Civil Engineering at University of Zagreb.

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Prof. Ronald Blab, Vienna University of Technology, Austria
Prof. Vesna Dragčević, University of Zagreb, Croatia
Prof. Nenad Gucunski, Rutgers University, USA
Prof. Željko Korlaet, University of Zagreb, Croatia
Prof. Zoran Krakutovski, University Sts. Cyril and Methodius, Rep. of Macedonia
Prof. Stjepan Lakušić, University of Zagreb, Croatia
Prof. Dirk Lauwers, Ghent University, Belgium
Prof. Giovanni Longo, University of Trieste, Italy
Prof. Janusz Madejski, Silesian University of Technology, Poland
Prof. Jan Mandula, Technical University of Kosice, Slovakia
Prof. Nencho Nenov, University of Transport in Sofia, Bulgaria
Prof. Athanassios Nikolaides, Aristotle University of Thessaloniki, Greece
Prof. Otto Plašek, Brno University of Technology, Czech Republic
Prof. Christos Pyrgidis, Aristotle University of Thessaloniki, Greece
Prof. Carmen Racanel, Technical University of Bucharest, Romania
Prof. Stefano Ricci, University of Rome, Italy
Prof. Tatjana Rukavina, University of Zagreb, Croatia
Prof. Mirjana Tomičić–Torlaković, Univiversity of Belgrade, Serbia
Prof. Brigita Salaiova, Technical University of Kosice, Slovakia
Prof. Peter Veit, Graz University of Technology, Austria
Prof. Marijan Žura, University of Ljubljana, Slovenia
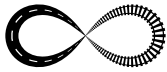
TRACK ACCESS CHARGE ALGORITHMS IN EU RAILWAYS: A DYNAMIC BENCHMARKING

Francesca Ciuffini[1], Stefano Ricci[2], Giulio Rocco Sitongia[1]
1 RFI, Italy
2 Sapienza University of Rome, Italy

Abstract

In this paper an overview on Track Access Charge systems in Europe is presented. TAC systems from 15 countries are compared from the point of view of the algorithm used to calculate the fee that Railway Undertaking has to pay to the Infrastructure Manager, to use the infrastructure with a specific train, in a specific time and on a specific route of the network. The aim of the benchmark and comparison analysis is to highlight the diversity, analogies and typical features of different systems, allowing a comprehension of existing pricing logics of railway infrastructure. Method and some results of the analysis are presented in the paper. The analysis starts from our own Network Statement's interpretation and leads to set them in a common framework, through the identification of a general formula. The classification of the system in homogeneous groups is therefore proposed together with a graphical synthetic representation in a three-dimensional space. In the research framework two different dynamic tools have been developed and presented in the paper: 1) a synoptic dynamic table, capable to facilitate comparison and understanding of different systems, providing a synthetic vision of pricing elements; 2) a dynamic tool, allowing comparison in a charging level, for any network and services classification.

Keywords: track access charge, network statement, railway package, infrastructure manager, railways undertakings

1 Introduction

In the last twenty years, the EU railway sector was interested in an important process of regulatory renewal, dealing with vertical separation among infrastructure and transport and free access to the infrastructure network. Goals of the railway reform were the development of the rail and enhancement of international traffic. In this new context what was before managed by a unique integrated railway company has been split into different subjects: one responsible for capacity allocation among applicants is in general the Infrastructure Manager (IM), who then sells capacity to the Railway Undertakings (RU) paying for assigned train-paths Track Access Charge (TAC). Therefore, capacity and TAC are the exchange elements between the IM and RU-s.

National pricing systems are quite different, due to different goals and different IM's pricing policies. Different are also average charging levels, depending on unit infrastructure costs, intensity of traffic on the network and, above all, level of State funding. Non-homogeneity in TACs is a critical element of the new regulatory system and problems of harmonization have been pointed out by the EU Commission, which presented a Recast version of the 2001 Railway Package Directives.

Many research works, often based on questionnaires or interview of the IMs, have been developed in the last years to compare pricing systems, from specific points of view, or to compare resulting charging level. For instance, relevant topics have been pointed out in OECD 2005 [1] and OECD 2008 about Marginal/Full Costs charging philosophies and consequent cost recovery rate by the access charge. Also in the OECD 2005 and 2008, a wide comparison in charging level has been given, on average and under specific, fixed conditions, i.e. market segments (freight/regional/long distance) and weight of the train. In the CENIT Railcalc research, dealing with general objectives related to the charging practice, a wide inventory of single systems is made and an assessment of current practices is given. Most of the research points out the heterogeneity of calculation methods as well as different levels of resulting charge. Regarding the first point, systems seem to be undoubtedly different among each other. As a matter of fact some analogies among different systems can be found and with common formalization an aggregation by similar families can be made.

Aim of the research, through the direct analysis of the algorithms, is: 1) to discover a possible common formalization of the formulas in order to frame different methods in similar families, focusing on analogies, differences and typical features; 2) to focus on the variation law of the charge, to better understand pricing parameters which influence the variation and the possible amplitude of the variation in order to give a more structured and synthetic view of the possible pricing logic of the charging systems.

The method used for such analysis is as follows: 1) interpretation of calculation methods from single Network Statements (NS) 2) identification of common features and definition of a general formula to frame different systems 3) construction of a synoptic dynamic table, as a synthesis of NS, to facilitate comparison and understanding of pricing parameters 4) classification of different system in homogeneous groups 5) examination of the variation law through graphical representation on abacus for each homogeneous groups 6) definition of a simple dynamic tool, to compare charging level, for any network and services classification. In the paper the method and some results of the research are presented.

2 Common frame and a general formula for algorithm analysis

From the Network Statement published on the IMs' web-sites, an individualization of a single algorithm has been made. Every IM uses his own formula and different symbols to identify similar parameters. Therefore, the first procedural step has been to translate the single algorithms in the same formalization.

As a first general synthetic formula the following one can be considered for the charge paid by a train running on a certain route of the network:

$$CHARGE=LINE\ CH.+STATIONS\ CH.+OTHER \tag{1}$$

The total charge is in general obtained as the sum of a charge for the use of the line infrastructure and a charge for the use of stations along the route. This second addendum is not always present. In this last case the charge for the use of stations is already included in the first one. The third addendum can include specific items, as externalities or specific crossings. Table 1 resumes the contributions considered in the examined systems. In the paper the focus is on the line charge only. A similar method is applicable for station components too.

Table 1 Charge addenda

	Line	Stations	Other addenda
Prorail, ÖBB, MAV, DB, REFER, PLK, INFRABEL, ADIF	√	√	
SBB	√	√	Bonus for low noise vehicles
SZDC, Sž, HŽ, RFF, RFI	√	NO	
Trafikverket	√	NO	Externalities for diesel Charge for specific crossings (e.g. Oresund)

2.1 Line charge

Regarding the first addendum, line charge, the following basic formula is proposed:

$$\text{LINE CH} = P_{km}(L, T, ..) * K * km + P_{tkm}(L, T, ..) * t.km + F \tag{2}$$

Where P_{km} is the unit price per train-km, P_{tkm} is the unit price per t-km and F is a fixed part, only present in a few systems. Both unit prices can in general depend from line (L) and train (T) categories or in few cases on further parameters, often considered by K modulators. This is the most general possible formulation. As better explained in the following chapters, various systems can be classified in different groups depending on how many addenda (1, 2 or 3) they take into account.

3 A synoptic table from Network Statements

Considering all possible addenda for the line charge, stations charge and other components, a general synoptic table, structured as a hypertext, has been developed from NS. For each IM and for each possible item a link to the tables from NS allows us to have, at a glance, a complete view of the structure and used parameters. Regarding the line charge, the components considered in Fig. 1 are the following: 1) Kilometric [Pkm* train-km * K] 2) Weight [Ptkm* t-km], 3) Supplement or reduction per train-km 4) Supplement or reduction per t-km. The last two items may increase or reduce basic price. A time component [Pmin* minutes * K] is also considered, as an alternative only in one case (nodes in Italian system).

Figure 1 A synoptic table from the Network Statement (extract)

From the NS table parameters considered to modulate the basic price and possible defined values may be derived. Parameters and symbols are exactly the same as proposed in the single NS, even though framed in a common structure. As a next step, more structured synoptic tables have been created, with parameters forced to algorithms homogeneity. Regarding line charge, classification of different algorithms can be made depending on how many addenda they have, as better detailed in the next chapter.

4 Classification of the algorithm for line charge

4.1 First group: simple formula without weight dependence

A first group of algorithms includes systems calculating the charge by a basic unit price multiplying run kilometres. Within this first group we can find system from Slovenia, Croatia, Germany and Portugal. For all these systems the basic price is modulated depending on categories of lines and trains:

$$\text{LINE CH} = P_{km} * L, T * K * km \tag{3}$$

Where L is a factor depending on line category, T is depending on train category and K is further modulating the charge. Despite the apparent diversity from NS explanations, these 3 systems have exactly the same algorithm structure, with differences on line and train categories only. The portuguese system is conceptually the same, though the basic price is not computable by a product of factor L and T, but specifically defined for each combination of line and train category. Systems of the first group can also consider a further modulation incremental factor (i.e. for heavily utilized sections, slow trains and regional factors). Germany also considers a supplement per train-km for trains heavier than 3000 t, but in all the remaining cases the weight has no influence on the charge.

In Fig. 2 the amplitude of the resulting charge is shown, considering the minimum and maximum of freight and passengers in a regional line as well as on a main line, for specific cases (Slovenia and Croatia) as an example.
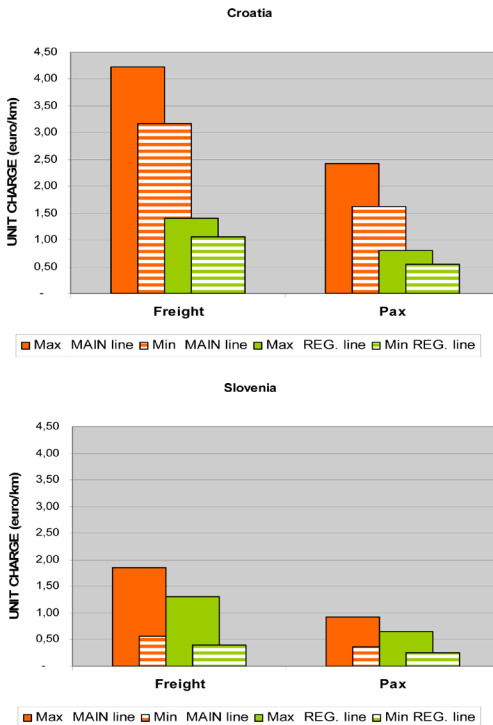

Figure 2 Amplitude of variation for the first group (example)

4.2 Second group: simple formula with weight dependence

In the second group, besides the component per train-km, again depending on lines' categories, a second component per t-km determines the charge.
The formula now has a second addendum, depending on the weight of the train:

$$\text{LINE CH} = P_{km} * L, T * K * km + P_{tkm}(L, T) * t.km \qquad (4)$$

In the same group we can also consider a specific sub-group (Belgium and Poland, not reported in the table) with only the charge per train-km, but with a unit price depending also on the weight category of the train. So in Polish case the price is depending on the line category as well as on the weight class of the train; in the Belgian case the price is modulated on the basis of the line category (with double characterization: operational importance and speed), the train category and the weight class. The charge variation is therefore linear with the weight of the train as represented in the first graphic of Fig. 3, where an example from Sweden, Netherlands and Austria is reported. In these cases gradient is the same within the same system, because of a unique value for price per t-km, but the intercept is different, depending on line's category and related kilometric price.
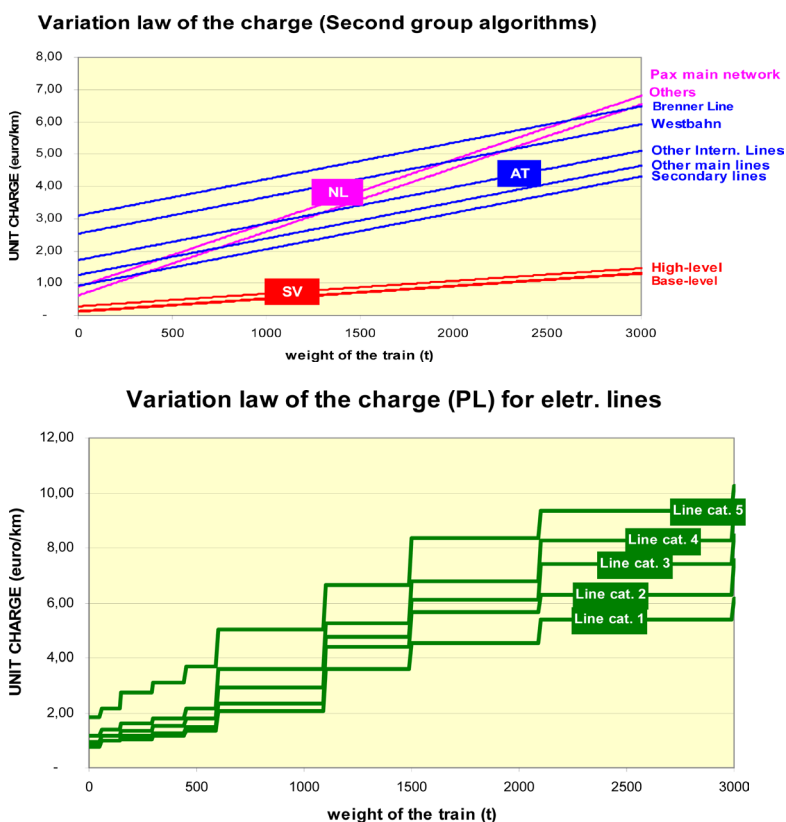
Figure 3   Charge variation for the second group (examples)

For other systems (e.g. Switzerland or Czech Republic) the gradient is also different, because the unit price per t-km varies according to the train or line category. For the Poland and Belgium sub-group, with a kilometric unit price depending also on the weight, the charge

variation with weight is discrete (second graphic of Fig. 3). Also systems of the second group can also consider a further modulation factor, i.e. for bottlenecks and freight traffic incentives (Austria), energy access (Hungary and Switzerland), galleries longer than 30 km (Switzerland), which increases or reduces unit price per train-km or per t-km. Another supplement is foreseen in Switzerland with a percentage on RU's revenues established by the Regulator.

4.3 Third group: complex formula with a fixed part

In the last group of formulas, a third contribution is added. In Italian and French cases it is a fixed part per section of line, charged whatever the length of the route run by the train: this means that the final charge per train-km may vary also depending on the length of the section and the route of the train. In the second graphic of Fig. 4 an example for the Italian case shows the unit price resulting from the fixed part: this is to be added to the kilometric rate. Values of the fixed part are defined for each section of the network, depending on the technical equipment. The French case is similar; the only difference is in the modulation of the fixed part, with a greater variability depending on line category, time window and train's features. In both cases this fixed part is supposed to be a reservation charge, which exist also in the Spanish formula as a part of the kilometric fee.
In Spanish and French systems a fixed access charge has to be paid only once, for the whole timetable period, by each RU running on the network in Spain and only by the regional trains in France. In the first case the amount varies depending on class of yearly volumes, in the second one it is directly defined for each Region. In both cases the bigger the amount of annual train-km run by the RU the lower will the kilometric extra fee deriving from the fixed part be.
Last possible fixed contribution, fee per train, is foreseen by the Hungarian and Swiss systems, nevertheless considered as a simple tariff in the second group.
A common feature in the third group is the greater complexity of the algorithm, depending on a larger number of parameters: a time window, considered in Italian, French and Spanish systems, the specific train-path only in Italy, where commercial and running speed of the train are needed to calculate the charge. Something similar exists in Belgium, where differences between the commercial speed of the train and the standard speed of the line section influence the charge through specific modulation coefficient. The last common feature in the group is that wear and tear is not directly charged through the weight of the train: for instance, in the Italian case it is charged as a function of weight and square running speed (proportional to energy). Variations by weight of the train are represented for the Italian case in the first graphic of Fig. 4. In the Spanish and French systems other parameters are considered for wear and tear as number of seats or speed of the freight train.

5 Graphic synthetic representation of the charge variation

A synthetic graphic representation of the possible algorithms in a 3-dimensional space is shown in Fig. 5, with unit resulting charge (Euro/km), depending on run kilometres and weight of the train: formulas of the first and second groups, not having fixed parts, can be represented in the space by a plane (or a step) surface, with a gradient on the weight axis due to the second group of algorithms, with charge varying depending on the weight. The presence of fixed parts in the third group curves the plane, bringing a reduction of total charge with the length of the route. The intercepts of the plane change according to train and line category and further parameters. The difference between the structures of the algorithms can be thought in terms of different surfaces per shape, intercept or gradient.

Variation law of the chilometric charge (IT) for M dens = 1
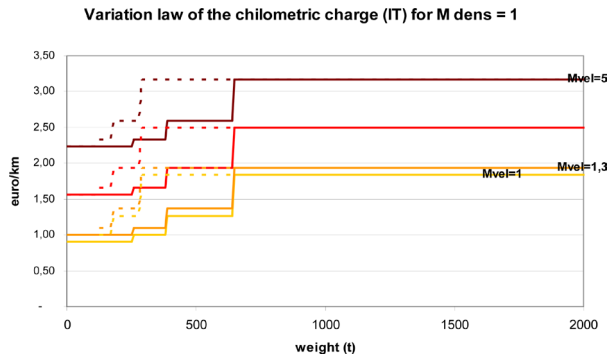
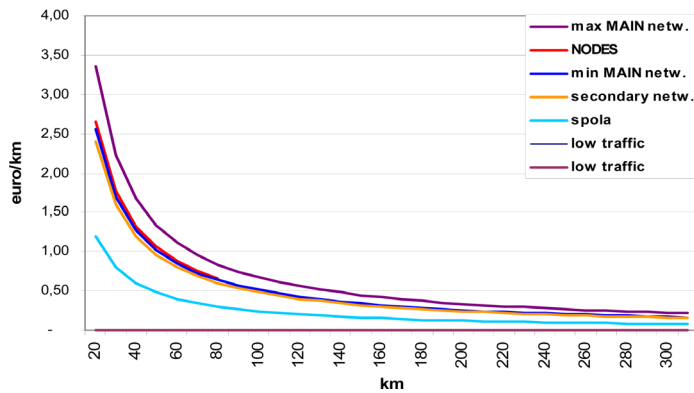**Variation law of the fixed part with lenght of the route (IT)**

Figure 4   Charge variation for third group: Italian case with dependence on weight and length of the route
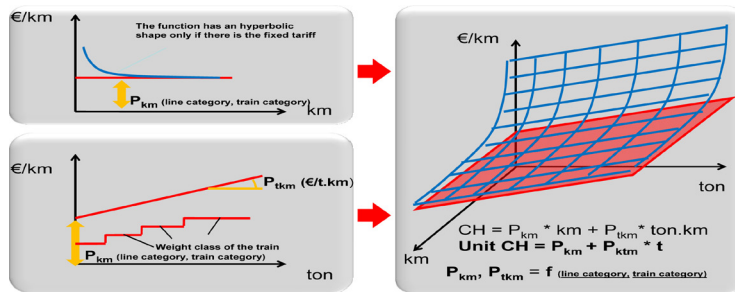

Figure 5   General graphical representation of the line charge formula

6   A dynamic tool for specific comparisons

Starting from the common frame and the involved parameters it is possible to develop a dyna-mic tool (Fig. 6) to calculate in real time the resulting charge per train-km in similar conditions. Selectable parameters are line and train category, weight of the train, length of the route. Extra parameters are a priori defined under certain hypothesis (i.e. commercial or running speed for different trains in the Italian system), but they can be checked and changed if needed.
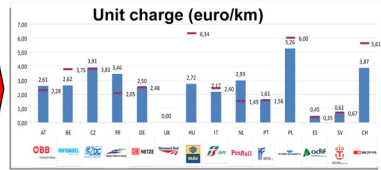
Figure 6   Dynamic tool example for line charge comparison

By means of this tool a specific comparison between different systems can be made to highlight the largest difference among the systems (e.g. different categorization of lines and trains). The aim of the tool is different from EICIS, the RNE platform for RU-s to simulate the charge for a specific route of the network. The present tool is mainly conceived for IM-s or regulators reasoning and debating about the possible charging models.

7   Conclusions

A structured analysis of railway charging algorithms, at first sight very different from each other, was presented in the paper with focus on the method and some results of the research. Through the definition of a common general formula, single systems could be the frame in a common structure and classified in three homogeneous groups. The synoptic tables and the dynamic tool developed for line charge are thought as means to reason about possible railway charging schemes. The charging model defines the possible variations of the charging, particularly defining what and how much to let pay (wear and tear, willingness to pay, scarcity of capacity etc.), with results in terms of different charging level between market segments and category of the network, but also in terms of minor or greater complexity of the calculation method and legibility of the system.

The research will be extended to other European systems and to develop the dynamic tool also for stations charge, with an improved interface and the possibility to share the tools among the IM-s.

References

[1]   CENIT, TIS PT, IWW, HERRY, RailCalc, Calculation of charges for the use of rail infrastructure, 2007

[2]   CER, Position paper - Track Access Charges, 2010

[3]   EICIS, RailNetEurope, www.rne.eu/

[4]   EIM Position Paper on charging, 2010

[5]   Esveld, C.: Modern Railway Track, Second edition, TU-Delft, 2001.

[6]   OECD-ECMT, Railway Reform & Charges for the Use of Infrastructure, 2005

[7]   OECD-ECMT, Charges for the Use of the Rail Infrastructure, 2008

[8]   Network Statement from ADIF, DB, HŽ, Infrabel, MAV, ÖBB, PLK, Refer, RFF, RFI, SBB, SŽ , SZDC, Prorail, Trafikverket,

[9]   UIC, Infrastructure charges for high performance passenger services in Europe