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HIGH SPEED RAIL: CARGO ON THE LISBON - MADRID LINE?

LEAL, DIANA SILVA, UNIVERSITY OF COIMBRA, COIMBRA, PORTUGAL, DIANA@DEC.UC.PT

PICADO-SANTOS, LUÍS GUILHERME, DECIVIL, INSTITUTO SUPERIOR TÉCNICO, TECHNICAL UNIVERSITY OF LISBON, LISBOA, PORTUGAL, PICADO.SANTOS@CIVIL.IST.UTL.PT

SANTOS, BRUNO FILIPE, UNIVERSITY OF COIMBRA, COIMBRA, PORTUGAL, BSANTOS@DEC.UC.PT

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Leal, Diana Silva, University of Coimbra, Coimbra, Portugal, diana@dec.uc.pt

Picado-Santos, Luís Guilherme, DECivil, Instituto Superior Técnico, Technical University of Lisbon, Lisboa, Portugal, picado.santos@civil.ist.utl.pt

Santos, Bruno Filipe, University of Coimbra, Coimbra, Portugal, bsantos@dec.uc.pt

ABSTRACT

The present paper deals with the study of a life-cycle application, taking into consideration containerized cargo on a regular operation in the future Lisbon – Madrid high-speed rail line. The cargo operation should minimize additional cost in the infrastructure and the usage of spare slots from passenger-service. This study considers the construction of two logistic (rail-road and rail-rail) freight facilities near both main cities. The market for high speed rail cargo service is considered to be goods for which travel time is a major concern – e.g., perishable high value products, such as fruit and fresh fish, light freight - mail or components for several types of industries, like car manufacturing, electronics and among others.
The methodology applied pretends to clarify the effects of the evaluation on various stakeholders and the estimation of the expected financial transfers between them and help in the decision making process. The process takes advantage of information that is usually available for the traditional cost-benefit analysis and uses other detailed data provided by the Lisbon-Madrid Portuguese project-managing agency. The information relates effects and stakeholders, summarizing the main economic and financial implications of the project, the transfer between stakeholder and the distribution of cost and benefits. It also integrates non-monetized effects and overall indicators of the investment profitability.
The result addresses the feasibility of the cargo service, besides passenger service, in the operation of the Lisbon-Madrid high-speed rail line. A comparison between a pure financial analysis and a socio-economic evaluation is provided with results. The results translate the stakeholder expectation regarding the project solution and suggest that light cargo should be considered as new target revenue for this transport segment, using the infrastructure applied for passengers and leading to a new way of delivering high-value goods.

Keywords: high-speed rail, multi-attribute analysis, cargo transportation, containerized cargo.

INTRODUCTION

The European Union considers the expansion of high-speed rail (HSR) network as a priority within the trans-European transport network (TEN-T). The TEN-T policy assigning an important part of Community funds for development and improvement railways as strategic model in order to integrate land, sea and air transport, allowing goods and people to easily circulate between member states (European Commission 2012). The rail revitalization, proposed by the European Commission, translated the relevance that HSR gain in Europe regarding the increased worries about congestion and traffic accidents on the roads, the delays associated with air traffic, as well as the negative environmental impacts of these modes. The HSR line between Lisbon and Madrid encourages the European rail continuity and is one of the structural projects of the TEN-T programme.

The allocation of public resources to the expansion of the HSR network is a significant element of transport policy. HSR lines are associated with massive fixed costs and with a huge traffic capacity (Rus and Nash 2007). According to Lisbon-Madrid network studies, passengers demand is not enough to support all the investment cost (Rave/Refer 2012). The introduction of freight (light cargo) on the operation of the Lisbon-Madrid HSR line seems to be a possible solution to overcome the demand default and is a way to increase the overall project revenue. The light cargo should undertake containerized cargo with perishable high value products. The operation should follow the quality of service expected for passengers and offer just-in-time deliveries, reliability, safety and enough capacity.

Investment decisions are central for any development strategy (Florino 2008).The cost-benefit methodology is used to assess public investments in infrastructures in a large number of countries (Olsson et al. 2012). Still, the method is often seen as a “black box” by the individuals not directly involved in the process (Kaufmann et al. 2008). Besides, the existence of non-valued costs and benefits, it also contributes to question the abilities of the cost-benefit analysis (Tavasszy et al. 2006). The authorities in each country provide the guidelines that strongly influence the outcome of all cost-benefit analysis (Olsson et al. 2012).

> The tendency of governments to look at their own financial interests should not detract from their ultimate goal, which is to promote the interests of society at large (European Investment Bank 2005).

HSR investment projects of European member countries have been financially supported by the European Commission. \`Revitalizing the railways´ (European Commission 2001) is on the front line of action to revitalize the railways. Several studies have been performed about appraisal methods and the economic impact of a HSR project. The economic evaluation of HSR investment has been covered from different perspectives by Rus (2008). A general assessment can be found in Nash (1991), Vickerman (1997), de Rus and Nombela (2007). The cost-benefit analysis of Spanish lines in: de Rus and Inglada (1997); de Rus and Nombela (2007), de Rus and Nash (2007), and Rus (2012) for the European Union. The regional effects of HSR investment in: Vickerman (1995, 2007). Besides all studies presented, the European Union prepared a set of reports in order to establish a guidelines for project approval: *Guide to cost-benefit analysis of investment projects*(Florino 1997), *RailPag*

- *Railway Project Appraisal* (European Investment Bank 2005), *Guide to cost-benefit analysis of investment projects: structural funds and instruments for pre-accession* (Florino 2008)

A huge variety of stakeholders is already a good indicator that the decision to invest in a rail project will follow a complex path (European Investment Bank 2005). The decision approach of a complex system such as the HSR mixed service (passenger and cargo) involves an increasing number of public and private partners related with rail investments. The distribution of costs and incomes among them is politically sensitive and is a crucial component in the decision-making process. Thus, it needs to be undertaken with a more widespread analysis than a traditional cost-benefit one, involving wide variety of decision-makers than just the political one.

This paper presents a multi-attribute life-cycle decision-support methodology applied to the study of introducing cargo operation on free-passengers slots on the Lisbon-Madrid HSR line. The background of the applied methodology is called MATE – Multi-Attribute Tradespace Exploration, a decision making tool developed at MIT (Massachusetts Institute of Technology) by Adam Ross (2003). For the study of the Lisbon-Madrid line, the rolling stock chosen for cargo delivery is of the same type as the passenger rolling stock. A comparison between a pure financial analysis – which main purpose is to use the project cash-flows to calculate suitable net return indicators, and a socio-economic evaluation – appraising the project contribution to the economic welfare, using shadow prices and based on the social opportunity cost, is provided with the results analysis.

This paper is organized as following: the next section explains the scope and the main assumptions of the study. Subsequently the methodology framework is introduced and the results of two different analyses are presented in the following section. The paper ends with conclusions and final remarks.

LISBON-MADRID HSR LINE CONNECTION

The Lisbon-Madrid HSR line connection follows the directions already approved by Iberian Summit established between the Portuguese and Spanish governments (Ministério dos Negócios Estrangeiros 2008).

The new line has a length of 645 km split between Portugal and Spain (Figure 1).

Line operations and management are considered separate entities regarding the European Railway Agency demand (European Railway Agency 2004). Nevertheless there is no difference between countries regarding the Operator or the Management of the Iberian line.

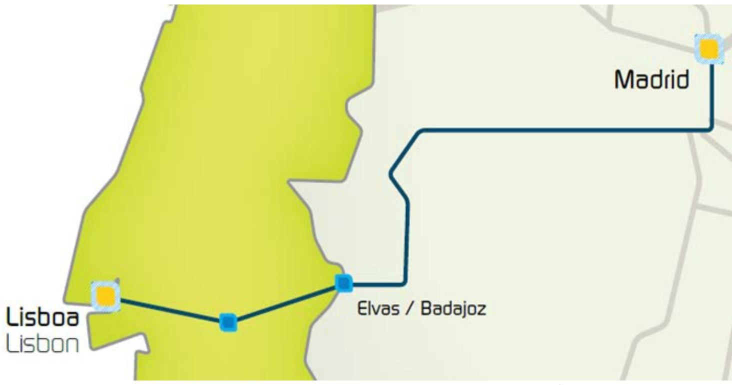

Figure 1 – Lisbon – Madrid link design (Rave/Refer 2012)

Rail Services

In order to develop the decision-support methodology, the Lisbon-Madrid line is built from scratch, considering all security and operating systems. The passenger model demand results from the assumptions made by Rave/Refer (EPYPSA and EXACTO 2011) – the Portuguese agency for high speed rail. According to Rave/Refer, demand model is based on origin-destination matrices for the nine stations (Figure 2) planned and based on different combinations of origin-destinations inside the line. According to (EPYPSA and EXACTO 2011), the line will start operations in 2015 and will last until 2045. However, the passenger services to be offered in this link are not defined yet, and in order to simplify the case studies, it is assumed the following demand considerations:

1. Demand Service 1: it serves the Lisbon-Madrid central Stations without stops as a direct service. The connection has a travel time of 2 hours and 45 minutes (Rave/Refer 2012) with a speed higher than 250 km per hour;

2. Demand Service 2: it serves all the intermediate stations - Lisbon (Oriente), Évora, International (Elvas/Badajoz), Mérida, Cáceres, Plasencia, Navalmoral, Talavera de La Reina and Madrid (Atocha) – with lower speed (around 200 km per hour). This medium-speed service is performed as two separate services, operating inside each country, with similar characteristics.

Cargo Services

When we think about cargo on HSR train, what cargo are we talking about?
Until now, rail freight transport only dealt with heavy raw cargo (needing more than 10 hours to get to the destination Lisbon-Madrid) and road-truck transport takes care of the other types, namely light cargo and containerized ones.
Last Rave/Refer reports (EPYPSA and EXACTO 2011) forecast that in 2045, the cargo demand between Spain and Portugal will achieve 55 million tons. According to the Portuguese agency, the Lisbon-Madrid HSR should capture an amount of 930 thousand tons in 2025 and 1250 thousand tons in 2045. For the present study, the cargo operation service has the same analysis period (2015-2045) than the passenger operation service.
In order to become viable the introduction of cargo on this line, some conditions are assumed:

1. The rolling stock required for cargo delivery has similar characteristics as passengers' rolling stock, regarding the load per axle and aerodynamic structure.

2. The products to be delivered have high added value, such as post, pharmaceutical items, fresh products (flowers, fish, vegetables or fruit), and electronic components, in order to provide a one-day (or less) stock operation for the final consumers or industries.

3. The price value for cargo rolling stock is considered to be 40% less than the market price for the passenger rolling stock defined for the high speed service.

4. The cargo service is never mixed with passenger service, and the cargo train should travel with a speed similar to the medium-speed service (200 km per hour).

5. The cargo service uses the free slots left by the passenger services and has also a daily operations schedule.

6. The cargo service is a direct connection between two intermodal rail-road terminals close to Lisbon and to Madrid. The first one is an upgrade of a terminal located in the village of Poceirão in Portugal (Figure 2) and defined according to the demands of Portugal Logistico report (MOPTC 2006). The second one, in Spain, is assumed to be built near Madrid. The best location for this facility is before the Lisbon-Madrid line merges with the Madrid-Seville line, fifty kilometers away from Madrid, near Toledo area (PK 50 in Figure 2). The dimension of this facility is five times more costly and larger than the one in Poceirão (MOPTC 2007).

Figure 2 – Poceirão Logistic Facility and PK 50 (Toledo area) in the Lisbon-Madrid line (Source: adapt from (Tis.pt and SENER 2008))

The cost of the HSR line is based on the life-cycle investment over a period of forty years, in which are included the overall project, construction, financing, operations, and maintenance. The overall project involves the construction of new lines and stations, the purchasing of new rolling stock and additional operating costs and also externalities costs (such as noise or air pollution). The required cost data is obtained from several European HSR lines studies (e.g., Janic (2007),Campos et al. (2008)). To supplement the reference data, also taken into consideration information provided by Rave/Refer (2012) and data obtained from some interviews conducted to the different stakeholders directly involved in the process (e.g. cargo companies, rail companies, and the Portuguese government).

METHODOLOGY

The ambition is to evaluate the feasibility of introducing cargo operations on the Lisbon-Madrid HSR passengers' line. The expectation is to make use of the extra capacity of the passenger service for the cargo delivery services. The goal is to find the solution(s) that have the highest utility (best judgment for someone in the context of a certain reality) for the main stakeholders involved. To deal with the combination of stakeholders, costs and utilities, the MATE (Multi-Attribute Tradespace Exploration) method developed by SEAri-MIT (SEAri 2009) is applied. This method was applied previously to several aerospace case studies (Ross 2006). However, MATE was recognized to have the potential to be relevant to other domains(Nickel 2010). Because of the complexity involved, transportation is certainly one of those domains and this study has made a first attempt to use the method in this field.

The investment in rail sector is rarely based on one single perspective. Different stakeholders are usually involved at different decision levels, including a wide range of institutions, companies and individuals, and increasing the complexity of the analysis.

Until now, for different reasons, cargo was not a target revenue segment for HSR lines (Leal and Picado-Santos 2010; Leal et al. 2012). The main reason for this is the serious maintenance and operational constraints that occurs when conventional freight trains are used in a HSR line. Namely, the high track maintenance costs, the additional costs related to passenger safety, and the limitation of using line slots with two different operational speeds.

The approach (Figure 3) involves the analysis of the different stakeholders' perspectives, while dealing efficiently with the required resources.

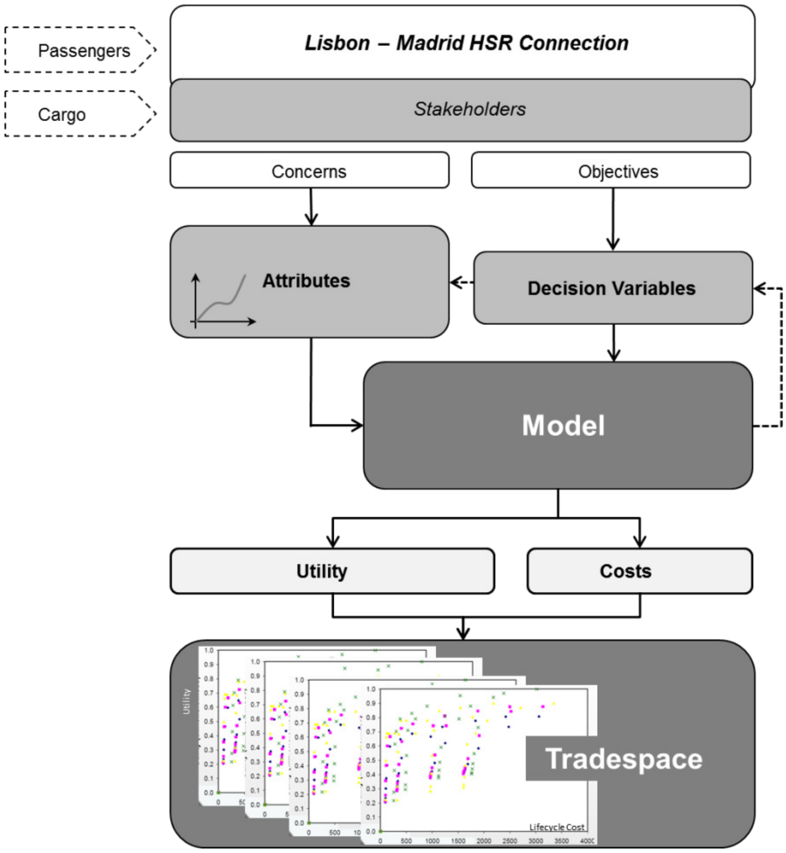

Figure 3 – Lisbon – Madrid HSR modeling approach

The stakeholders have different objectives and concerns with regards to the HSR line. The objectives are related to the way that stakeholders assess decisions variables. These variables are mainly related to the HSR service design (e.g., frequency of the trains) but also with business interactions between stakeholders (e.g., track rent paid by the operator), and assume a value in a certain discrete variation interval. The concerns of each stakeholder are expressed by a set of attributes of the HSR project (e.g., average travel time, operational costs, and rolling stock investment). These attributes depend on the value of the decision variables and are evaluated by each stakeholder. The translation of this evaluation is a "utility function" established in the region "value of the attribute" (x's axis) and "best judgment of the stakeholder" (y's axis, ranging from 0 to 1). Together, decision variables and attributes define the characteristics of the framework and "utility functions" which describe the way stakeholders appraise the HSR service.

The model generates a set of possible solutions combining the different decision variables. Each solution is analyzed in terms of cost and utility. For a given solution, there is a cost ("value of the attribute") and utility ("best judgment of the stakeholder") by stakeholder. The solution cost is assessed according to the life-cycle cost of each stakeholder "keep in mind" a particular solution. The solution cost is computed from the life-cycle analysis regarding the HSR service, not only considering the impact of the decision variables but also all the other costs associated with the HSR line (e.g., infrastructure costs, externalities). The utility is calculated based on single attribute curves. The single attribute curves describe, by stakeholder how the utility level changes within the attribute range given the same life-cycle analysis.

The model results in a tradespace, representing the cost and utility relation for each HSR design solutions represented by stakeholder. The tradespace representation by stakeholder is a cloud of points, combining the life-cycle cost with the utility for each design solution determined. The clouds represent the space of trade-off and their fusion is the global vision of all the stakeholders in order to reach the final result of the assessment.

FRAMEWORK

The case variables for the both analysis preformed are described below.

Stakeholders

According to Rail Appraisal Guidelines (European Investment Bank 2005) the relevant stakeholders in a rail investment project are:

1. The Users: they are the critical group in the financial and socio-economic analysis, since they represent the potential demand and are the payers of both HSR line and other alternative transport services. Their goal is to have a competitive, high frequency, safe service with the lowest fares.

2. The Transport Service Operators: the public or private companies that operate the rail and road transportation services (passenger and freight). Included here is the future HSR line operator(s). The aim of the HSR line operator(s) is to obtain the best deal from the investment done (European Investment Bank 2005). That is, to have high fare revenues by paying the minimum for the service operation. The other (non HSR line) operators aim to keep their current business without losing market share of the new HSR service or aim to benefit from it.

3. The Infrastructure Manager: the private company or the public authority that administrates the HSR line infrastructure and its use. Regarding the European regulations, the infrastructure manager (that could also be the owner of the infrastructure) and the service operators cannot be the same entity (European Investment Bank 2005). The goal of the manager is to grant the use of the line to operators, charging a rent for this, and keeping maintenance costs as low as possible.

4. The Government: the various political decision makers (European Union, national, regional or local) that are involved in the project. They represent society and its perspective with regards to the HSR project. Their goal is to reduce the negative impacts (e.g., accidents, environmental impacts) and to have the best social-economic benefits from the project. In some cases, the government also subsidizes the project construction and operation.

Decision Variables

The decision variables (Table 1) chosen are key quantitative parameters that define the service that is provided by the HSR line in study.

Table 1 – Decision Variables

Decision Variables	Definition	Variable type (discrete choice)			
		High Speed Service (HS)	Medium Speed Service (MS)		Cargo Service
			Portugal	Spain	
Frequency	Number of trains per day	11 13 16	1 3 6	5 9 14	3 6 9
Fares	Value paid by the user to the operator (€/pass.km or €/ton.km)	0.111 0.139 0.167	0.066 0.083 0.100		0.055 0.058 0.061
Rent	Value paid by the operator in order to use of the track, rolling stock and terminals	2.0 % 3.5 % 5.0 %			
Elasticity	Demand analysis	± 20%	± 20%		± 5%

The frequency is related to the number of trains per day for each service considering both passenger services (the direct train and the one with intermediate stops) and the cargo service. The fares represent the trip value (by passenger-km or ton-km) to be charged to the HSR users. The rent is the amount of money annually paid by the HSR operator to the infrastructure manager in order to use the rail infrastructure. The amount paid annually by the HSR operator is expressed as a percentage of the net present value (NPV) of the total investment done by the infrastructure manager.

For each decision variable considered is defined a discrete set of values, within a pre-defined range. The range and the set of values are based on previous assumptions and also on data from Rave reports (EPYPSA and EXACTO 2011):

1. The frequency ranges for the passenger services are based on the frequencies proposed by Rave/Refer. Regarding cargo service, the frequency range is established according to the number of necessary trips to transport the referred demand.

2. Regarding cargo, it is assumed that each car is equivalent to two TEU that has a capacity of 28.6 metric tons per car. With an average load factor per train of 0.75 and considering the operation occurs during 300 days per year. The load units are determined according by Janic (2007) study on intermodal rail-truck transport network .

3. The fares ranges for the high speed service (HS) and for the medium speed service (MS) are defined by Rave demand studies (EPYPSA and EXACTO 2011). The minimum and maximum fare values are determined as elasticity function defined on *Modelo Integrado de Procura de Passageiros* (Steer Davies Gleave 2007) and according to RailPag (European Investment Bank 2005). The fares

range for cargo services are based on the elasticity studies made by Beuthe et al. (2001). The elasticity assumed is the one that represents the total cost variation for a NST-R type 9 and considering the long distance rail mode.

4. The rent range is determined by the European Bank Appraisal for High Speed Rail Investment (European Investment Bank 2005). A set of three rent levels within the proposed range is assumed for this study.

With the set of results provided by the decision variable, it is than obtained the reliability of each service and its convenience regarding the number of trains per day by service.

Attributes

The attributes are divided in four categories, based on the Rail Appraisal Guidelines (European Investment Bank 2005), namely: User Service, Operation, Assets and External Effects (Table 2). The values of the attributes are set according to Rave studies (Rave/Refer 2012), data provided by other European HSR lines, and also from interviews made to several stakeholders (Rave, rail and road freight operators).
Two types of attributes are considered: the attributes that can be influenced by the solution obtained and thus can be described as a function of the decision variables (e.g., travel time, accidents, the external effects, asset rent, and the service values that represents the amount of money collected by the operator when charging the fares); and the attributes that, are assumed to be constant, that are not part of the decision making process (e.g., the infrastructure investment, station location).
The attribute convenience is added to evaluate the system performance.

Stakeholder Expectation

Regarding stakeholders' expectations, not all of them share the same concerns. In fact, they do not share the same attributes in a project appraisal. That is the case of the HSR user that is not directly interested in the rent paid by the HSR operator, or the infrastructure manager that is not directly interested in the fares charged to the users. Moreover, the stakeholders usually address different priorities for the different attributes that they are concerned with. Intuitively or consciously, they have different priority (weights) for each attribute assumed in their project assessment.
The evaluation of the stakeholders and priorities evaluation are performed by interviews made to some stakeholders and addresses the concerns assumed by European Union (European Investment Bank 2005). The interviews were performed to a few decision-makers from each group of stakeholders in order to get a perspective on business environment. The questions has as main objective to assess the level of interest about attributes and how single attribute curve can perform regarding each interest group.

Table 2 - Attributes selected

					Users				Transport Service Operators		Infrast. Manager	Government
					Rail Lines		Alternative Modes					
Attributes			Applied to:	Units	Pax	Cargo	Pax	Cargo	Rail Operator	Other Modes	Rail Manager	
User Service	Convenience		HS	#	0.113		0.113		0.022	0.100	0.035	0.035
			MS	#	0.057		0.057		0.022	0.100	0.025	0.025
			Cargo	#		0.200		0.200	0.020	0.110	0.025	0.025
	Service Value		HS	[€/pass.km]	0.150		0.215		0.031	0.230		
			MS	[€/pass.km]	0.150		0.215		0.031	0.230		
			Cargo	[€/ton.km]		0.350		0.600	0.031	0.230		
	Travel Time		Work	[€/pass.km]	0.150		0.200					
			Leisure	[€/pass.km]	0.150		0.200					
			Cargo	[€/ton]		0.310		0.200				
	Safety/Accidents		HS/MS	[€/pass.km]	0.230							0.057
			Cargo	[€/ton.km]		0.140						0.019
Operation	Direct	Fee	HS/MS	[€/train.km]					0.250		0.320	0.150
			Cargo	[€/train.km]					0.025		0.032	0.015
		Vehicle Operation Costs	HS/MS	[€/un.year]					0.048			0.030
			Cargo	[€/un.year]					0.024			0.015
		Track Operation	HS/MS	[€/unid.km]					0.048			0.030
			Cargo	[€/unid.km]					0.024			0.015
		Operation Personnel		[€/worker]					0.15			0.09
				[€/un.h]					0.025			0.015
		Facilities Operation	HS/MS	[€/pass.km]					0.072			0.045
		Rail-Road Facilities	Cargo	[€/ton.km]					0.048			0.030
	Indirect	Overhead Management		[€/seat]					0.024			0.015
		Subsidies		%					0.010		0.015	0.008
Assets	Investment	Overall Initial Investment		[€/km]					0.013		0.110	0.020
		Rolling Stock (Vehicles s130)*rent	HS	[€/un]					0.01		0.047	0.008
		Rolling Stock (Vehicles s102)	HS	[€/un]					0.013		0.047	0.009
		Rolling Stock (Vehicles s104)	MS	[€/un]					0.013		0.047	0.009
		Rolling Stock (Cargo)	Cargo	[€/un]					0.013		0.047	0.009
		Rail-Road Facilities		[€]					0.013		0.100	0.020
		Residual Value		%					0.020		0.030	0.020
	Maintenance (Routine)	Infrastructure & Superstructure		[€/km]							0.060	0.018
		Rail-Road Facilities		[€]							0.060	0.018
External Effects	Network		HS/MS	[€/pass.km]								0.105
			Cargo	[€/ton.km]								0.020
	Environmental		HS/MS	[€/pass.km]								0.105
			Cargo	[€/ton.km]								0.020

Attribute Curves

Each pair of stakeholder-attribute is associated with an attribute curve that represents the utility variation for that stakeholder with the appropriate attribute considered. To simplify, linear functions are assumed between utility and costs (value of each attribute). These curves have positive or negative slopes according with stakeholders view with regards to the evaluated attributes.

Solution Search

To search for the best solution, all solutions have been tested – that is, all the possible combinations of design variables have been studied. The solutions are assessed stakeholder by stakeholder, according to the attributes assignment and the attribute curves. The costs are calculated according to the life cycle NPV of the Lisbon-Madrid HSR line project, considering a life period of 40 years.
The solutions can be represented in a tradespace of design. As can be seen in Figure 4, the tradespaces are, as expected, different for each stakeholder. Moreover, when the best solutions are identified by stakeholder (based on the Pareto Front concept and signalized with red stars in Figure 4), it is impossible to identify the best common solution that compromises all stakeholders.

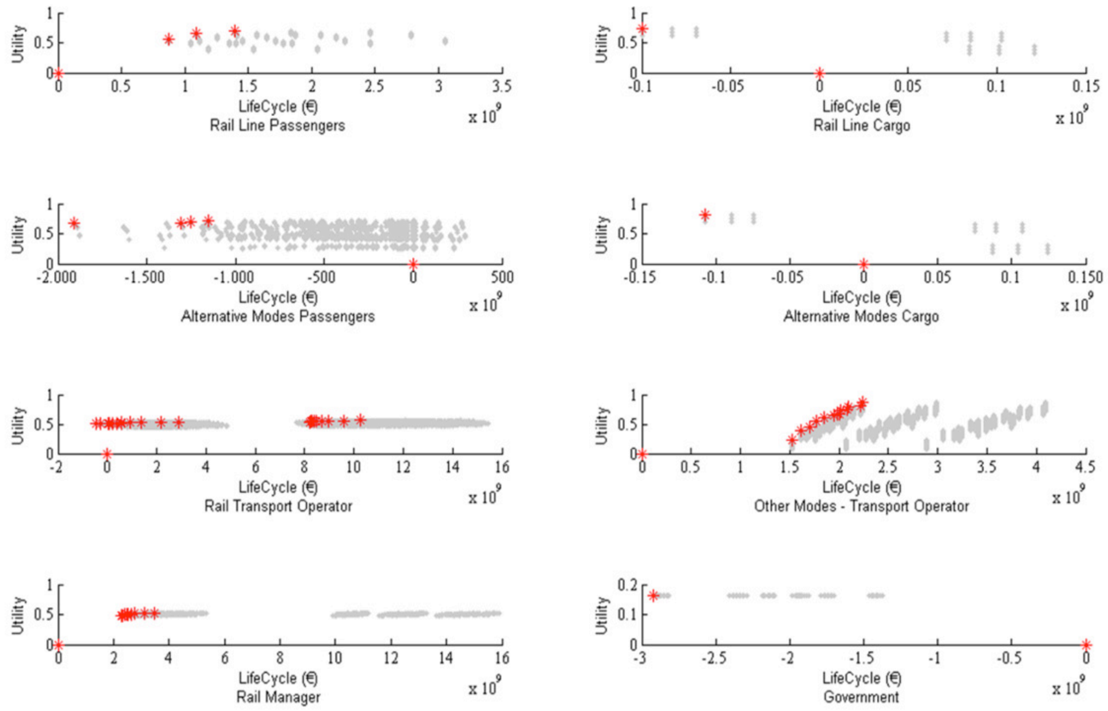

Figure 4 – Tradespace Result

Thus, in order to identify the best common solution, a relaxation of the stakeholders' objectives needs to be assumed. That is, stakeholders are willing to reduce their expectations and to consider good solutions that are not included in the Pareto front.

This relaxation is done according to a translation of the Pareto front curve for all stakeholders until a common solution is found. The translation is described by a value K that represents, in percentage, the difference between the utility in the Pareto front and the utility in the Translated front. The K value is obtained through a step-wise process according to the following steps:

1. Adjust a second order polynomial function to the Pareto front of each stakeholder. For the case study of the Lisbon-Madrid line, these functions, called Pareto curve, fitted well with the solutions founded in the Pareto front, with determination coefficients (R^2) higher than 0.868 for the different stakeholders.

2. A value of K equal to 0 is initially assumed.

3. Increase the value of K in 0.01.

4. Relax the second order polynomial function by assuming a translation of the Pareto curve in K%, representing a loss of utility in the same magnitude.

5. Collect each non-efficient solution within the solution area between the Pareto curve and the curve corresponding to the K% relaxation - Translated front.

6. Compare the non-efficient solutions of each stakeholder.

7. If common solutions exist for all stakeholders, the search stops and the common solution is assumed to the best solution that represents the best design option regarding all stakeholders' preferences. Otherwise, return to step 3.

RESULTS DISCUSSION

In this section, the results obtained from the Lisbon-Madrid HSR line case study are presented and discussed. The discussion is split in two analyses. The first analysis considers the financial flow regarding the different stakeholders. The second analyses deals with the socio-economic effects, considered by the government as the final decision-maker, in the decision of (any) huge project.

Financial flow analysis

The financial flow analysis represents the project itself. The evaluation considers the difference between the net costs and benefits for each stakeholder. According to this, the stakeholders will be willing to support the project, if their net present value (NPV) returns positive (or not too negative).
The exploitation revenues are obtained by several taxes applied to the infrastructure, stations or cargo delivery, and this should face all the infrastructure investment or operations related with maintenance or overall costs. It is also determined a residual value for the infrastructure and rolling stock. No taxes are included in this evaluation, so the manager does not take into account the amortization amount. The operation revenues are obtained given the fare

revenue for cargo and passengers and all the costs are related to a line operation and the investments associated with the operation.

Table 3 presents the common solution obtained for the financial flow analysis, with the cost per stakeholder, the utility value and the loss of utility between the Pareto front and the common solution.

Table 3 –Financial flow analysis result

Stakeholders		Cost (10^8 €)	Utility	K	Δ
Users Rail Line	HS/MS	18.697	0.644	1%	-0.097
	Cargo	1.025	0.530	29%	0.208
Users Alternative Modes	HS/MS	-11553.483	0.608	11%	0.111
	Cargo	1.075	0.660	19%	0.151
Transport Service Operators	Rail Operator	125.360	0.501	10%	0.054
	Other Modes	34.943	0.449	2%	0.069
Infrastructure Manager	Rail Manager	42.014	0.503	1%	0.010
Government (financial appraisal)		-28.964	0.163	1%	0.000

Frequency (#)			
HS	MS Pt	MS Sp	Cargo
13 ≈	6 ↑	14 ↑	3 ↓

	Fares (€/X.km)		
	HS	MS	Cargo
	0.1390	0.0664	0.0583
Δ Fare	0%	-20%	0%
Δ Demand	0%	9%	0%

Rate (%)
2%

The common solution found, the Users of the HSR line Cargo Service and the Alternative Cargo Modes are the ones that have to sacrifice their goals, with an objective relaxation (K) of 29% and 19%, respectively. According to this solution, the fare charged to MS services should be the lower value to increase demand and turn the service more profitable. The HS frequency has a reference value of - 13 services per day, according to Rave/Refer (EPYPSA and EXACTO 2011), but all other passenger frequencies should increase. Regarding cargo, the model assumes that the reference result is too high – 6 services per day, and frequency should decrease – 3 cargo services per day. The rate applied to the value that is to be paid regarding the use of the track, rolling stock and terminals is 2%.

Socio-economic analysis

The socio-economic analysis is determined by comparing the differences between the investment flows, costs and benefit. Thus, compare what project offers to the society and the cost that are necessary to accomplish.
In the socio-economic evaluation, all the investments done in the infrastructure and in the rolling stock, as well as the exploitation cost, are obtained by an adjustment of financial evaluations through the Table 4 values:

Table 4 - Adjust values (source: (EPYPSA and EXACTO 2011))

Infrastructure (Investment Cost)	0.70
Rolling Stock (Investment Cost)	0.70
Infrastructure (Maintenance)	0.70
Costs related with sales	0.70
Cost related with passengers	0.88
Cost related with time	0.70
Cost related with travel	0.82
Other costs	0.82

The socio-economic analysis of the project is the difference between the social benefits (and savings with regard to the total investment) and the project costs. To apply the socio-economic evaluation, the adjust values are only considered by the stakeholder government. Stakeholder government is on behalf of the whole of society, based on the social opportunity costs.
The focus is to evaluate how the financial appraisal responds when the “price” environment changes. The evaluation only considers the stakeholder government, and pretends to evaluate the response behavior of the appraisal. The results are present on Table 5.

Table 5 - Socio-economic analysis result

Stakeholders		Cost (10^8 €)	Utility	K	Δ
Users Rail Line	HS/MS	21.907	0.576	1%	-0.290
	Cargo	1.025	0.530	29%	0.208
Users Alternative Modes	HS/MS	-9715.540	0.570	20%	0.214
	Cargo	1.075	0.660	19%	0.151
Transport Service Operators	Rail Operator	110.640	0.515	8%	0.039
	Other Modes	36.646	0.637	1%	-0.294
Infrastructure Manager	Rail Manager	34.600	0.494	5%	0.028
Government (socio-economic appraisal)		96.800	0.454	1%	0.000

Frequency (#)			
HS	MS Pt	MS Sp	Cargo
11 ↓	1 ↓	14 ↑	3 ↓

	Fares (€/X.km)				Rate (%)
	HS	MS	Cargo		
	0.1390	0.0830	0.0583		
∆ Fare	0%	0%	0%		Rate (%)
∆ Demand	0%	0%	0%		2%

As can be seen in the design solution change, which is represents a different combination of solutions by the stakeholders. To reach the common solution, besides the loss-acceptance from Cargo supplier - Users and Alternative Cargo Modes (from financial flow analysis), all the other stakeholders are invited to relax their initial demands. Out of this group are the Passenger Users and the Government Stakeholder. With the adjustment prices the optimal fares to be charged are the same as referenced by Rave/Refer studies (EPYPSA and EXACTO 2011) for all the services related. Given this, the Frequency also changes, and as can be seen in Table 5 the minimum values of the frequencies range (Table 1) for HS services (11 passenger services per day) and MS services (1 passenger service per day) inside Portugal are selected.
The rate applied to the value of pay regarding the use of the track, rolling stock and terminals is 2%, as in the financial flow analysis.

Discussion

Besides all the adjustments done for all stakeholders in order to find a common solution, a remark should be added to Cost results. Comparing Table 3 and Table 5, it is notorious that besides Fares and Frequency differences, the Cost addressed by each stakeholder should be discussed. Even the loss-acceptance for the stakeholder Government being 1% (K), the final cost is a benefit as shown on Table 3 and a cost in Table 5. The result from Table 3 case just takes into account “good” externalities - Safety/Accidents or External Effects. On the other hand, Table 5 case considers the social opportunity cost to be implemented in the studied rail solution. Nevertheless, the cost trends for all the other stakeholders remain similar. The stakeholders’ adjustment, regarding the introduction of the concern "loss of acceptance", between Table 3 and Table 5 cases, reveals the main differences for the approach behaviors, dealing with the project contribution to society (Table 5 case) instead of just to the owner (Table 3 case).

CONCLUSIONS AND RECOMMEDATIONS

The methodology applied is the one that allowed the analysis of the available data and the fusion of the perspective of multi-stakeholders involved in a decision process. The work done addresses the feasibility of the introduction of cargo on the operation of this line, assessing the costs throughout different phases, in order to contribute to a more conscientious decision-making process. With this, it is expected to have an answer to the options done (not only to the past decisions but also to some future strategic options), in the Lisbon-Madrid rail connection.

The results show that this model can be adapted to different cost-benefits analysis or appraisal methods and answer positively regarding the changes. The assumptions made by each stakeholder can be modified or even adapted during the life-cycle and are determinant for the final design solution.

Regarding cargo, the approach is formulated in order to always consider cargo. On previous formulations, it was considered the option “do minimum” (in which cargo frequency option is equal to zero), and the answer has always considered the cargo service as a real option. Cargo shows to be a plus on the project appraisal.

Some improvements could be implemented to the analysis, namely:

1. With respect to the stakeholders involved, there are some other attributes that could to be considered and have not been taken into account at this stage. The travel comfort measure and the timetable convenience are some of these attributes.

2. The extending of the analysis to other considerations regarding stakeholder' opinion during the life-cycle time. Thus, given the economic evaluation of the financial environment could modify the stakeholder opinion.

3. The evaluation of new scenarios consideration, mainly the new framework defined by the Portuguese and the Spanish governments, in which they have to face the economic crisis, or consider different types of subsidization.

4. Analysis of the impact of adding cargo directly from Sines seaport in Portugal.

5. Applying this approach to other means of transport and integrate it with a more detailed Cost-Benefit analysis.

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