ASSESSMENT OF THE INTRODUCTION OF FREIGHT TRAFFIC ON A HIGH SPEED RAIL LINE

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ABSTRACT

High speed rail (HSR) investment does not only saves time but also increases the capacity for passengers and freight by providing capacity itself and by freeing existing routes. In those routes characterized by serious bottlenecks, the opportunity to upgrade the existing services is a factor which may well increase the added value of high speed rail. At this time, railway freight transportation presents one of the biggest demands on the competitiveness of many industries and the economy of European countries.

The introduction of freight-rail services in the Lisbon – Madrid HSR line will propose new trade markets and new commercial opportunities. The freight-rail systems could provide significant public benefits by cost-effective transportation that is vital to national economic development and sustainability, reducing truck travel congestion and highway costs, providing a critical intermodal link for a very specific international trade, and contribute to improve air quality and fuel efficiency.

This paper proposes a methodology for estimating the feasibility of having cargo on HSR Lisbon-Madrid line, involving the connection to sea ports locate at the south coast of Portugal and to the logistic platforms that serve the objective. It is based on a fleet model tool capable of generating scenarios to support strategic options on the high speed rail line. This procedure will allow the identification of preferences and concerns from the most important stakeholders involved and evaluate the scenarios through different eras, improve or change their preferences and include or modify the initial scope of the project.

The main idea is to prove that this investment in freight-rail services could provide a critical link in the national intermodal freight transportation system, serving not only trucking and maritime shipping industries, but also supporting the Portuguese intermodal trade and global competitiveness.

Keywords: high-speed rail, freight-rail service, Lisbon-Madrid connection.

INTRODUCTION

The ability of using rail to differentiate deliver services has become a strategic weapon rather than an operational tool in the new competitive rail environment. Improving service quality has become a more important issue to the railroad industry in the era of regulation. This became an important demand in order to attract not only passengers but also new market shares.

The high speed rail investment does not only save time but also increases the capacity for passengers and, is hoped, for cargo. The demand for introduction of cargo-rail services in the Lisbon-Madrid HSR line, should frame in the Portuguese Development Plan of National Logistical Facilities. In this direction, it will be possible to improve rationalization on logistic activities, contribute to planning and raise attractive conditions for new markets. It will promote interchangeability, valuing the existent network and structures in order to expand the rail cargo market. It is expected that the new possibility promotes environmental gains and contributes to the national economical development, generating employment and wealth.

This paper proposes a methodology for estimating the feasibility connection between the main sea ports, logistical platforms, roads and the conventional rail with the new HSR line Lisbon-Madrid. It is based on a model/tool capable of generating scenarios to support strategic options during the life cycle time of the infrastructure, helping the decision makers to establish the investment prioritization.

GENERAL PROJECT OVERVIEW

The discussion about the economic benefits of high-speed rail investment and the opportunity of devoting public funds to its development is usually too imprecise, based on economic development arguments, common to the literature on infrastructures and growth (Gramlich, 1994). Decisions to build HSR lines are taken, in general, without any clear overall plan (Vickerman, 1997). Besides, the Trans-European Transport Network program suffers from problems of moral hazard, given the mixed financial responsibilities and the presence of non-economic objectives (Sichelschmidt, 1999). A truth must be underlined: the economic benefits of the construction of a new high-speed rail are very sensitive to the volume of demand (Rus & Nombela, 2007).

The high-speed train is a technological break-through in passenger transport which has allowed increasing railways to share on a split modal, catering to medium range distances (in the range 200-700km), and competing with road and air transport.

The development of high-speed rail in Europe has been encouraged and financially supported by the European Commission. High-speed rail technology is basically presented as a solution to congested roads and airports (Rus & Nombela, 2007).It can be add that investing in the high-speed rail is faced as one of the front lines actions to revitalize the railway option. The ultimate objective is to change modal split in passenger's transport, with the aim of reducing congestion, accidents and environmental externalities (Rus G. d., 2008).

And what about cargo? Until now cargo was not a target revenue segment for high speed rail. It has been seen as a secondary strategy. In fact, there are serious operational

constrains when conventional cargo trains are evaluate to be introduced in a HSR line, namely in terms of track maintenance and safety for HSR passenger trains. This work wants to evaluate if this vision could have a feasible alternative improving investment return of the HSR implementation. The design of a railway network from scratch is impossible in a historical grown infrastructure, but due to high-speed trains, new stations, capacity extension and reduction, the railway network are changing (Bussieck, Winter, & Zimmermann, 1997).
It is expected that Lisbon-Madrid connection (figure 1) could work as the backbone of all the transport infrastructure design for this alignment. In this way a good articulation between conventional line roads, intermodal freight facilities, sea ports and even the new airport will be, more than expected, required.

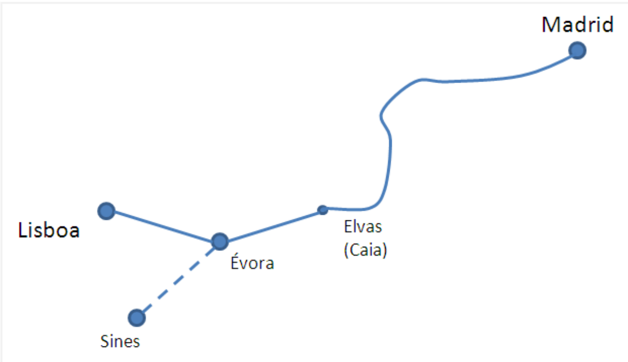

Figure 1 – Lisbon – Madrid link

With this new perspective of investment it will be possible to contribute to a more efficient distribution both of goods and passengers. The Lisbon-Madrid connection has been modelled to have a travel time of 2h45m for direct connections between the two capitals. The extension of the project will be 640km, 203 of which will be inside Portugal.
The lifecycle investment will be made over a period of 40 years and this includes the project, construction, financing, maintenance and prevision of all rail infrastructures.

SCOPE OF THE PROJECT

Railway infrastructure is a large and complex system with a long useful life. Therefore, once installed it is very difficult and costly to modify the initial design. Thus the performance of the infrastructure depends on the initial project preparation and design together with maintenance and renewal decisions taken during its lifecycle. Responsibilities for parts of the railway system are often handed over to different actors. In order to guarantee an optimal long-term result for the railway system, the effects of decisions taken should be systematically evaluated (Zoeteman, 1999). So, it is mandatory that all perspectives (pre and pos operation) are evaluated in order to better serve demand and improve investment efficiency.
In that direction, the main idea of this project is to prove that the investment in cargo-rail services could provide a critical link in the national intermodal freight transport system,

serving not only trucking and maritime shipping industries, but also supporting the Portuguese intermodal trade and global competitiveness.

This intermodal trade could be done with high add-value markets, such as the Spanish Extremadura, the Autonomous Community of Madrid or even more distant markets.

In order to allow the feasibility of cargo introduction in a HSR line, this project considers two main pre-establish analysis conditions:

1. The rolling stock required for cargo delivery will have similar characteristics as passengers rolling stock chosen, as well as the load per axel and the traffic load (tonnage) running on the line (Profillidis, 2006) – which are critical factures for track and subgrade fatigue control and all the maintenance aspects of the line.

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

MULTI-ATTRIBUTE TRADESPACE EXPLORATION AS ANALYSIS TOOL

Multi-Attribute Tradespace Exploration has been applied to several aerospace case studies in the past several years. Ross (Ross A. , 2006) described the application of MATE to several satellite conceptual design studies. Spaulding (Spaulding, 2003) discussed the application of MATE to analyze evolutionary acquisition for a space-based radar system. Derleth (Derleth, 2003) applied MATE to a small-diameter bomb design problem. McManus (McManus & Schuman, 2003) discussed a case application of MATE to a space tug satellite. Nevertheless, MATE may be applicable to other domains, such as transportation, with some enhancements, and these applications are currently being explored (Nickel, Ross, & Rhodes, 2008). This project aims to be part of this progress.

Multi-Attribute Tradespace Exploration Applicability

The motivation for this research was followed by the discovery of the MATE (Multi-Attribute Tradespace Exploration) method and its applicability in the development process for several type of products and situations. The MATE method has been then selected for the purpose of identifying the preferable options for this type of HSR study.

The method classifies the options into a ranking and allows for the establishment of a trade-off between countable numbers of criteria and to understand the space of possible solutions in depth. This knowledge is useful not just for finding the best solution, but it is to be used to make the best decisions according to a range of options.

The MATE process itself can be described (Ross & Hastings, 2005) as a process with the following steps:

1. Need identification;
2. Architecture-level exploration and evaluation;
3. Design-level exploration and evaluation;

The goal of the method (figure 2) is to create a system that fulfils some of the needs as well as need while efficiently utilizing resources within some context. The context surrounds the entire endeavour, including the roles of participants and their domain influence. The Stakeholder role includes influence over the definition and evaluation of the needs. The Funder role includes influence over the allocation of the resources. The Decision Maker role acts as the gatekeeper of needs and resources, determining whether to pursue a system development effort. The Design role includes influence over the definition of the system, while efficiently utilizing resources and fulfilling needs, as determined by the Decision Maker (Ross A. , 2006).

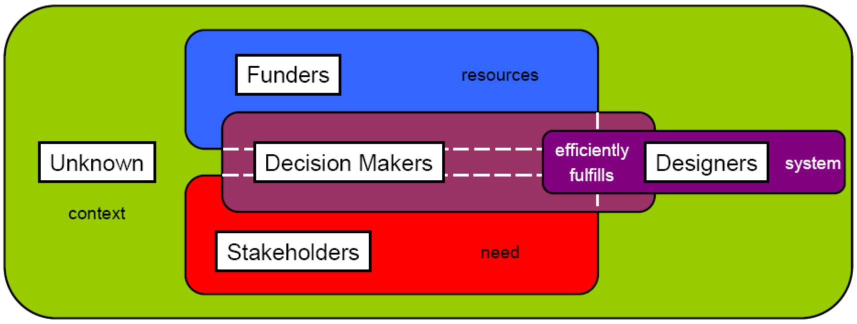

Figure 2 - The goal of design (Ross A. , 2006)

MATE approach has been seen as an important area of ongoing research. With this methodology it is possible to define and improve all important preferences and concerns from the different stakeholders. Improve or change their preferences through the project and include or modify the scope of the project. Tradespace analysis may be used as a quantitative tool in order to evaluate benefits, cost, and risk of alternatives chosen but also technical capabilities. This tool will also be useful to explore the implications of policy uncertainties and changing value perception.

Stakeholders

Defining the stakeholder concept, according to Sussman (Sussman, 2000), is stressing that stakeholders are organizations and individuals that may not be users of transportation, explicit suppliers of service or goods to transportation organizations, but vitally concerned with transportation enterprises and their operating and investment practise. Another assumption according to the same author is that the general public is in a very real sense, a stakeholder in the transportations enterprise. There is a relationship between transportation and economic development and quality of life – all interests are of great interest to the general public. So, to a greater or less extent, everybody is a stakeholder in transportation.

In Portugal following the usual European framework various interest groups may be involved in decision-making related to the development and implementation of a HSR transport system. In general, these may be users (passengers), system operators, the public, semi-public and private investors, policy makers at local (regional), national (country) and international (European) level and local community members. All these groups may hold different preferences and different objectives with respect to the performance of particular high speed systems. Investors in transport infrastructure (public, semi-private and private), and manufacturers of rolling stock, guidance and control systems, facilities (as Terminals) and equipment, may expect different (higher or faster) returns of investment. Further, policy-makers at different levels may expect a contribution to global improvement in the efficiency of the transport sector and the economy in general, whereas community members may expect local socio-economic benefits nearby their homes, such as new jobs and improved spatial accessibility in the region where they live in.

Besides that, each railway activity must be examined in relation to its internal and external environment. The whole organization of railways must be characterized by the principle of adaptability that is the ability to be adapted at changing situations (Profillidis, 2006) of its internal and external environment (figure 3).

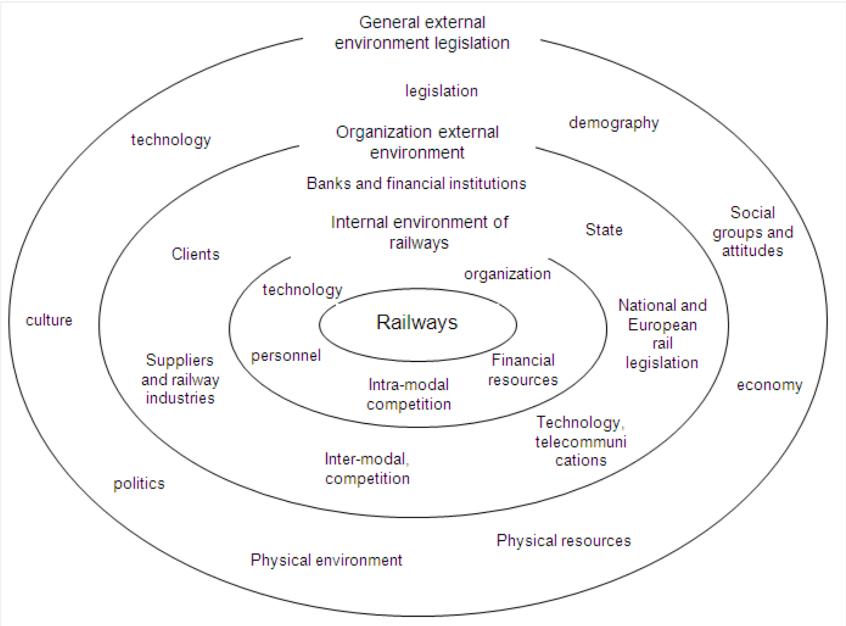

Figure 3 – Railway environment (Profillidis, 2006)

Planning issues for cargo transport in a HSR line

The planning process stared with the definition of the routes and lines of the railway network. Improving services quality has became a more important issue to the railroad industry nowadays. To attract customers, regular services routes connecting stations had to be guaranteed. Assignment and dispatch of locomotives railroad carriage, and personal became more and more involved. These days, the number of passengers transported has been increasing (Claessens, van Dijk, & Zwaneveld, 1995). On the other side, public freight transport on the rails is decreasing, due to trucks which provide much more flexibility for the transport management.

However, this project wants to evaluate in what conditions it is possible to introduce cargo delivery in a HSR line and for this, several circumstances must be taking into account.

In general, public transport companies offer several railroad subsystems to meet the requirement of the costumers (Bussieck, Winter, & Zimmermann, 1997). This railroad will be exclusive for the rolling stock, chosen due to its singular characteristics. Although, the set of stations where a train should stop has to be determined, in order to satisfy the commuter trains operation on the railroad network. This decision is based on technical constrains as well as on an economical and political analysis.

Planning freight transport is different of planning passenger transport. Models from passengers transport are of limited use, since they are based on quite different assumptions. The usually shared railroad network has to be planned according to the respective needs. Apart from the relatively small amount of freight trains directly connecting the origin with the destination, trains have to be split and cars have to be regrouped according to their final destination at intermediate marshalling yards (Bussieck, Winter, & Zimmermann, 1997).

Shippers have become more sensitive to the logistics-related costs and they now require transportation services that can improve their logistic process to the supply chain. In this way, different shippers have different services requirements, and the railroad needs to design and deliver different service products for them. Some shippers require fast and highly reliable services and may accept a higher price. Other shippers require less costly services and may accept slower and less reliable moves (Kwon, Martland, & Sussman, 1998). Such heterogeneity of traffic, needs to be considered in order to built trip plans sensitive to the stakeholders involved in this process.

The development of this scheduling system was initiated by the Missouri Pacific Railroad and consisted of four components: define and control operations, trip generation, establish field viability of the trip plan and support information requirements. According to this model, trips plans are generated based on some heuristic procedure such as (Railroad, 1977):

1. The generation of a trip plan begins by determining the yard block for the car;
2. Once a yard block has been selected, a list of trains which carry that block is identified;
3. Car scheduling assigns car to be the earliest candidate train that the car can make;
4. Once the appropriate candidate train has been selected, car scheduling repeats this trip plan generation process from the location where the train will set out the car's block until the complete trip plan is generated.

This scheduling model was upgraded by Kwon (Kwon, Martland, & Sussman, 1998), and it is a dynamic car routing that incorporates heterogeneity of traffic, traffic variability, and train capacity restrictions (length and weight) so that it produces trip plans that are more sensitive to service requirements of stakeholders. Figure 4 shows the dynamic car scheduling scheme.

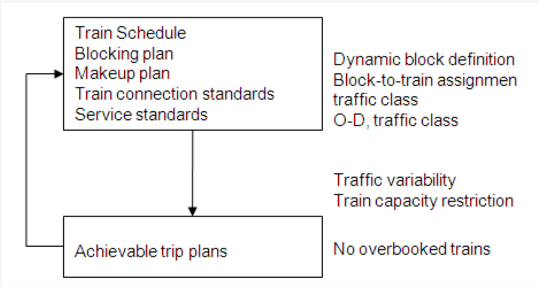

Figure 4 – Dynamic car scheduling (Kwon, Martland, & Sussman, 1998)

Attributes

In order to model this project it is necessary to have resources. These resources are the concerns, expectations and objectives that stakeholders have regarding this project. They should be explicitly determined through interactions with their decision makers. The stakeholders have the experience and the feel required to evaluate the best option and strategies. In this way the veracity of the system will be more representative of the reality.
Each decision-maker has a set of objectives. In this case study, a metric for meeting objectives will be called attributes. An attribute (Ross A. , 2003) is a decision maker-perceived metric that measures how well a decision maker-defined objective is met. According to the same author, the characteristic of an attribute includes its definition, units and range from least to most acceptable values.
Due to the fact that this is a transportation study, decision-makers have a massive list of objectives, multiple objectives, and therefore a set of attributes. Keeney and Raiffa (Keeney & Raiffa, 1993) defined the attribute set as complete, operational, decomposable, non-redundant, minimal, perceived and independent.
An example set of attributes for this study are exposed in table 1:

Table 1 - Attributes

Attributes	**Definition**	**Range**	**Units**
Total Project Cost (1)	Total cost of the engineering, planning, infrastructure, construction, stations and border connection from Lisbon–Madrid.	$[8\text{-}30]*10^6$	€
Portuguese Cost Share	Share of project cost that Portugal has to allow.	[40-100]	%

EU Cost Share	Share of project cost that the EU will provide to this link	[5-50]	%
Spain Cost Share	Share of costs related to the border connection provided by Spain.	[30-35]	%
Private Investor Contribution	Contribution given by the private investors to this project. The financial support will be shared with some private investors.	[45-70]	%
Maintenance Cost (2)	Maintenance cost per kilometre	[30-35]*10^3	€/km
Operation Cost (3)	Operation cost per kilometre	[18-43]*10^6	€/km
Net Travel Time	Travel time without stops	[38-384]	Min
Number of Stops	Total number of stops	[3-8]	#
Overall Travel Time (Passengers)	Overall travel time related to passenger trains	[0-10]	Min
Overall Travel Time (Cargo)	Overall travel time related to freight trains	[0-30]	Min
Level of Coordination	Quality of coordination related to the border connection. The scale runs from the least amount of coordination (1) to a friendly and cooperative atmosphere between the Portuguese and Spanish side (5).	[1-5]	
Max Throughput	Maximum load possible to travel per day in the entire line		ton/day
Max Capacity	Maximum capacity for passengers per day		pass/day
Loads Transference	Ease of transference cargo from the train to trucks or from the intermodal freight facilities. 1 means the difficulty to load/unload and 5 is the best scenario with perfect conditions to transfer.	[1-5]	
Risk	Associated to the private investors. Denotes the best or worst ability to invest their money in this project.	[1-9]	
Safety (4)	Level of risk applied to this mean of transport	[1-5]	

From table 1 several notes could be assigned:

1. Cost can be defined as the amount of available resources spent in conjunction with the construction or operation of a railway activity (UIC, 1988). The definition of cost in this high speed rail line will be referred either to the construction of a line and called construction costs or to the operation of a railway service (passenger, freight, terminals), and these are called operation costs. It is necessary to take into account that there exists a separation of infrastructure from operation. So the infrastructure cost is the sum of track costs pertaining to the provision and use of the track, including the cost of maintenance and operation: cost pertaining to subgrade, ballast, sleepers, rails, signalling, telecommunications, electrical traction installation, lighting, police inspections, as well as to station installation and staff needed to work the infrastructure (UIC, 1988).

2. Total Project Cost (1) - The construction cost of a new high speed rail line are marked by the challenge to overcome the technical problems which avoid reaching speeds above 300 km per hour, such as roadway level crossing, frequent stops or sharp

curves, new signal mechanisms and more power electrification systems. Building new HSR infrastructure involves three major types of costs: planning and land costs, infrastructure building and superstructure costs (UIC, High Speed Rail's Leading asset for customers and society, 2005). To do this evaluation it will also be considered costs related with the construction of feasible connections to the sea port of Sines, sea port of Lisbon or the freight logistic platforms display in the line corridor. These platforms will act as a connector between road and rail systems. It is also necessary to consider stations and the strategic bypasses through the line.

3. Maintenance and Operating Costs (2)(3) - The operation of high speed rail services involves two types of costs: infrastructure maintenance and operation costs, and those related to the provision of transport services using the infrastructure. Operating costs includes costs of labour, energy and other material consumed by the maintenance and operation of the tracks, terminals, stations, energy supplying and signalling systems, as well as traffic management and safety systems. Some of these costs are fixed and depend on operations routinely performed in accordance to technical and safety standards. In other cases, as in the maintenance of tracks, the cost is affected by the traffic intensity. Similarly, the cost of maintenance, electrical traction installation and the catenary depends on the number of trains running on the infrastructure. The operating cost of high speed rail services vary across rail operators depending on the specific technology used by trains and traffic volumes (Rus G. d., 2008a). Inside maintenance and operation costs is also necessary to include and differentiate actions related with cargo and with passengers. Related with cargo, the main differences will not be the loads but the use of the railroad in a more demanding form (higher number of trains per day).

4. Security (4) – The safety level of rail transport is far higher compared to other transport modes. According to International Organization for Standardization (ISO), safety can be defined as the release from unacceptable risks, a risk being a combination of harm probability and of gravity of harm (Hadi-Mabrouk & Triki, 2003). In the railway sector, the risk can be defined in relation to the events that damages safety (fatalities or injuries of passenger or employees) or transportation stability (delay) (Profillidis, 2006).

After the attributes have been determined, the utility function, which captures the perceived value under uncertainty for each attribute, can be elicited. The single attribute curve is shown, in figure 5, it represents the single utility curve for the number of stops.

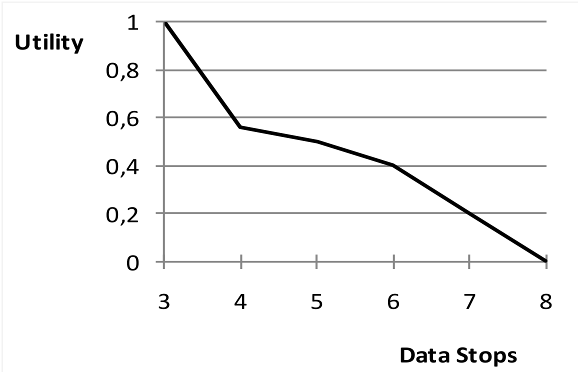

Figure 5 – Single attribute utility curve

These curves will translate the stakeholder's expectative regarding the attributes according to the project evaluation.

A multi-attribute utility function can be formed, aggregating the single attribute utility values into a single decision metric (Ross A. , 2006). In order to calculate it, Keeney and Raiffa (Keeney & Raiffa, 1993) defined the multi-attribute function as:

$$KU(\underline{U})+1=\prod_{i=1}^{M}\left[Kk_iU^i\left(X^i\right)+1\right], \; where \;\; K+1=\prod_{i=1}^{M}\left[Kk_i+1\right]$$

and $U(\underline{X})$ is the multi-attribute utility function, K is a normalization constant, is k_i the relative weight for attribute X^i and $U^i\left(X^i\right)$ is the single attribute utility function for attribute X^i.

The multi-attribute utility value represents the satisfaction of a decision maker. These functions are defined over the range of 0 to 1. A utility value of zero corresponds to an attribute at its least acceptable level and a utility value of one corresponds to an attribute at its best level, beyond which no additional value is perceived.

Design Variables

According to Ross (Ross A. , 2006) a design variable is a designer-controlled quantitative parameter that reflects an aspect of concept, which taken together as a set uniquely defines a system or architecture design. The design variables are the key quantitative tradable parameters.

Some examples of design variables and its units are expressed in table 2.

Table 2 – Design Variables

Design Variables	Definition	units
Network Routing	Different route options that can be chosen	Discrete choice
Loads	Maximum load	ton/axle
Train Capacity	Technical specifications envisaged by the manufacture	Dependent on the

	and the specific internal configuration agreed with the buyer.	brand
Intermodal Freight Facilities	Better location regarding shipping and unshipping loads regarding trains and trucks.	Feasible Locations
Border Connection	International connection.	Articulation between two sides
Number of connections /stops	Number of stops and stations on the Portuguese line	[1…5]
HSR Link to Sines	Connection to Sines. If there is a connection it will be defined as 1, and 0 means conventional connection	[0-1]
Cost share Portugal	Project Cost supported by Portugal	%
Cost share Private Investor	Project Cost contributed by the Private Investors	%
Cost share operations Portugal	Portuguese cost related to operations	%
Rail Tarification	Charged paid by the users of the rail service	€

Epoch Variables

The system lifecycle is used to characterize the phases of a system during its lifespan, from initial concept to end of life. System lifecycle processes are beneficial to the designer for organizing the various activities required to design, develop, and operate a system. The system lifecycle is comprised of phases that have defined end points, but these are typically based on the resources available to complete a set of phase activities (Ross & Rhodes, 2008).

Epoch-Era Analysis is an approach for conceptualizing system timelines. The full lifespan of system is referred to as the System Era, which can be decomposed into Epochs. An Epoch is a period of time for which the system has fixed context and fixed value expectations. Each epoch is characterized by static constraints, available design concepts, available technology, and articulated attributes. Analysis of a design over many different epochs and multiple eras can help decision makers identify designs that are potentially value robust, and thus are desirable choices for more detailed design (Chattopadhyay, 2009).

Some examples of epoch variable types are listed below:

1. Policy changes such as the application of new regulations or laws.
2. Resource changes such as change in available funds for the system.
3. Infrastructure changes such as availability of additional system.
4. Technology changes such as future technical advances that can be utilized by the system.

These variables can be obtained from interviewing system stakeholders, from domain experts or from historical analysis of past context changes for similar systems. The epoch vector contains these epoch variables representing context and needs changes.

Some examples of the epoch variable chosen, for the first model approach are shown in table 3:

Table 3 - Epoch Variables

Epoch Variables	**Definition**	**units**
Demand level	Demand for cargo/freight	ton/year
Demand level	Demand for passengers	pass/year
Economic situation of EU/World	Economic scale: 1 denotes a global economic recession, shortage of capital, public investment are in fierce competition with each other. Level 5 the economy is booming and the public investment is available.	[1-5]
Portuguese Economy	Economic State of the Portuguese Economy. Level 1 denotes economic recession, shortage of capital, public investment are in fierce competition to each other. In Level 5 the economy is booming and public investment is available.	[1-5]
New Logistic Platforms	Open of new freight facilities (such as near Madrid)	[0-1]

During each epoch, in the system era path, analysis it can be conducted, utilizing an accessibility matrix generated by the tradespace exploration process. This process denotes which designs in the tradespace are reachable from another design that already exists in the tradespace by application of a transition rule (Ross & Hastings, 2006).
The use of Epoch-Era Analysis, as part of tradespace exploration, provides a means for the natural extension of static views to the dynamic view that is essential for designing systems for changeability.

Tradespaces

To develop the MATE scheme the notion of tradespace is fundamental. The tradespace analysis includes not only the space of the design but also the space of attribute trades.
The main objective is to find the highest utility at a given cost level. This is done through the Pareto frontier of solutions. The decision maker is allowed to decide the most appropriate trade off resource. As an example, it will be possible to know regarding all design variables how many stops will be required do to the design of the line or the financial resources.
A reasonable approach to comparing a large number of systems simultaneously is through a tradespace (Ross & Hastings, 2005). Figure 6 depicts the element that go into tradespace development. Typically during concept exploration, a number of system designs and concepts are considered and assessed in terms of cost and benefit (i.e., value) to decision makers. The design parameter set, $\{DV^N\}$, represents the physical degrees of freedom for the system and can be assessed in terms of cost to develop, C, through the mapping f_C: $\{DV^N\}>C$.
The attribute set, $\{X^M\}$, is a parameterization of value perceived by particular decision makers. Each decision maker specifies his or her own set with acceptable ranges, but whose specific values are derived from system designs being considered. The attributes can be aggregated in terms of value delivered to a decision maker through the concept of utility, U, with a function mapping f_U:$\{X^M\}>U$.

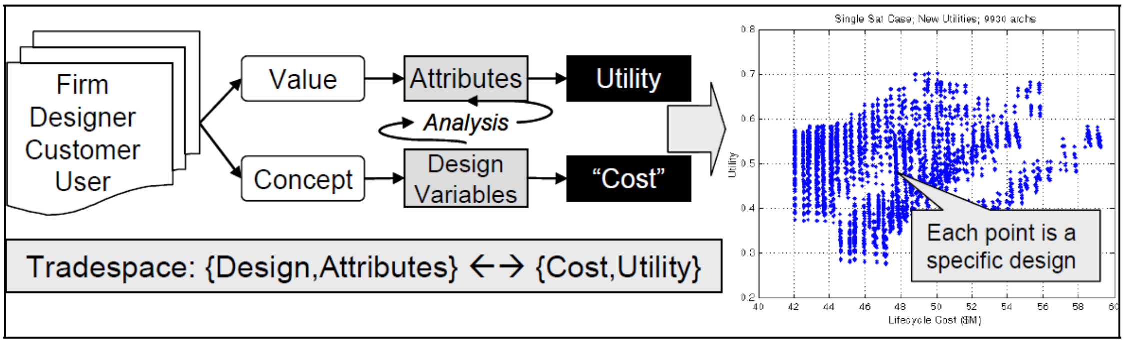

Figure 6 - Tradespace analysis (Ross, Rhodes, & Hastings, 2009)

This method is useful not only to find the 'best' solution but to find the 'best' decision about the set of alternatives in the study. The main value is that the stakeholders have the opportunity to give their true opinion about what they most care about and evaluate the design variable in the study. Figure 7 shows the utility-cost tradespace for a design.

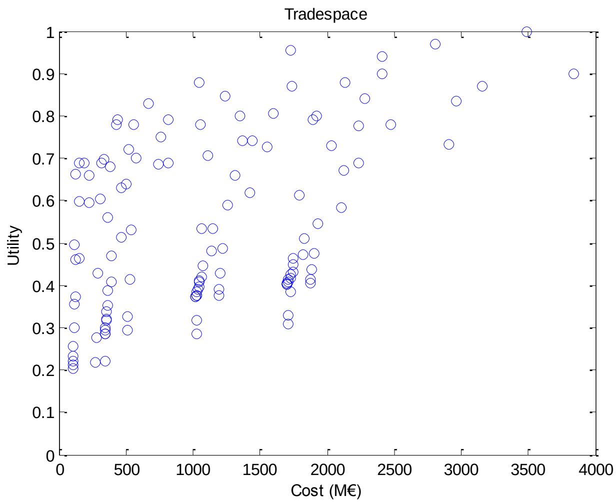

Figure 7 – Utility-cost tradespace

This design undertakes the feasible solution set. The feasible solution set may conversely contain solutions that meet or exceed the decision makers' needs. The tradespace may function as a communication tool between the analyst, designer, users and stakeholders. The typical tradespace plot displays the system design on a Utility-Lifecycle Cost space, showing the resources required (cost) and value delivered (utility) for the system in a concise format.

CONCLUSION

Life-cycle costs analysis is a process that involves structuring costs, but most of all assessing the costs of a product throughout different phases, in order to contribute to a more conscientious decision-making process. This paper present the description of a methodology applied to a life-cycle approach design for high-speed rail line. With this methodology will be expected to have an answer about the options done (not only the past decisions but also some future strategic options), in the Lisbon-Madrid rail connection.
In order to have real data management, it will be necessary to have real data from the stakeholders. This will be useful to create reference documents to be used by all those involved in the network management.
The fleet model tool based on MATE approach follows the idea of scenarios generation in order to obtain the “Best Value” based in a sensitive analysis (figure 8).

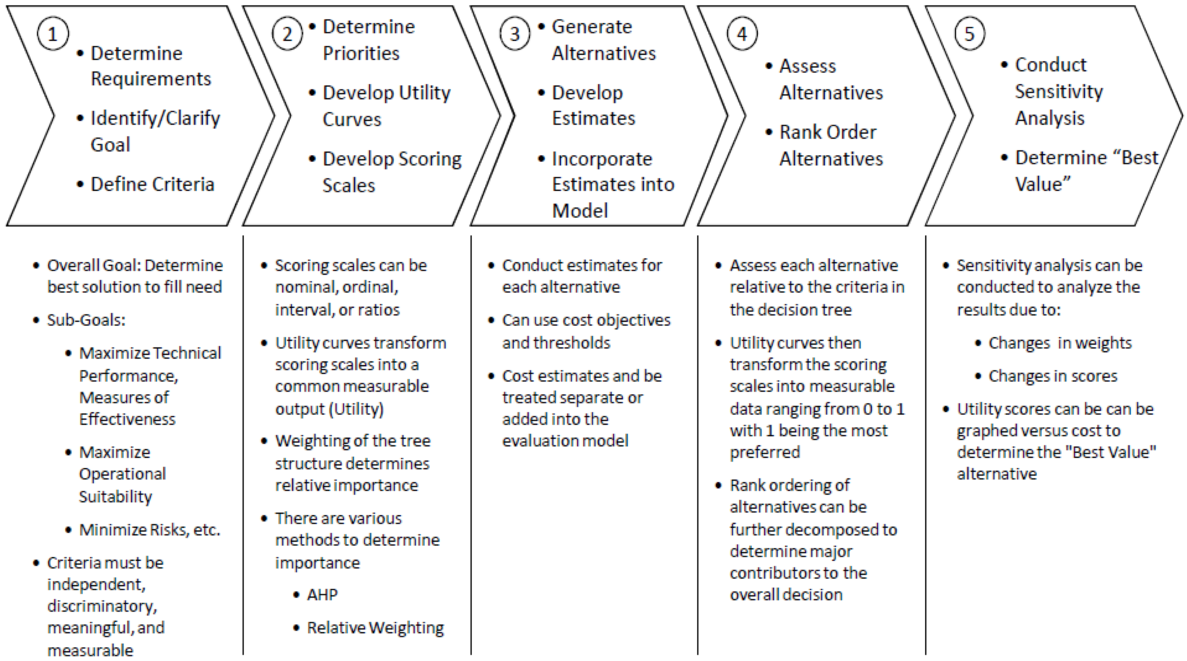

Figure 8 – Structure Process

The goal is to create a model that fulfils some need, while efficiently utilizing resources. This model includes not only the most properly stakeholders, funds and decision makers of the project, but also the operational and maintenance concerns supported by life cycle analysis.
It is expected that this fleet tool to be an efficient support to deal with strategic options in high speed rail investment (figure 9).

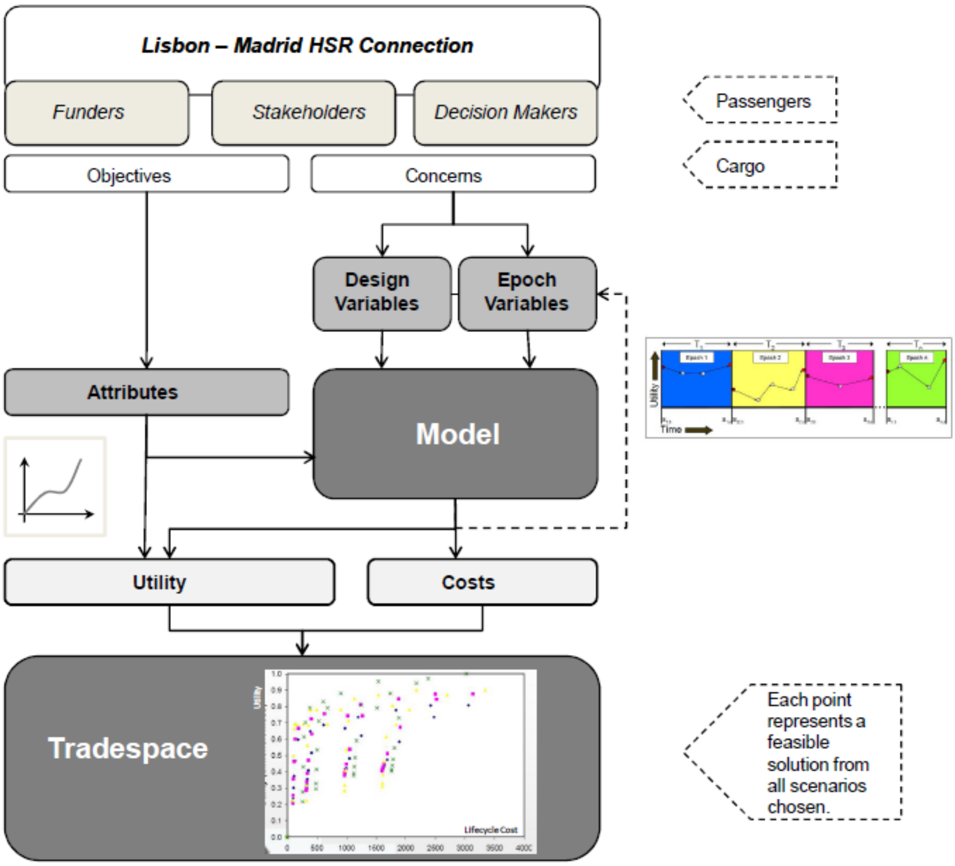

Figure 9 – Lisbon-Madrid high speed rail connection in MATE

The result will be the tradespace. There will be possible to find the best solution related with the best scenario in study. The scene includes all information concerning with stakeholders expectation, network model, state of the line and different changes that could occur during the lifecycle time of the high-speed rail connection between Lisbon and Madrid.

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