wctr'04
4-8 july 2004 / istanbul-turkey

RAIL ACCESS CHARGING FOR INTERURBAN PASSENGER RAIL SERVICES: APPLICATION FOR THE GREEK RAILWAYS

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Abstract

Ten years ago in Europe only vertically integrated railways existed. Recently, the European Union policies and legislation introduced the legal separation between railway operations and infrastructure management. Thus, the infrastructure management companies should start applying infrastructure charges (termed access pricing) to train operating companies. Although European policies and legislation set the basic access pricing principles, they did not provide specific rules or methods for the derivation of infrastructure charging systems. The scope of this paper is to develop such an access pricing system to be applied for interurban passenger rail services to be part of the required by the European Union legislation Network Statement. Initially the basic principles, the economic concepts and characteristics of railways infrastructure charging are outlined. Then an overview of existing railways practices in EU and the USA is provided. The proposed structure of the infrastructure charges system is presented next, where a distinction is introduced between the basic charge, which includes costs for train planning and line operation, infrastructure damage/ wear and tear costs and quality of services, and the additional components. For each of the components the corresponding expressions are presented. Finally, in order to test robustness of the proposed system, it is applied for the Greek Railways Network Statement.

Keywords: Railways access charging; Interurban rail; Passenger services; Pricing principles; Charging system; Railways Network statement
Topic Area: H5 Innovation in Transport Policy

1. Introduction

Ten years ago Europe was predominantly dominated by state owned vertically integrated railways, thus the question of infrastructure charging was irrelevant for most European countries *(Tanzcos, 2000)*. The European Directive 91/440 and the 2001/14 that amended it introduced the possibility of infrastructure charging with the legal separation between railway operations and infrastructure management. Although EU Directives set the basic pricing principles for charging as well as the underlying policy objectives, they did not provide specific rules or methods for the derivation of infrastructure access charging systems. Therefore, explicit methods for charging the use of rail infrastructure (termed access pricing) are to be developed. However, the elaboration of an access pricing system encounters some difficulties, especially in the case of interurban passenger rail *(EC, 2000)*.

Firstly, from the policy point of view: interurban passenger services are "socially strict" and sometimes contradictory, i.e. accessibility; land-use planning; transport safety; intermodality etc. Thus, not all components of an "economic" model could be included in a charging system, without making it complex, non-transparent and difficult to understand. Secondly, from the economic point of view: the train operating companies (TOCs) are not only competing between them but they face strong competition from the other land modes for the same routes. Thus a “ceiling” of the infrastructure charging that indirectly affects the ticket price for passengers has to be introduced. It is determined by taking into consideration the transport costs for passengers using the other modes (bus/ coach, car etc.). Finally, from the technical point of view interoperability issues arise, since railway passenger services might include light rail, heavy rail and even metro rail using the same infrastructure or parallel routes.

The objective of this paper is to derive a system for charging interurban passenger rail services using the railway infrastructure, which will constitute a section of the required by EU legislation Network Statement. Its elaboration takes into account the economic theory, EU directives and policies, national/local policy objectives and competition among modes. The proposed charging system is applied for the case of the Greek Railways, when publishing the Network Statement.

2. Objectives

Infrastructure charging provides a very valuable instrument to the policy maker. The main objectives to be pursued, in a interurban environment, although some contradictory *(Gibson 2003, Nash 2002, EC 1998, Quinet 1990, NERA, 1999)*, are:

Societal optimal use of rail network: management of priorities in rail operations (routes/slots/paths) and economic efficiency (e.g. production surplus) and non-discrimination among TOCs. The efficient price, which generates the optimal use of infrastructure, is equal to the marginal cost imposed to society, by one additional train unit that uses the infrastructure.

Recover operating and maintenance costs of the rail network: Recovering of these costs is done partly or wholly for the section where the charge is imposed. However, this introduces some distortions, but Ramsey-pricing will minimize the deadweight losses that the increased charges incur.

Level of service quality provided to the TOCs: A typical variable is the minimum provided headway, which determines the frequency of service.

Recuperate the investment costs for developing the rail network: Although it is seldomly used in Europe (due to governmental subsidies for infrastructure provision), some kind of LTIC (Long-term incremental cost-function) is required.

Encourage the use of rail transport. The rail infrastructure charges has to take into account transport costs to the users of other competing transport services, which as it is the case of road transport, they pay less than the actual costs for infrastructure provision.

It is evident that not all of these objectives can be fulfilled, and thus an infrastructure charging system should prioritize them.

3. Theoretical background

3.1 Economic concepts and policy settings

The economic concepts of the railway industry are:

- **Decreasing cost industry:** Railways are a decreasing cost industry; therefore, some customers of a railway (i.e. TOCs) must pay higher prices than others for the same service (differential pricing). Consequently, at least the logic behind this practice is necessary to be considered *(Beshers, 2000)*.

- **Monopoly:** Some accept that railway sector is a natural monopoly, and thus the market mechanism doesn't lead to the best allocation of resources *(ECMT, 1998)*. For a firm to be a natural monopoly, two conditions are necessary: the subadditivity of a representative firm's cost function; the existence of long-run economies of scale *(Sharkey, 1987)*. In the railway sector, economies of scale are caused by numerous indivisibilities, including investment and functional indivisibilities, such as co-ordination of activities between upstream (infrastructure provision) and downstream (train operation) of production *(ECMT, 1998)*, hence some features of natural monopoly are present.
- **Private and public goods:** Railways exhibit some features of private as well as public goods. Rail infrastructure constitutes a quasi perfectly excludable good but there is, to a certain extent, a non-rivalry in consumption. In effect, the consumption of a slot might cause a delay for other trains, but not their exclusion *(Button, 1993)*.
- **Externalities:** Rail companies operating in a competitive environment, usually exhibit externalities like congestion, scarcity, environmental and accident costs, which could produce potential market failures *(Boyer, 1997)*.

From the policy point of view, it is accepted that marginal cost (MC) pricing contributes to social efficiency. Thus, for the railway industry MC pricing is preferable from societal viewpoint, due to the nature of services provided, especially when it comes to passenger services in an interurban environment *(EC, 1995)*. MC can be either Short Run Marginal Cost (SRMC) or Long Run Marginal Cost (LRMC). In any case, MC is calculated, as in (1):

$$MC = \frac{\partial(TC)}{\partial(Q)} \qquad (1)$$

Where:
MC : Marginal Cost for quantity produced (e.g. train-kms)
TC : Total Cost for quantity produced, where TC = f(Q)
Q : Quantity produced (e.g. train-kms)

3.2 Practices in Europe

At the present all the European countries are applying some kind of infrastructure charging system. Regardless the different economic principles (i.e. total cost recovery, marginal cost pricing etc.) the components of the charging system are almost the same, classified as *(Kieran 2001, IMPROVERAIL 2002, Hansson 1991, DTRL 2002)*: line infrastructure and traffic control, tear and wear of the infrastructure, quality of services, energy costs, external costs and use of stations.

Research conducted for the International Union of Railways (UIC) *(IMPROVERAIL, 2003)*, regarding the harmonization of charging systems among the European countries and their compliance with the new EU Directives, proposes a common structure for the European infrastructure charging systems, with the above charging components.

Regarding the economic principles behind infrastructure charging, the European Union indicates that the Social Marginal Costing (SMC) approach is the best when setting infrastructure charges *(EC, 2001)*, which could include as components:

Operating costs: train control, labor etc.

Infrastructure damage costs: maintenance costs, wear and tear of the infrastructure.

Congestion and scarcity costs: related to time delays to other users or non-users resulted from congested rail lines. Moreover, a specific TOC use of infrastructure may prevent another TOC from using it, and thus a premium has to be paid.

External costs: Environmental (air, water and noise pollution); Accident (costs in terms of material damage, pain and suffering and production losses).

3.3 Practices in the USA

Unlike Europe, in the USA, railway companies are vertically as well as horizontally integrated, plus they do not operate in a monopoly environment. Therefore, access pricing in the USA is about the price of an input (e.g. train-path) sold to a competitor. The different environments (of Europe and the USA) demand different access pricing approaches, but still a comparison is useful.

The regulatory regime set in place by the Staggers Act in 1980, recognizes that differential pricing is a necessary aspect of a private-sector railway industry, as the one in USA. Current regulatory practice (known as constrained market pricing) is that directly variable cost (DVC) is the lower limit, and stand-alone cost (SAC) is the upper limit, for setting rail prices. Regarding the lower limit concept, a similarity exists with the European policy context, although in Europe it refers to variable costs of infrastructure management, whereas for the USA refers to infrastructure management and train operations as well *(Beshers, 2000)*.

Recently, the Federal Railway Administration (FRA) asked for a review of railway access price as stipulated by Staggers Rail Act of 1980 (Liberty Heaven Foundation), using three approaches, i.e.:

- Efficient component pricing rule (ECPR)
- Market-determined efficient component pricing rule (M-ECPR)
- Total element long-run incremental cost (TELRIC)

Regarding the access price components, a study conducted for FRA includes the following: labour, materials and supplies, fuel, equipment and way and structures. It is noted that there are similarities with the European context, except for the component of “fuel”, due to the fact that unlike European railway companies, in the USA railway companies are vertically integrated, and thus train operation costs are included as well.

3.4 Outline of charging system

Based on the above, the general structure of the proposed charging system is presented in Figure 1 and the infrastructure charging is estimated by (2), which is a linear function of four basic charging components.

$$TP_{Final} = f\,(P_{Operations}, P_{Infrastructure\ Damage}, P_{Path\ Allocation}, P_{Additional\ Costs}) \qquad (2)$$

Where:

$\mathbf{TP_{Final}}$	: Total infrastructure charge (access price)
$\mathbf{P_{Operations}}$	: Component related to train planning and line operation costs
$\mathbf{P_{Infrastructure\ Damage}}$	: Component related to wear and tear costs
$\mathbf{P_{Path\ Allocation}}$	: Component related to the coverage of path allocation costs i.e. priority, quality of services etc.
$\mathbf{P_{Additional\ Costs}}$	: Component related to additional costs (i.e. energy consumption, stations etc.)

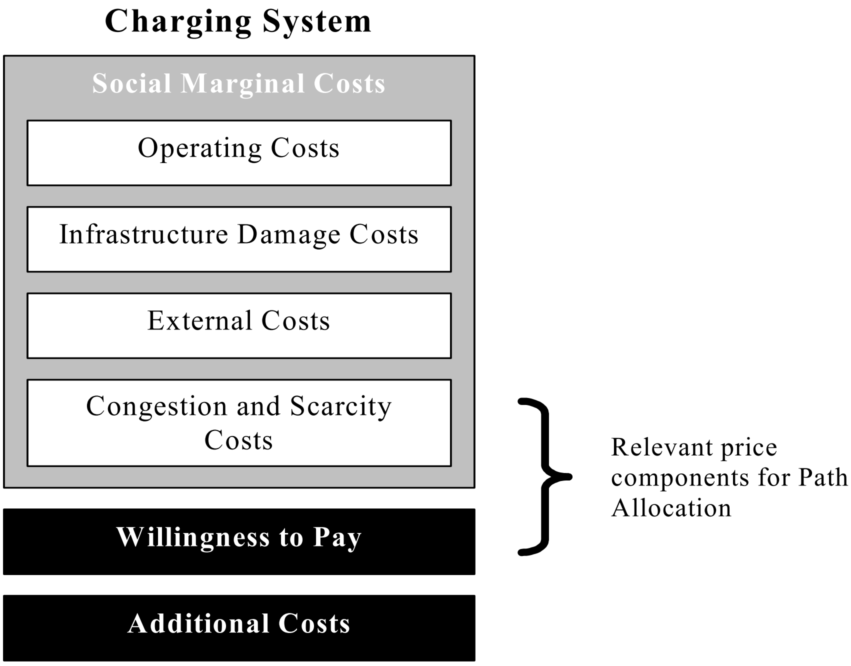

Figure 1. Outline of a Charging System and Relevant Components.

The above components are, either expressed in money terms and thus they are calculated on marginal cost basis or on other economic theory basis, or are expressed as quality factors.

4. Principles for infrastructure charging

4.1 Identification and calculation of cost types

For all cost elements, a Life Cycle Cost Analysis (LCCA) is applied for the inclusion of the time dimension and the corresponding opportunity cost of capital. The main steps for the LCCA, as presented in Figure 2, are:

- Establish the management profile;
- Construct a complete database by identifying all the LCC elements; (costs and infrastructure components)
- Determine and Calculate all cost parameters; (and the sub-cost parameters) - *the calculation of all costs is related to each infrastructure component*
- Calculate all costs at current prices;
- Calculate future costs, corrected for inflation;
- Discount all costs to the base year;
- Calculate the present value.

The costs related to train planning and line operations, assets maintenance and assets renewal, are: *a) Train Planning and Line Operation Costs*: telecommunication, train control and command, train planning, congestion costs, management overheads, station operation, marshalling yard operation and deport/terminal operation, *b) Maintenance and Renewal Costs:* track, electrification, signaling, structures, station assets, marshalling yard assets and deport/terminal assets.

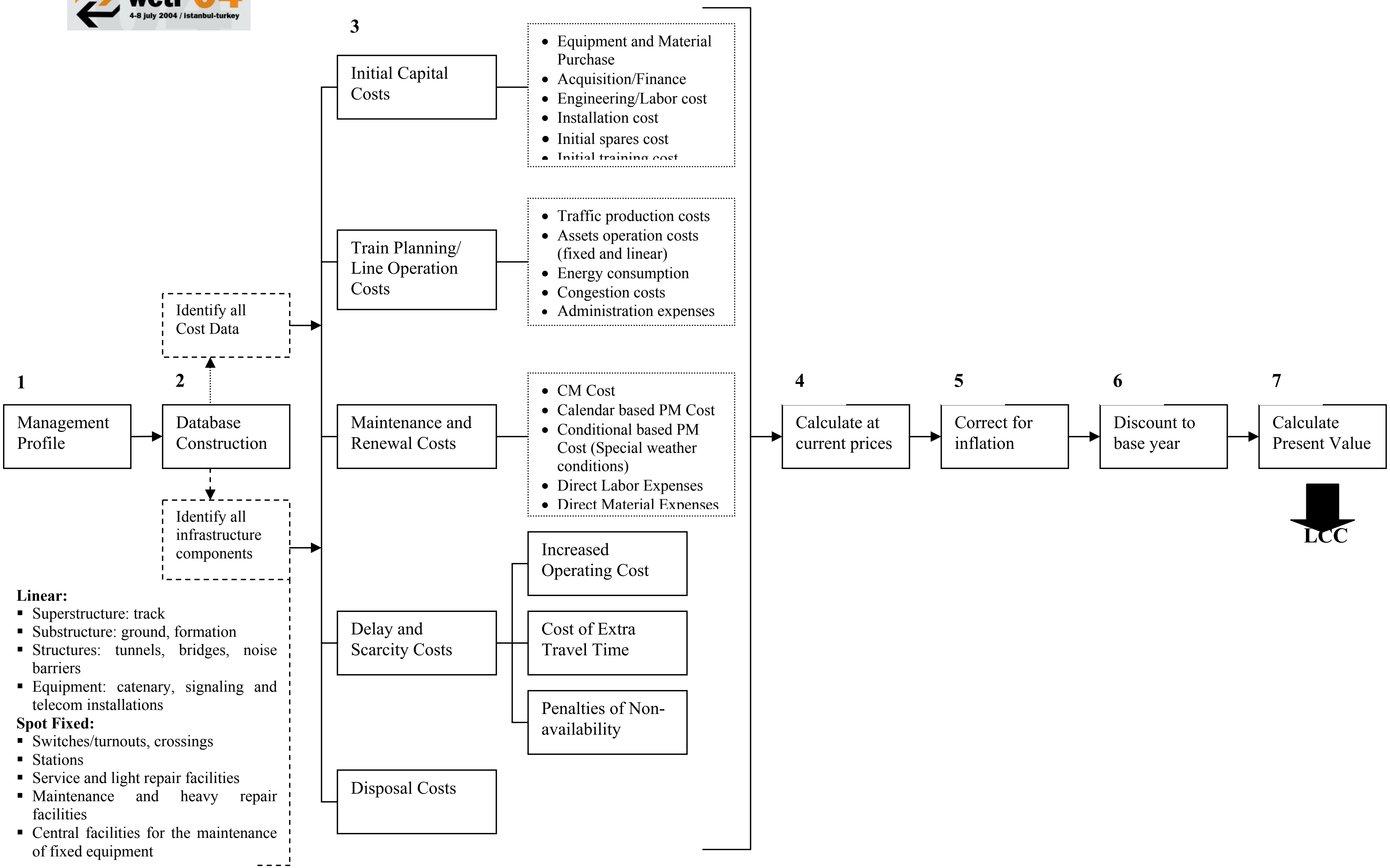

Figure 2. Life Cycle Costing Formulation. *(Source: IMPROVERAIL, 2002)*

4.2 Identification of key cost drivers

The following cost drivers (related to cost types) are considered significant as a basis for a transparent differentiated cost-based charging system: *a) for Train Planning and Line Operation costs:* number and frequency of trains, path reservation and headway, train priority and time of day/week, *b) for Asset Maintenance and Renewal costs*: number of trains/axles, train weight, vehicle weight, axle weight (expressed in gross tones), vehicle component design, vehicle condition, train speed and asset type.

4.3 Charging categories

There are four possible charging categories that act as proxies for the cost drivers and could be applied to introduce differentiated charges. They are based related to: (a) train type, (b) train path, (c) market characteristics and (d) route specification.

The key charging category is *train type* that captures the most of the wear and tear costs (especially for track) and speed and weight cost drivers. Therefore, *train type* will be used to develop the basic charge for a specific section.

4.4 Charging measurement units

The charging measurement unit introduced is: per train-km (for each train type).

5. Proposed charging system design

The proposed structure of the infrastructure charges system introduces a distinction between the basic charge and the additional components, following the policy and the existing practices in Europe.

For each of the components the corresponding expressions are presented with the relevant variables. These expressions are based either on the marginal cost approach or on a "Ramsey pricing" concept. Where needed, linearity assumptions are made for simplicity.

5.1 Basic charge

Following equation (2), the basic infrastructure charge is linear (3), and it consists of three components (analyzed below). The result of (3), multiplied with the track length of the section, produces the basic charge per train run on the railway section considered.

$$\mathbf{P_{Basic}}\ (€/\text{train-km}) = \mathbf{P_{Operations}}\ (€/\text{train-km}) * \mathbf{F_{Quality}} + \mathbf{P_{Infrastructure}}{}_{\text{ Damage}}\ (€/\text{train-km}) \quad (3)$$

1st Component: Train Planning and Line Operation ($P_{Operations}$)

Reflects the costs directly incurred to set the trains planning on the railway line and the operation of the line. The "direct variable cost" approach is accepted in both European and USA context. The calculation is based on marginal cost approach, with some differentiations according to line's speed and capacity utilization (4):

$$P_{Operations}\ (€/\ \text{train-km}) = MC_{Operations}\ (€/\text{train-km}) * L_1 * L_2 \quad (4)$$

Where:

$\mathbf{P_{Operations}}$	: Charging of train planning and line operation
$\mathbf{MC_{Operations}}$	: Marginal Cost of train planning and line operation
$\mathbf{L_1}$	: Speed coefficient
$\mathbf{L_2}$	: Capacity utilization coefficient

A proxy for the calculation of marginal costs could be introduced, in case of difficulties related to data. In such a case, the calculation of the average cost change over the change of the product outputs during the same time period has to be introduced. Hence, the marginal cost of train planning and line operation can be calculated as a function of the annual change of the average cost and the outputs as presented in (5).

It has to be noted that, in general, this kind of MC calculation bears the risk of producing negative results, if there are simultaneously a downward sloping average cost function and an upward sloping quantity function. However, this is unlikely for small increases in traffic demand over the considered time period.

$$\mathbf{MC_{Operations}\ (€/train\text{-}km) \cong D_{Annual}[AC\ (€)]/D_{Annual}Q\ (train\text{-}km)} \quad (5)$$

Where:
AC (€) = Average cost of train planning and line operation
Q = Produced train-km

It is noted that the average cost calculation (6) comprises all the line-relevant costs related to *Train Planning and Line Operation Costs,* i.e. the costs for telecommunication, train control and command, train planning and management overheads. The rest of the costs under this category are, either station related, therefore not included in the basic charge, or congestion related and are included in the coefficient L_2.

$$AC\ (€) = C_{Telecommunication} + C_{Control\ and\ Command} + C_{Planning} + C_{Overheads} \quad (6)$$

The calculation of coefficient $\mathbf{L_1}$ in (7) reflects the case of a train operating at a lower speed than the design speed of the railway line, and thus it occupies the line section more than it should, hence an extra charge must be levied. According to the theory of line capacity calculation, train speed and the required minimum time interval between the trains are analogous quantities. Therefore, the higher the trains' speed, the higher the length of the minimum time intervals in a train sequence. If there is "static" situation (considering only the space dimension), this would lead to a decreased line capacity. But since the situation is a "dynamic" one (considering both time and space dimensions), the intervals are "moving" faster with the high speeds and therefore line capacity increases.

$$L_1 = (\text{Line Speed/ Train Speed}) \quad (7)$$

As for $\mathbf{L_2}$**,** it reflects the time period of train operations, for which the charge is applied (8). This is related to MC pricing: it is necessary to correct it to deal with specific characteristics, such as peak and off-peak demand. This is crucial for the railways, since demand has to be accommodated with the same installed capacity, and so, optimization in capacity utilization is required. Assuming that line capacity is fixed at Q_0, and D_1 and D_2 are the demand curves for the two periods. On marginal cost pricing principles, the price in Period 1 (off-peak) should be set at P^*_1, implying an output of Q^*_1, which is below capacity. If it is accepted that capacity should be rationed by price, then price in Period 2 (peak) should be P^*_2, when demand D_2, is almost equal to capacity Q_0. The fact that D_2 is higher than D_1 implies that, the price at peak periods should be higher than at off-peak times. Research conducted for the International

Union of Railways (UIC), showed that -in average- the price in peak periods is almost 50% more than in the off-peak period. An intermediate value for near peak period is introduced also, to cover the whole spectrum of demand. Therefore L_2 is calculated as:

$$\mathbf{L_2} = \begin{cases} 1{,}5 & \text{if a train runs in a } \textbf{peak} \text{ time period} \\ 1{,}25 & \text{if a train runs in a } \textbf{near peak} \text{ time period} \\ 1 & \text{if a train runs in an } \textbf{off-peak} \text{ time period} \end{cases} \quad (8)$$

2nd Component: Infrastructure Damage ($P_{Infrastructure\ Damage}$)

The best way of calculating infrastructure damage (wear and tear) costs is by using econometric models *(UNITE, 2001)*, using the cost drivers of the previous section. For the case of railway industry, the translog function is suggested since: i) it enables to analyze cost behavior starting with the general case and specializing the function stepwise to the specific field of application, ii) is a flexible mathematical tool, a second order approximation of an unknown production function, iii) it imposes only few restrictions on the underlying production technology and it contains all relevant properties of production theory such as factor substitution, economies of scale and technological change.

Since the pricing system is specified for each train type and train service, thus the inputs are fixed. This simplifies the translog function to equation (9):

$$C = e^{f(\ln Y + \ln \beta)} = e^{f(\ln Y)} + \beta' \quad (9)$$

Where:
Y : the produced train-km and
β, β': constant values that encompasses all the input values, in the translog function, which are fixed.

Thus the MC that refers only to infrastructure damage is calculated by from (10).

$$MC_{\text{Infrastructure Damage}} = dC/dY \quad (10)$$

Therefore:

$$P_{\text{Infrastructure Damage}}\,(\text{€/train-km}) = MC_{\text{Infrastructure Damage}} \quad (11)$$

The marginal cost of infrastructure damage comprises all the wear and tear relevant costs identified previously by *Maintenance and Renewal Costs*, except those related to stations, marshalling yards and depot/terminals, which are included in the additional charges.

3rd Component: Quality of Services (F_Q)

Quality of services is referred to the path priority given to a specific train service. Unlike the other two components, quality of services is a multiplying factor, related to slot allocation. Research conducted for the International Union of Railways (UIC) *(33)*, has found the following values:

$$\mathbf{F_Q} = \begin{cases} 1{,}6 & \text{priority for a specific TOCs demands} \\ 1{,}35 & \text{priority to TOCs with frequent services} \\ 1 & \text{flexibility to the infrastructure company} \end{cases} \quad (12)$$

For $\mathbf{F_Q}$=1, the infrastructure company has the flexibility to assign the time period (slot) for the train service to the specific TOC. In the other two cases, the infrastructure company provides “higher” than the basic quality service to the TOC, and therefore an extra charge must be levied.

5.2 Additional charges

Three additional charges are envisaged related to: electricity energy consumption, station use and performance regime.

Charge for Electricity Energy Consumption (P_{Energy})

Energy consumption, according to Figure 2, could be placed under the Train Planning and Line Operation Costs. This is true if all lines were electrified, which not the case is. Hence, electricity energy supply is considered as an additional service, and as such it cannot be included in the basic charge. The charge is proposed per train category, according to actual electric traction consumption. It has to be mentioned that electricity cost vary with time of the day (peak, off-peak etc.), therefore this has to be taken into account. The consumption of electric traction energy is measured with installed electricity meters on the locomotives or, in the case that they are not equipped, is estimated by the locomotive type, the train weight and the distance covered.

Charging for Stations ($P_{Station}$)

The charge is calculated by (13):

$$P_{Station}\ (€/train) = N * [DC_{Station} / AT]\ (€/train) \qquad (13)$$

Where:

$\mathbf{P_{Station}}$	: Charging for the use of stations by trains
N	: Number of stations in the railway section
$\mathbf{DC_{Station}}$	: Direct variable costs of operation and maintenance of stations
AT	: Number of stopping trains

The direct variable costs of all the station-relevant costs identified previously by *Train Planning and Line Operation Costs and Maintenance and Renewal Costs*, related only to stations, marshalling yards and depot/terminals.

These direct variable costs do not include costs for operations such as passengers handling, but only operations dealing directly with train services in the station. This is because -in Europe-, stations can be managed by other companies than the railway infrastructure manager, i.e. as it is the case in the passenger rail station at the new Athens airport “Eleftherios Venizelos”, which belongs to the airport company whereas the tracks and the signaling system of the station belong to the Greek Railways.

Performance Regime Charge ($P_{Performance\ Regime}$)

This is related to the costs of delays per train, which is caused by either the TOC or the rail infrastructure company. It includes also lost revenues due to possible sequential delays. Hence, these charges are attributed accordingly either as an additional charge for the railway company, if it caused the delay, or as a deduction from the total charge imposed on TOC, if the infrastructure company caused the delay.

Since infrastructure charges are published each year in the Network Statement, and cannot be changed during the whole year, the formula for calculating the performance regime has to be known in advance. Consequently this charge is calculated by (14):

$P_{Performance\ Regime}$ (€/train) = ± {[$C_{Personnel}$ (€/min)+ $C_{Additional\ Energy}$ (€/min)+ OC_{Train} (€/min)] * M (delay) + NOTD*RL (€)} (14)

Where:

$P_{Performance\ Regime}$: Performance regime
$C_{Personnel}$: Train's personnel costs
$C_{Additional\ Energy}$: Cost for increased energy consumption
OC_{Train} : Train operational cost
M : Minutes of delay
NOTD : Number of trains delayed
LR : Lost ridership per train delayed

The calculation of increased personnel costs due to delays, it assumed that depends on the number of staff per train (driver, attendants) and their wages (€/hour). If such costs are based on different principles, according to labour agreements, they should be converted to €/ hour.

The costs for increased energy consumption depend on the line layout, train mass and the driving standards.

Lost revenue is calculated by multiplying the amount of passengers lost -for each train due to possible sequential delays- with the ticket price. In case that a specific TOC causes the delay, NOTD express the number of trains of other TOCs that are delayed due to the incident. In case the infrastructure manager causes the delay, NOTD refers to trains of all TOCs that are affected.

5.3 Viability of TOC operations towards competing modes

According to the EU Directives, the charging system should deter significant distortions of competition between modes. This is crucial, so that railway transport be competitive with the other (mainly) road transport modes, which so far seem to present advantages in an interurban environment.

Therefore, a test was designed to check whether the access pricing puts the specific TOC in a disadvantage against the other transport modes. This checks if the costs of providing the service -by a specific TOC- that includes infrastructure charges, balance well against the revenues in order to safeguard TOC competitiveness. This is accomplished since revenues depend on the ticket price that affects ridership, and as such it must be competitive with the other modes. This test comprises three steps:

Step 1: Produce the Initial Infrastructure Charge (**$IC_{Initial}$**) per train.

Step 2: According to the expected daily demand scenarios for peak (D_1) and off-peak periods (D_2) - provided by TOCs- and the fare price elasticity, the calculation of the passenger fares (ticket price) takes place for both peak (P_1) and off-peak (P_2) periods. It is noted that, to protect the public interest, for interurban as well as urban public passenger transport, there is a "ceiling" (P_{max}) for passenger fares, which cannot be exceeded by the TOCs. Then the Total Operational Revenues per day (**OR**), for the specific TOC are:

$OR = P_1 * D_1 + P_2 * D_2$ (15)

Step 3: Calculate Profit or Loss for the TOC, applying (16):

$(IC_{Initial} + OC) * N \leq P_1 * D_1 + P_2 * D_2$ (16)

Where:

OC: Train operational cost
N: Number of trains per day for the suburban line

In case that (16) does hold, then the test is positive for the infrastructure charge level, since there is a profit –even marginal- for the TOC. If (16) does not hold, then Step 2 is repeated by setting higher prices P'_1 and P'_2 and by using own and cross-price elasticity for the calculation of new demand volumes D'_1 and D'_2. Then, following Step 3, the new OR', is again checked against the sum of $IC_{Initial}$ and OC. This is repeated until the limit P_{max}.

If (16) does not return positive result at the P_{max}, then there are two solutions: either infrastructure company decides to reduce the infrastructure charge or the TOC asks for a subsidy in order to keep the fares at the P_{max} and not going out of business. In either case it is the state that has to cover financially the difference, since interurban and urban services by public transport are considered a needed service to be provided by the state to the public. In Europe, law through public service contracts procedures stipulates this.

6. Application for The Greek Railways

The proposed charging system, was applied for the case of interurban passenger rail services provided on the Greek Railways infrastructure, since it is necessary for the Infrastructure Manager, according to the new EU Directives, to publish the charges for the use of the infrastructure in the annual Network Statement.

All the necessary costs (infrastructure, maintenance, renewal, planning, station), technical characteristics (line length, line design speed etc.) and operational (maximum permitted axle weight, type of wagons etc.) data were collected from the Greek Railways (OSE-CH) in order to calculate the basic, as well as the final charge, following step by step the proposed charging system. These will appear in the Network Statement to be published by the Greek railways early 2004. The data on costs breakdown is not publicly available.

The results are presented in the next Tables, although no details are presented, after the request of the Greek Railways.

Table 1. Price for Train Planning and Line Operation

Marginal Price	**1 €/train-km**		
Differentiation	**Marginal Price** x L_1 x L_2		
Speed Coefficient L_1	$\mathbf{V_{Train}}$ **x** 0,005	High Speed	
	$\mathbf{V_{Train}}$ **x** 0,00625	IC	
	$\mathbf{V_{Train}}$ **x** 0,00625	Regional Fast Traffic	
	$\mathbf{V_{Train}}$ **x** 0,00625	Regional Slow Traffic	
	$\mathbf{V_{Train}}$ **x** 0,00625	Suburban Traffic	
	$\mathbf{V_{Train}}$ **x** 0,01	Mixed Traffic	
Capacity Utilization Coefficient L_2	Peak Hour	Near Peak Hour	Off Peak Hour
	1,5	1,25	1

Table 2. Price for Infrastructure Damage

Marginal Price	**3 €/ train-km**
Differentiation	**Marginal Price** x ($\Phi_{\text{Wear and Tear}}$)
Train Dynamic Weight Coefficient $\Phi_{\text{Wear and Tear}}$	$\Phi_{\text{Wear and Tear}} = 0{,}003$ x Train Weight

Table 3. Price for Quality of Services

Marginal Price	**-**		
Differentiation	Priority	Frequency	Flexibility
Capacity Utilization Coefficient L_2	1,6	1,35	1

Table 4. Price for Energy Consumption

Differentiation per Train Type	**Price**
High Speed	0,0021 € /**train-km**
IC	0,0021 €/ **train-km**
Regional	0,0048 €/ **train-km**
Suburban	0,0048 €/ **train-km**

Table 5. Price for Stations

Price Fixed per Station	10 €/train

7. Summary and conclusions

This is one of the first attempts to present a comprehensive charging system for interurban passenger train services. The application of social marginal cost pricing for infrastructure charging, although in compliance with the economic theory, exhibits problems in the implementation, such as: in measurement, complexity of pricing system, possible financial implications, "decreasing cost industry", competition implications within the rail sector and with other modes, acceptability on behalf of TOCs and infrastructure managers, as well as the end-users (passengers).

The proposed charging system manages to overcome some of the above: it is simple, transparent and easy to understand and apply. The "decreasing cost industry" is partly confronted by the separation of the charging system into different components, with each component calculated differently according to its nature. In addition, the system is designed in such a way to avoid possible distortions of competition, internal and external to rail industry, by developing a test to check its viability. The proposed infrastructure charging system can be applied to any type of service and railway company, by differentiating the charges accordingly to the TOCs services and demands and the rail infrastructure characteristics.

The charging system when applied for the preparation of the Greek Railway's Network Statement case has calculated the infrastructure charge, broken down into its components. This is useful for practical purposes and produces charges that are transparent, as envisaged by the Network Statement.

Concluding, the above-presented charging system could be useful not only to academic world but to TOCs and railway infrastructure owners, European or not, since several of its characteristics are in compliance with theory, policy and existing practices.

Acknowledgment

This paper is based on research financed by the Hellenic Railways Organisation.

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