4. Methodology

4.1 Criteria for Apprising Urban Transport Projects

The criteria taken to evaluate Urban Transport Projects are based on the: *Relevance, Efficiency, and Sustainability* present in ach project. Starting off of these criteria it's appropriate to estimate the financial and economic rates of return, as well as economical and operational benefits, investment, operation and maintenance costs, demand and supply of each project.

Every project has it own characteristic that differences it from the others, but it has common characteristic as well; those characteristics allow establishing the differences between a viable project and one, which is not.

For the aims of this research an analysis of single variables and a combinatory analysis of variables seem to be the right ways to get to the objectives of elaborating the "UTP analysis tool".

The single variable analysis allows establishing the ranges of permissibility of values that can have a variable in a certain project compare to others similar. As the combinatory analysis will allow to determine which are the variables highlighting the project's relevancy.

4.2 Parameters for the Analysis

As already known the main objectives of an UTP, it must be considered the variables that could lead establish the viability of the project.

Each project financed by the EIB has a description paper called "Appraisal Report", in which is contained all the relevant information of this project. Usually these documents, The Appraisal Reports, contains from 20 to 25 pages, including a description, operational information, economical information, financial information and annexes (which include the layout of the route, sensitivity analysis, technical description, etc.).
Once having the appraisal report is easier to find the parameters that facilitate the evaluation of these projects in order to determinate their feasibility, but to seek every time trough 20 pages for each project to find information would take a lot of time.

Therefore it is adequate to elaborate some kind of document that could store all the needed information for the analysis. The description of the information and their modus to operate is described below:

a) *Project Identification*

Projects are like people, they need a card to identify themselves from the others projects. This ID contains:

- **Name of Project**.

- **Country** in which take place the project.

- **ID Number**, which is an eight digit number data that facilitates the identification of a certain project.

- **Description**. As its name implies, gives a short description of the project.

b) *Operational Information*

In order to guarantee a high quality service of transportation to its users, it must be known the following parameters in a UTP:

- **Project Technical Life**. UTP's are not going to be in function for ever, therefore it is very important to know the project technical life. Usually for LRT and Tramways projects this technical life is between 20 and 25 years, as for Metro projects it is between 25 and 30.

- **City Population**. It is necessary to know the population of a city in which is going to construct a UTP. This data is useful in the analysis of sensibility and to estimate the demand along the period of operation of the project.

- **Length of Route** of the project.

- **Demand**.
  - Annual Demand, is the number of passengers per year which are going to use this service
  - Daily Demand is the number of passengers per working day estimated to be transported.
  - Future Demand. It is useful to know the approximate demand that the project will have along it technical life.

    *Dx = Demand/Year + (X * Population Growth Factor)*

    Where: Dx = Demand in the requested year.
    X = years from the actual date.

    The population growth factor is information usually given by the Promoter.

- **Supply**:
  - Capacity per Train. It is necessary to know the number of car per train (usually in tramways/LRT there are two cars per train and in Metro projects from 3 to 6 cars per train) to set up the total number of passenger seated and standee per train. UTP's usually consider from 4 to 8 standee passengers per square meter, for this analysis *6 pax/m²* is going to be assumed.

- Peak Hour Capacity. This parameter gives the number of passengers per hour and per direction that are capable of being transported by the project.
- Annual Capacity. The number of the capacity that a project has to transport people annually is given by this equation:

  $$Cap/Year = (Hours\ Op.\ Day) \ast (Days\ Op.\ Year) \ast (Number\ of\ Trains) \ast (Train\ Capacity)$$

- Production Supplied is the indicator of kilometers per vehicles per year supplied to satisfy the demand.
- Headway. Is the Interval between train sets in peak hours.

- **Number of Trains** working in peak hour per day**.**

- **Days of Operation per Year.** Sometimes the administration gives the information. Other times it is calculated from this formula:

  $$250 < Demand/Year\ /\ Passengers\ per\ Working\ Day < 300;$$

  Where, 250 Days are the minimum and 300 Days are the maximum considered for this analysis.

- **Hours of Operation per Day.** Most of the time the administration gives the information, but when it is not given the assumption will be between *18 to 20* hours a day.

- **Employment.** Detail of the people employed:
- During Construction. The personnel per year need to execute this project.
- Operation Employees. The ones need to maintain a good service once the project is already in functions.

c) *Economical and Financial Parameters*

Not only in transportation, but also in every business, the economical and financial aspects are very important to analyze the viability of projects. As projects have different years of construction, it must be brought all the economical parameters to the date using the Inflation Index:

- **Year Base.** It is important to know the year base of cost in order to establish the real economical terms to the present.

- **Inflation Indicators.** Very important to know the index of inflation actualized in order to know current numbers. For the rates used in this work, *see Annex II of Inflation Indicators per country*.

- **Loan Approved.** The Loan that the EIB conceded to the project.

- **Costs:** The structure and distribution of cost of the urban transport companies have been evolving since the beginning.

- Total Investment Cost. The total price of project at the time of the inversion.
- Project Unit Cost. Cost per kilometers of projects excluding the Rolling Stock.
- Rolling Stock Unit Cost. Cost per Unit and Cost per Place.
- Operation and Maintenance Cost. Cost per year and cost per vehicle kilometer crossed.
- Total Cost of Project. The cost of the project during its technical life

- **Benefits**
  - Project's Benefits. The earnings of the project during its technical life
  - Value of Time. Economical mean of the value earned versus the other modes of transportation.
  - Time Gains. Minutes saved per every journey versus other transport modes.
  - Time Savings. Information of benefits obtained respects other modes of transportation.

- **Operation and Maintenance Cost Cover Ratios** are difficult to analyze, as there are different dimensions to variations in the indicator. High cost coverage may be an indicator of insufficient maintenance, or disinvestments. Since it can be much higher on line with high patronage, networks with high cost coverage may also in effect be limiting services to those lines with the highest patronage. When the cost coverage in urban public transport is often low, is often a result of poor productivity in terms of productions cost, very ambitious supply patterns and extremely low fares.

- **Fares.** The fact of consider the Public Transport as a multimode service has originated the reframing of the fare systems for the users, the type of transport title, the validation methods of the titles, and the distribution of the incomes by the administrations operating the system.
  - Single Fare Ticket is the price of a single ticket per passenger.
  - Average Revenue is the average price per passenger of the project. Usually when the project is working under an integrated fare system the average revenue is lower than other cases, and often in the cities there are temporary or multi – journeys tickets that are less expensive per journey than the single one.

- **Economic Rate of Return (ERR).** Efficiency is typically measured by a project's ERR, although in the evaluated projects this does not capture all projects benefits.

- **Financial Rate of Return (FRR).** The revenues reached by the project give the FRR. It is important to emphasize that most of the time Urban Transport Project does not achieve a positive Finance Rate of Return, and the existing gap between the obtained FRR and the Real Cost has to be covered; usually it is covered by the administration.

- **Actual data.** Actualized to year 2004 to compare projects in the same scenario:
  - <u>Investment Cost 2004:</u>
    Investment Cost * (100 + Inflation Rate)/100
  - <u>Project Unit Cost 2004:</u>
    Project Unit Cost * (100 + Inflation Rate)/100
  - <u>Special Work Unit Cost 2004. Formula:</u>
    Special Work Unit Cost * (100 + Inflation Rate)/100
  - <u>Rolling Stock Unit Cost 2004. Formula:</u>
    Rolling Stock Unit Cost * (100 + Inflation Rate)/100
  - <u>Demand 2004</u>. Usually obtained from the information given by the promoter or from the interpolation between year base Demand and D10 or D20.
  - <u>Single Fare Ticket 2004. Formula:</u>
    Single Fare Ticket * (100 + Inflation Rate)/100
  - <u>Average Revenue per Passenger 2004. Formula:</u>
    Average Revenue * (100 + Inflation Rate)/100
  - <u>Operation and Maintenance Cost 2004. Formula:</u>
    M & O Cost * (100 + Inflation Rate)/100
  - <u>Total Cost 2004. Formula:</u>
    Total Cost * (100 + Inflation Rate)/100
  - <u>Benefits 2004. Formula:</u>
    Benefits * (100 + Inflation Rate)/100

d) *Environmental Parameters.* Every UTP must have an Environmental Impact study to be approved; therefore it is necessary to include the conclusions of this study.

- **Environmental acceptability.** UTP's can be classified with an impact rating of A, B1, B2 and C letters, being the A the highest score and the C the lowest environmental impact rating accepted.

- **Project's Risks.** Usually in projects of this spread and magnitude, they're always some kind of risk taken. This parameter allows rating these risks classifying them in *Low, Medium or High*. Usually the UTP's are in the low risk rate, and sometimes it can be found someone in the medium rage.

4.3 URBAN TRANSPORT PROJECTS' DATA BASE

Once established the parameters and variables that lead to make an appropriate evaluation of an Urban Transport Project, it is proper to collect all this information in a Data Base.

The parameters exposed above are classified into tables that will allow to a quick search of the variables of a project without spending much time seeking trough each project's document. The result of this classification is these three Data Base Tables:

1. *Tramways and LRT Projects Data Base* is a Table that contains five subgroups (Project Data, Operation Data, Cost/Benefits Data, Economical/Financial Data and Actual Data), which display the information necessary to make the analysis of a certain project. See *Annexes III* for Tramways and LRT Data Base Tables examples.

2. *Metro Projects Data Base* is really similar to Tramways and LRT one, with the particularly difference that the main unit of analysis here is per car and not per train like the one above. In the similarities remark the existence of the five subgroups too. See *Annexes IV* for Metro Data Base Tables examples.

3. *Environmental Impact Studies Data Base*, as the two tables before the aim of this DB is to group the parameters taken of the appraisal reports in order to have access to them easier and faster. It is a very simple table, which contains the environmental impact study rating, the project's risks and the summary of the study. For *Environmental Impact Study Data Base and Results see Chapter 5.3: Environmental Impact Analysis Results*.

4.4 ANALYSIS OF THE BASIC PARAMETERS

4.4.1 Analysis of the Singles Variables

For the analysis of simple variables, for Tramways/LRT and for Metros as well, the aid of the Microsoft Excel software is required, which, through Tables of Values is capable of guiding to the obtaining of mathematical functions that allow reaching the goal results in this research.

The best way to determine if a project is feasible or not is to compare it performance with other projects financed before. Therefore the establishing of conditions with the purpose of compare the situation of the new projects respect others already financed is required.

To get to these conditions, we have to make an analysis with financed project establishing their mathematical characteristic using the following functions should be made:

a) The Arithmetical Mean, which is the average of "N" data values:

$$Mean = \frac{x1 + x2 + x3 + x4 + xn}{N-1}$$

b) The Median is the point of the scale that divides exactly by the half the values of de data. The median is the point of the abscissas axis, which divides the histogram in two equal areas.

c) The Mode is the most common value of the data; therefore, is the value that repeats more times.

d) The Standard Deviation (σ). First, the deviation definition has to be understood as: "The grade in which the numerical data tends to extend around an average numerical value", then the Standard Deviation would be the square root of the arithmetic mean of the squares of the data deviation respect to the average. Its formula is:

$$\sigma = \sqrt{\frac{[\Sigma\,(i=1,i=n)\,(xi - Mean)^2]}{N-1}}$$

e) The Relative Dispersion, which is measure by the *variation coefficient*, is the absolute dispersion (the Standard Deviation) divided by the average (the Mean):

$$Variation\ coefficient = (\sigma / Mean) * 100$$

The idea is that this coefficient would be the less possible that would indicate a low dispersion between the data value.

f) Asymmetry (As). There are 3 types of asymmetry in a distribution:
- If As = 0; the distribution does not have an asymmetry. Is perfectly symmetric.
- If As > 0; the distribution is asymmetric, and the asymmetry is positive (slightly to the left).
- If As < 0; the distribution is asymmetric, and the asymmetry is negative (slightly to the right).

As is given by the following formula:

$$As = \frac{Mean - Mode}{\sigma}$$

g) The Group Coefficient (Z) determines the percentage of the data that will be inside the range of the dispersion. Mathematically it is demonstrated that if:
- Z = 1 → approximately the 68,28 – 75 % of the data would be inside the range.
- Z = 1,96 → approximately the 95% of the data would be inside the range.
- Z = 2,58 → approximately the 99% of the data would be inside the range.

h) Range of Permissibility. As its name implies it is the parameter that establishes the interval between the lowest acceptable value (*Xi*) and highest one (*Xf*). The equations to get to this range are:

$$Xi = Mean - (\sigma * Z)$$
$$Xf = Mean + (\sigma * Z)$$

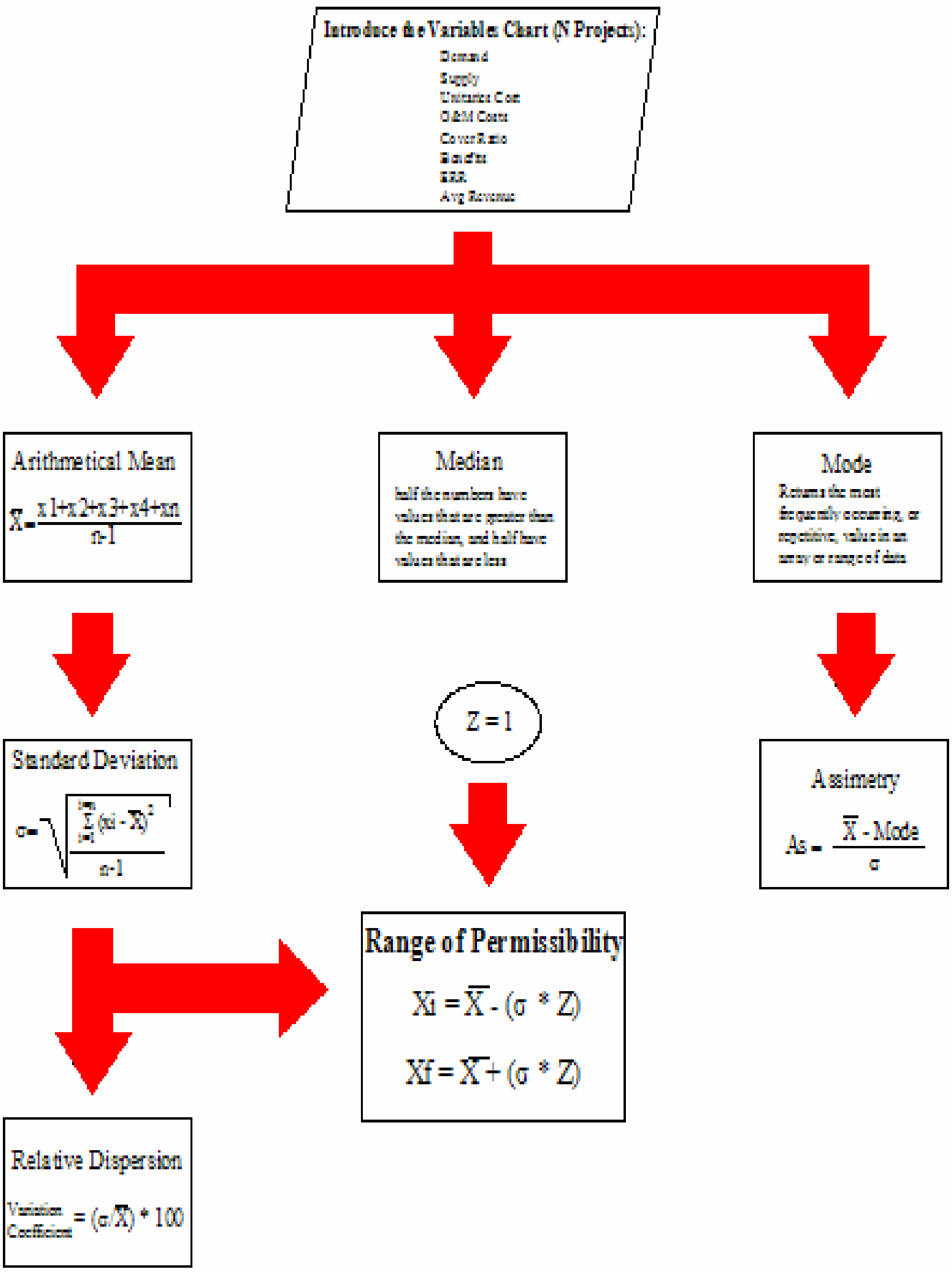
Where, for the case of this research will be used a value of Z = 1 that allows that around the 68 – 75 % of the data will fit in this range.

Once knowing the mathematical functions that will help us to analyze the parameters of each project it is necessary to know the variables that would possible be relevant at the time of establishing the conclusions of the analysis. The word "possible" is used, because at the time the certainties of which variables are going to be the "relevant" is not clear.

- Demand (Passengers/Year)
- Project Unitary Cost (M€/Km)
- Rolling Stock Unitary Cost (M€/Unit)
- Rolling Stock Occupation Cost (K€/Place)
- Average Revenue of Fares per Passenger (€)
- Total Train Capacity (Pax)
- Peak Hour Train Capacity (Pax/dir/hour)
- Operation and Maintenance Costs (€/Veh-Km)
- O&M Costs Cover Ratio (%)
- Benefits in Time Gained vs. Other modes (Min/Journey)
- Benefits on Value of Time vs. Other Modes (€/Pax-hour)
- Economic Rate of Return (%)

All these mathematical functions and project parameters allow stabling a range, which gives an idea of the values of acceptance obtained by projects evaluated. Using the Data Base created to store project information, and grouping projects values in tables according to the variable under study we can get to the values of the ranges *(see Analysis flux gram in the next page)*.

Single Variable Analisys Flux-gram



4.4.2 Outranges

Outrange can be defined as: "exceed in the range; is to have a greater range than something else of the same class"[9].

Starting off this definition, in a values data table, the outranges are the values which are not in the line with the others, and that have to be taken out of the analysis in order to get to the best possible distribution of values.

One of the objectives of this research is to identify "outranges" present in the analysis of parameters and exclude them, explaining the possible causes why this variable is considered an "outrange" respect the others.

4.4.3 Analysis of Combined Variables

To make the analysis of combined variable, it has been taken in consideration the parameters exposed in the topic *4.4.1 analysis of singles variables*. The aim is to analyze them not in an individual way like explained before, but combining two of these parameters in order to try to get a good correlation of this analysis, and this way to determine the Relevant Comparative Ratios for these kinds of projects.

Reviewing the list of parameters to analyze, and adding some ones that could lead to better conclusions:

- Demand (per Year)
- Supply (Capacity per Train/Car, Peak Hour Capacity and Capacity per Year)
- Investment Costs (Total, Unitary, Rolling Stocks)
- O&M Costs
- O&M Costs Cover Ratio
- Benefits (Total, per Year and Time Savings vs. Bus/Car)
- Average Revenues
- Economic Rate of Return

To establish the possible combinations of these variables it is going to lean in a research made in the PJ Directorate Data Base, which is the Data Base of the EIB, about correlations between existence and non-existence variables in it[10].

Of all the combinations made in that analysis, the ones that are going to be used on this analysis are the following:

- Ru = Demand/Capacity
- Rp = Benefits/Demand

[9] According to MSN Encarta Encyclopaedia.
[10] Research made on October 2003 by Nuria Corominas obtaining some conclusions helpful for the developing of this type of analysis.

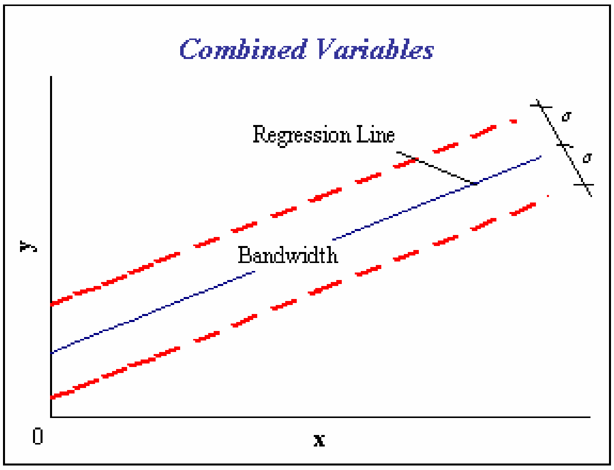
- Investment/Benefits
- Population/Network
- Demand/Investment
- Ru/O&M Costs
- Ru/Cover Ratio
- Passenger's Profit = Rp (Demand/Benefits) - Avg. Revenue

Not having the certainty of finding good correlation between all of them, at first sight seemed to be the ones with most reasonable results in the analysis made.

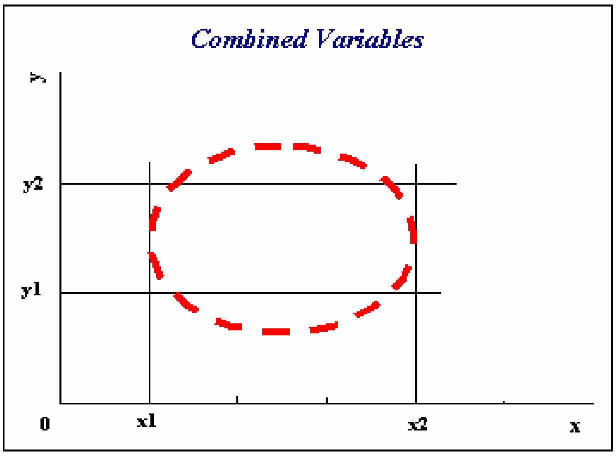
A similar procedure of the one used for the single variable analysis is going to be used, and plus to this mathematical analysis exposed above there is going to be range graphics that could allow to locate the project to analyze respect other similar used to make this research.

The comparatives graphics are based on regression lines and clouds of points obtained in each analysis of these combinations according to each result.

In the case of regression lines obtained by a equation in a distribution of values (in a Bidimensional Cartesian System), is going to be set a bandwidth, which allows to locate either inside the range (regression line + and – the standard deviation) or outside the one.



For the case of appearing clouds of points the appropriate thing to do, after verifying the non-existence of a good correlation between values, is to use the geometrical figure (Rectangle, Square, Circle, Oval, etc) that better surrounds this cloud of points, in order to try to locate the project analyze respect other similar.



4.5 DECISION SUPPORT SYSTEM

The Decision Support System (DSS) is a tool that allows establishing the viability of a project once setting the parameters that characterize these types of projects. Therefore, the DSS must be seeing as an aid tool to determine is the project under study could be financed or not, in other words, the DSS gives the location of the project respect others, economical, financial and operationally speaking (*see Annexes V for the DSS tools of LRT and Metro projects)*.

The DSS is a tool created as the result of the analysis of the single variables and the relevant ratios of the 44 projects evaluated during this research. The name "Decision Support System" is due to its main function, which is helping to take the decision of consider feasible or not the financing of the project under evaluation. However it is important to highlight that this software was developed by the result of the analysis of projects already financed, and therefore is a tool based on empiricist methods.
The decision Support System consists of three main parts: *(I) The Data Entry, which is the part of the document where all the required information is going to be filled; (II) The Range of Values of Parameters, which is the part of the document where the analytical results are displayed; (III) Project Performance, which is the final part of the DSS and represents the graphical results of the project, comparing these results with the ones set in the analysis of other similar projects.*

4.5.1 Data Entry

The Data entry section is the introduction part of the DSS, in this part all the required information needs to be filled in order to get to the expected results. This Data Entry section includes six fields of the project that are described below:

1. The general Information about the project. It is always important to know the main information about each project evaluated in order to try to seek for an explanation of some results in the hypothetical case that would be required. The information to fill in this field are:

- *Project Name*
- *City*
- *Country*
- *Project Technical Life*

2. The *Demand* of the project as explained before is one of the most relevant parameter to measure, along others parameters, the feasibility of a project.

3. The Supply. Whenever making an operational comparison the supply goes along with the demand. The supply information required is:
   - *Capacity per Train*
   - *Peak Hour Capacity*
   - *Capacity Pear Year*

4. Project's Costs:
   - *Investment Cost*
   - *Project Unitary Cost*
   - *Rolling Stock Unitary Cost* { *Train/Car Cost*, *Place Cost* }
   - *O&M Cost*

5. Project's Benefits. The benefits in a project (along the costs) are parameters that help to establish the viability of a projects as well as the ERR. Normally the benefits are on savings in time and economical:
   - *Total Benefits*
   - *Benefits per Year*
   - *Time Gain (Savings)* { *vs. Bus*, *vs. car* }

6. Economic Profit:
   - *Average Revenue*
   - *Economic Rate of Return (ERR)*
   - *O&M Cost Cover Ratio*

4.5.2 Range of Values of Parameters

Once the values are entered in the Entry Data, this second section of the DSS is in charge of set the analytical comparison between the variables of the project that is being evaluated and the range of the acceptability of the variables of projects evaluated in the analysis before.

Two tables compose this section. The first one, establish a comparison between the values of the single variable of the project and the acceptable ranges of projects similar, and give an answer of the in range – outrange project condition; while the second one, has as main task to calculate the distance in Z direction of the point in the graphic (see section 3 of project performance) of the comparative ratios, and as the first table does, it gives an answer of the in range – outrange condition of these data.

Both tables have different operation modes, but at the end display the same conclusion, the range situation of the project's variable:

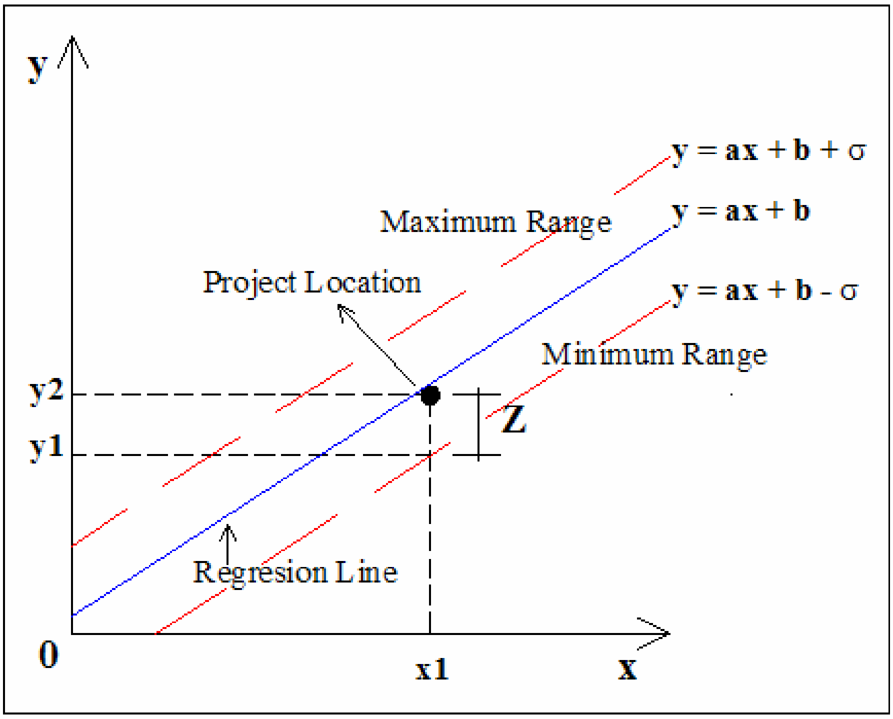
- TABLE 1: INDIVIDUAL VARIABLES

The table is composed by 5 columns: the first one contains the name of the variable; The second one contains the value of the variable, which is dragged from the entry data section; the third column consists in the range of acceptability column, and is subdivided by two columns as well, the minimum range and the maximum range, both values set by the results in the analysis of single variables of projects *(sections 3.1.1 and 3.2.1 of these research)*; the fourth column is the one that gives the answer about the range (in or out) condition of the project, by making a simple comparison between column two and three (if value in column two is greater than the maximum in column three or if it is smaller than the minimum in the same column three the situation of the project is outrange, if not the project is considered in range respect the others); finally the last column, that is column 5, gives a description of the reason of outrange (in case that column four says so), each variable described in column five has from two to five different reasons for the outrange condition.

- TABLE 2: COMPARATIVES RATIOS

In the case of this second table, the thing is a little big more complicated than the first one, and is strictly associated with the third section of this DSS although it operation is completely independent of the other one.

This table contains four columns: the first column is equivalent to the one of the table explain above, with the different that the names that appear here are the ones of the comparative ratios; column two shows the calculation of the Z value, which is equal to the vertical distance in a Cartesian chart, of the ratio in question (*see graphic in the next page for an illustration of this operation*); the third column is similar to column four of the table of individual variable; and column 5 is similar to the column 6 of the table explained before as well.



The best way to understand how operates this DSS tool is trough an example of the evaluation of a project *(see Chapter 6 of Decision Support System for Urban Guided Transport project feasibility analysis)*.

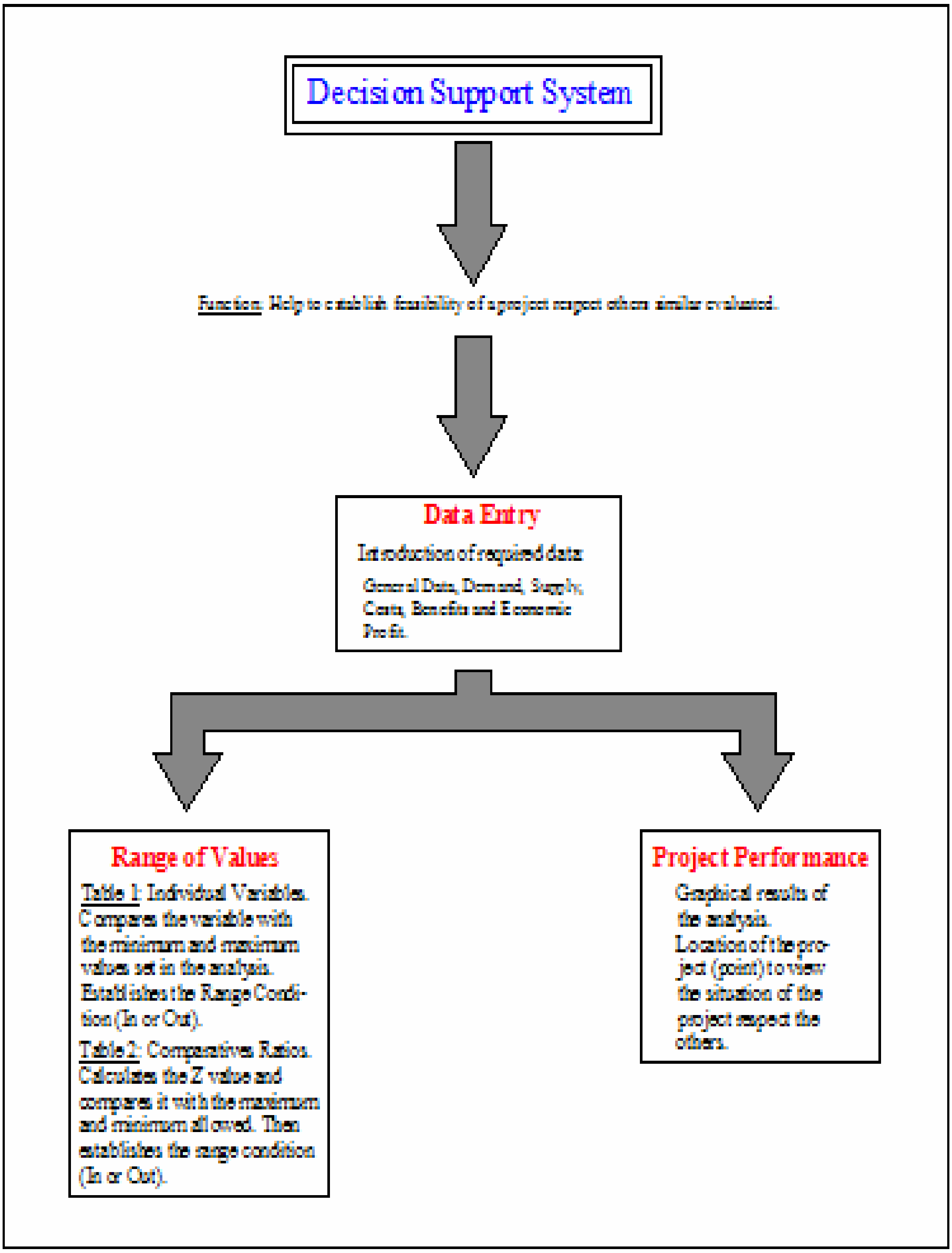
4.5.3 Project Performance

The third section of this supporting software represents the graphical part of the DSS, in which are used the graphics explained and exposed in the topic *4.6.4 of analysis of Combined Variables.*

Therefore graphics of regression line and of cloud of points are in charge of measuring the performance of the project respect the ones evaluated before, giving a location (exact point) of the project respect the regression line, the maximum range and the minimum one.

4.5.4 Algorithm Flux Gram

To help to describe the DSS, in addition to what exposed in topics *4.6.1, 4.6.2, and 4.6.3*, a flux gram with an abstract of the description of the algorithm (DSS) and it main function is presented in the next page:



Decision Support System
Function: Help to establish feasibility of a project respect others similar evaluated.
Data Entry
Introduction of required data:
General Data, Demand, Supply, Costs, Benefits and Economic Profit.
Range of Values
Table 1: Individual Variables. Compares the variable with the minimum and maximum values set in the analysis. Establishes the Range Condition (In or Out).
Table 2: Comparatives Ratios. Calculates the Z value and compares it with the maximum and minimum allowed. Then establishes the range condition (In or Out).
Project Performance
Graphical results of the analysis. Location of the project (point) to view the situation of the project respect the others.

4.5.5 DSS Example

The best way to illustrate the operating modus of the Decision Support System is by showing an example on a project, which did not take part of the analysis carried out. Therefore the following Example of the Tramway of Clermont – Ferrand is showed:

Decision Support System (DSS)		
Tramways and Light Rail Transit Projects		
1. Data Entry		
Project Name	**Tramway de Clermont - Ferrand**	
City	**Clermont - Ferrand**	
Country	**France**	
Project Technical Life	**30**	Years
Demand	**16,5**	M Passenger per Year
Supply		
Capacity per Train	**214**	Passengers
Peak Hour Capacity	**2600**	Pax/Hour/Direction
Capacity per Year	**19,3**	M Passengers
Costs		
Investment Cost	**371,7**	M EUR
Project Unitary Cost	**15,4**	M EUR per Km.
Rolling Unitary Stock		
Train Cost	**2,2**	M EUR per Unit
Place Cost	**10**	EUR per Place
O&M Cost	**4,16**	EUR/Train-Km/Year
Benefits		
Total Benefits	**305,9**	M EUR
Benefits per Year	**10,2**	M EUR per Year
Time Gain (Savings)		
vs. Bus	**7,4**	Minutes per Journey
vs. Car	**3,7**	Minutes per Journey
Economic Profit		
Average Revenue	**0,48**	EUR per Passenger
Economic Rate of Return	**5 %**	Over Technical Life
M & O Cost Cover Ratio	**39 %**	

Decision Support System (DSS)

Tramways and Light Rail Transit Projects

2. Range of Values of Parameters

Tramway de Clermont - Ferrand

2.1 Individual Variables

Variable	Value	Range of Acceptability			Condition	Description (If Outrange)
		Minimum	-	Maximum		
Demand per year	16,5 M	10,0 M	-	26,0 M	In Range	
Capacity per Train	214	205	-	360	In Range	
Peak Hour Capacity	2.600	2.300	-	3.850	In Range	
Project Unitary Cost	15,4 M	9,0 M	-	21,0 M	In Range	
Rolling Stock Unitary Cost	2,2 M	1,5 M	-	2,4 M	In Range	
Rolling Stock Place Cost	10	6.300	-	8.500	Outrange	No clear reason for Outrange
M & O Cost	4,16	3,50	-	5,70	In Range	
Time Gain vs. Bus (Savings)	7,4	7	-	15	In Range	
Time Gain Vs Car (Savings)	3,7	5	-	11	Outrange	Not appropiate to consider values outrange
Average Revenue	0,48	0,35	-	0,77	In Range	
Economic Rate of Return	5,0 %	3,6 %	-	8,8 %	In Range	
M & O Cost Cover Ratio	39 %	40 %	-	78 %	Outrange	

2.2 Comparative Ratios

Variable	Z Value	Condition	Interpretation
Ru (Demand/Capacity)	-13,9	In Range	Case 2: Z negative + In range, capacity low for demand, but in a permissi
Investment/Benefits	-85,4	In Range	Case 2: Z negative + In range, Benefits low respect investment (permissil
Demand/Investment	3,3	In Range	Case 4: Z Positive + In range, investment high for demand (permissible ra
Passenger Profits	1,14 EUR/Passenger		Note: Pax Profit = Rp(Demand/Benefits) - Avg Revenue

Decision Support System (DSS)

Tramways and Light Rail Transit Projects

3. Project Performance

Tramway de Clermont - Ferrand