ON THE VALUE OF PUNCTUALITY ON SUBURBAN TRAINS TO AND FROM PARIS

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1. INTRODUCTION

Quality of service is a key factor to get people to use public transport instead of their private car. Improving the quality of public transport is therefore a priority for transport policies and public subsidies allocation in Ile de France (this is the Paris region). As a matter of fact, it is now agreed in Ile de France that creating new infrastructures to develop the public transport network is of no use if the existing network is not of high quality.

However, the impacts of quality enhancements on travellers' behaviour are only partially known, qualitatively as well as quantitatively. Thus we do not have objective criteria to select measures to improve quality that could have rather different costs.

With this in mind STIF (Syndicat des Transports d'Ile de France), the public transport authority in the Ile de France region, decided to conduct studies focused on the question of appraisal of measures to improve quality of service. Among all types of quality items and possible measures, it is clear that punctuality of the services is a major element for the traveller. STIF therefore decided, together with their partners RATP, SNCF and RFF, to conduct a study on punctuality of the suburban railway network.

2. OBJECTIVES

The main objective of this study is to provide a robust operational methodology that enables STIF to evaluate possible alternative investments aiming to improve the quality of the suburban rail services to and from Paris. The methodology is needed to assist the decision-making process regarding possible alternative projects (combinations of measures) to improve the punctuality of the suburban rail services. This is to be achieved by enabling a quantitative appraisal of the perceived value of all punctuality benefits to the passengers, and the expected impact on patronage and revenues. In the framework of this study, the key aspect of the quality of railway services is punctuality. Punctuality is defined here as the provision of rail services with actual train departure times from and arrival times at stations as published in the timetable.

The starting point of the evaluation process needs to be an accurate and reliable translation of each project (investment/series of measures aimed at improving the punctuality) into operational performance statistics, which are then turned into passenger valuations and finally into equivalent amounts of perceived travel time or monetary cost. This should enable STIF to assess the expected impact on patronage and revenues. Against this background it must be noted that the research needs to take into account the existing statistics objectively describing the railway performance as supplied by the operators (SNCF and RATP).

3. PARIS SUBURBAN TRAINS

The railway network linking Paris to its suburbs comprises 1400 kilometres of railway lines and serves 443 stations in total. Most of the lines are part of the express regional network (RER lines A, B, C, D and E) that offers different underground access points in Paris from the suburbs. Some other lines remain operated like classic trains stopping at only one terminal station inside Paris.

The railway network is operated by two state-owned companies: SNCF (French national railway company) and RATP (which operates also the metro network). SNCF operates services on the French national railway network (owned by Réseau Ferré de France, RFF). SNCF operates the major part of the regional suburban network: all classic railway lines, RER C, D and E alone. RER A and B are operated jointly by SNCF and RATP.

In fact, the way of operation between SNCF and RATP is rather different for historical reasons.

- SNCF has always operated railway services in France. It means that the tracks used by its Ile de France suburban services are not dedicated to these services, but are also used by other type of trains services: French Intercity trains, international trains, TGV services and freight services. For a long time, priority of investments on the National Railway Network was not Ile de France services. This has led to a certain dilapidation of the suburban railway facilities. In day-to-day operation, priority is generally given to services of high value like TGV services, and not to suburban services. The management of incidents on tracks used by a mixture of services is not in favour of suburban services. The lack of facilities to allow a good management of incidents is the major reason of unpunctuality of SNCF services.
- RATP on the contrary has only operated suburban services on dedicated lines. But as the two RER lines RATP operates are operated jointly with SNCF, difficulties are in fact shared by both operators.

SNCF and RATP operation is ruled by specific contracts concluded between STIF and these operators. These contracts address the provision of transport services, fares that apply, the quality of service standards to be complied with, the operators remuneration and a financial incentive system based on actual performance. This system includes a bonus-malus system based on the quality of service actually achieved.

The punctuality indicators specified in the contracts differ between the STIF / RATP contract and the STIF / SNCF contract mainly because of data availability which is different according to the operator. For RATP, the punctuality indicator consists of the number of passengers (per day, per month and for the whole year) whose arrival at destination station has been delayed by more than 5 minutes, and the number of those for which delay exceeds 15 minutes. For SNCF, the indicator consists of the number of trains arriving at their terminal stations with a delay of more than 5 minutes during the morning and evening peak periods for the most crowded direction only (towards Paris in the morning and towards suburbs in the evening).

Punctuality is at the moment the major problem of quality of service in Ile de France, as unpunctuality has been increasing continually since the year 2000. In 2004, during peak hours, between 5 % and 16 % (depending on the line considered) of the trains on the SNCF network didn't arrive on time. The best values are observed on lines where only suburban services run, and on the RATP part of the network.

4. RESEARCH APPROACH

Given that there was little information readily available about the many elements associated with unpunctuality of trains and the value that passengers attach to improving the punctuality of suburban rail services, a comprehensive research programme was carried out. This was structured in three main phases.

Phase 1: Improving our knowledge of punctuality. The main objective of this phase was to learn about the key operational elements of punctuality associated with suburban rail. In order to achieve this, the international literature was reviewed, the available statistical data concerning Paris-oriented suburban rail were analysed and a passenger survey was organised and analysed to learn about actual passenger arrival patterns (and hence their waiting times) at rail stations and platforms.

Phase 2: Qualitative research on the impact of unpunctuality on passengers. The main objective of this phase was to find out how delayed trains affect rail passengers, and what the consequences are. In order to achieve this, three group discussions were organised. The groups consisted of a carefully selected mix of suburban rail passengers of different ages, professional activities and household responsibilities, with different journey purposes, and using rail lines with different punctuality levels.

Phase 3: Quantitative analysis of the impacts of unpunctuality. The main objective of this phase was to quantify the disutility associated with unpunctuality as perceived by the passengers. In order to do this, a stated preference (or trade-off) survey was carried out among a large number of rail passengers, in which different frequencies of delays were traded off against mean travel time, in-train comfort and the provision of information about delays. The results were analysed to obtain utility estimates, which were expressed in equivalent minutes of mean travel time (e.g. reducing the frequency of delays from 10% to 5% of all trains is worth the same as a 5-minute reduction of travel time).

Finally, a methodology was developed to enable STIF to assess investments aimed at improving the service quality. In the following sections of this paper we will concentrate on the SP research and the tool that was developed.

5. STATED PREFERENCE RESEARCH AND MAIN FINDINGS

In order to appraise *a priori* the monetary benefits of different possible measures to improve the regularity of the Paris suburban train network, it is imperative to quantify how passengers value the quality of the service offered. This can be done by conducting a “stated preference” discrete choice experiment. In such research a sample of passengers is offered choices between two (or more) hypothetical alternative train services. These services differ in characteristics, such as travel time, reliability, comfort level, etc. Passengers are asked to state their preference for one of the alternatives.

Qualitative research

In order to test and validate the different possible ways in which to present the selected key variables in the stated preference survey, qualitative research was carried out by Catherine Delannoy & Associés*.* This involved a group discussion with rail passengers, during which three different types of stated preference questionnaire were presented:

- version 1, with frequencies of train delays per month presented as percentages: “5% of all trains have a delay of 5–15 minutes”;
- version 2, with frequencies of train delays per month presented as *n* times out of 20: “1 train out of 20 has a delay of 5–15 minutes”; and
- version 3, with frequencies of train delays per month presented graphically (with dashes and crosses indicating trains with and without delays of 5-15 minutes on certain days).

It turned out that version 2 was understood best, and was the most clear to the majority of all passengers. Consequently, this presentation was retained in the stated preference survey.

Stated Preference survey

More than 1,200 rail travellers participated in the stated preference survey. They were recruited on platforms of a selection of train stations in Paris, or in the trains between these stations. The recruited travellers were spread over the different passenger segments that were under investigation. These segments differed by:

- journey purpose (commute/education or other);
- frequency of service of the line where traveller was recruited (high or low);
- regularity of the line where traveller was recruited (good or bad); and
- direction of the trip (to or from Paris).

Table 1 shows the number of respondents in each of the segments (targets and realisations).

Frequency + Regularity combination Purpose	Low frequency + Good regularity	Low frequency + Bad regularity	High frequency + Good regularity	High frequency + Bad regularity	Total
Commute / education	195 *(200)*	266 *(200)*	195 *(200)*	249 *(200)*	**905** ***(800)***
Other	92 *(100)*	83 *(100)*	106 *(100)*	87 *(100)*	**368** ***(400)***
Total	**287** ***(300)***	**349** ***(300)***	**301** ***(300)***	**336** ***(300)***	**1273** ***(1200)***
				Of which are travelling from Paris	624 *(600)*
				Of which are travelling towards Paris	649 *(600)*

Table 1 Observed distribution of the SP survey respondents over the segments. The figure in brackets is the number of respondents aimed at in each segment.

The recruited train travellers received by ordinary mail a personalised questionnaire, based upon their travel characteristics. A few days later they were phoned by the fieldwork agency to conduct the interview and record the answers. These interviews were conducted in the last week of June and the first weeks of July 2004.

Each interviewed train traveller was asked to make 19 choices, each time between two alternative train services. Each train alternative was described by:

- the travel time for the train trip;
- the frequency of short delays (delays between 5 and 15 minutes);
- the frequency of long delays (delays of more than 15 minutes);
- the comfort level for the train trip; and
- the level of information provided on delays.

The value of these attributes varied between a low, a base and a high level. The base levels of travel time and frequency of the short and long delays were equal to the current levels as perceived (reported) by the traveller. The low and high level of the travel time differed 5%, 10%, 20% or 30% (determined by random draw) from the current level. The low level of the frequency of delays was about half the current level; the high level was about double the current level.

The level of comfort could be either of three options: seated; standing; or standing in a very crowded environment. The information about delays was presented as “announcement of disturbances” (level 1); “announcements of disturbances and their causes” (level 2); “announcement of disturbances, their causes and the expected amounts of delay” (level 3).

Figure 1 shows an example of a choice card as used in the interviews.

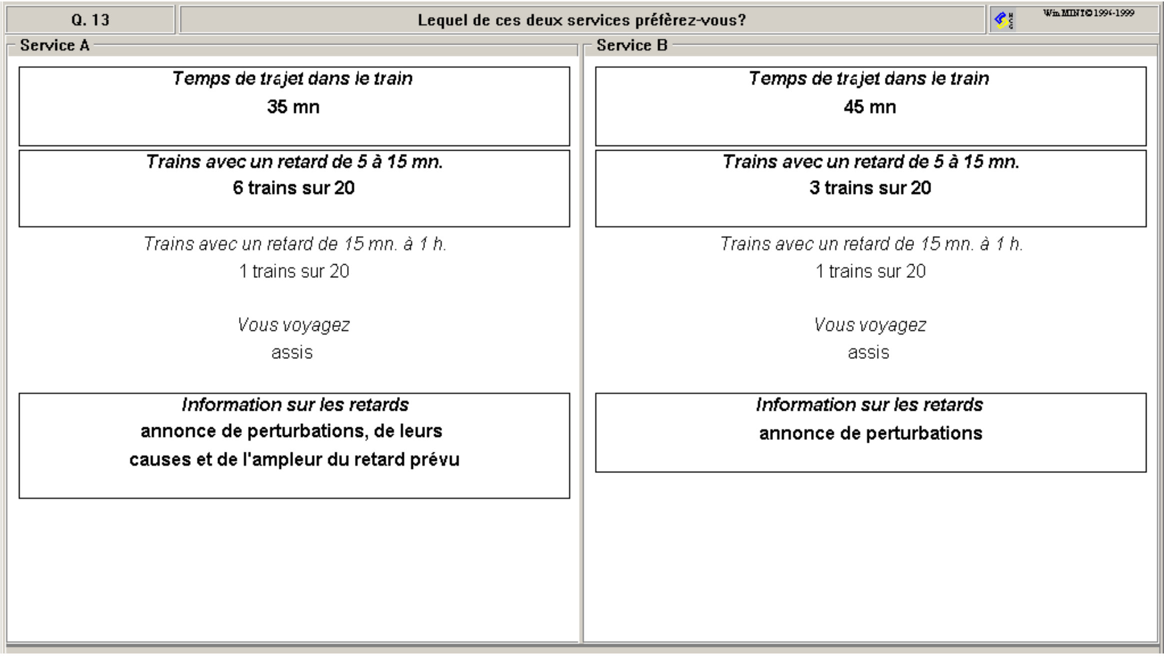

Figure 1 Example of an SP choice (card as seen by the interviewer)

Statistical analysis

The stated preferences (or actually: hypothetical choices) provided by the train travellers in the SP survey were used to determine the relative weight of each of the factors of service quality using discrete choice analysis methods. In this case we used a method called “logit” analysis.

All estimated coefficients that were obtained in the final models have the intuitive, expected sign, and a plausible size. Separate coefficients were estimated for people travelling with different purposes (commuting, education or other). The final results are shown in Table 2. For a complete overview of the model results (including the significance of each of the coefficients) we refer to our Technical Report on the stated preference data analysis (RAND Europe/Stratec, 2004).

Table 2 indicates the value of each parameter relative to one minute of travel time. For example, a person travelling from Paris on a commute trip on a line with good punctuality values a 5% probability of having a **short delay** (1 out of 20 trains) equal to 4.6 minutes of travel time. So the value of reducing the frequency of short delays from, say, 10% (2 out of 20 trains) to 5% (1 out of 20 trains) for a commuter is equivalent to a travel time saving of 4.6 minutes.

If this person is travelling for another purpose (not commute/education), he values this delay probability equal to 6.2 minutes of travel time. It may seem counter-intuitive that passengers that go to work value punctuality as less important than travellers that go shopping, for instance. However, it was already observed in the group discussions that for commuter’s unexpected train delays were often accepted as a

		Commute / education trips								Other trips							
		Travelling from Paris				Travelling towards Paris				Travelling from Paris				Travelling towards Paris			
		Good regularity	t-ratio	Bad regularity	t-ratio	Good regularity	t-ratio	Bad regularity	t-ratio	Good regularity	t-ratio	Bad regularity	t-ratio	Good regularity	t-ratio	Bad regularity	t-ratio
Traveltime	for each minute of traveltime	1.0	(*)	1.0	(*)	1.0	(*)	1.0	(*)	1.0	(*)	1.0	(*)	1.0	(*)	1.0	(*)
Short delays (between 5 and 15 minutes)	1 out of 20 trains	4.6	(10)	4.6	(10)	4.6	(10)	4.6	(10)	6.2	(8)	6.2	(8)	6.2	(8)	6.2	(8)
	2 out of 20 trains	9.2	(10)	9.2	(10)	9.2	(10)	9.2	(10)	12.3	(8)	12.3	(8)	12.3	(8)	12.3	(8)
	3 out of 20 trains	13.8	(10)	13.8	(10)	13.8	(10)	13.8	(10)	18.5	(8)	18.5	(8)	18.5	(8)	18.5	(8)
	4 out of 20 trains	18.0	(13)	18.0	(13)	18.0	(13)	18.0	(13)	24.1	(10)	24.1	(10)	24.1	(10)	24.1	(10)
	5 out of 20 trains	22.2	(14)	22.2	(14)	22.2	(14)	22.2	(14)	29.7	(11)	29.7	(11)	29.7	(11)	29.7	(11)
	6 out of 20 trains	26.4	(15)	26.4	(15)	26.4	(15)	26.4	(15)	35.3	(11)	35.3	(11)	35.3	(11)	35.3	(11)
	7 out of 20 trains	29.0	(17)	29.0	(17)	29.0	(17)	29.0	(17)	37.2	(12)	37.2	(12)	37.2	(12)	37.2	(12)
	+ for each extra delayed train out of 20	2.6	(14)	2.6	(14)	2.6	(14)	2.6	(14)	1.9	(5)	1.9	(5)	1.9	(5)	1.9	(5)
Long delays (more than 15 minutes)	1 out of 20 trains	6.7	(17)	6.7	(17)	6.7	(17)	6.7	(17)	8.9	(10)	8.9	(10)	8.9	(10)	8.9	(10)
	2 out of 20 trains	13.3	(17)	13.3	(17)	13.3	(17)	13.3	(17)	17.8	(10)	17.8	(10)	17.8	(10)	17.8	(10)
	3 out of 20 trains	20.0	(17)	20.0	(17)	20.0	(17)	20.0	(17)	26.7	(10)	26.7	(10)	26.7	(10)	26.7	(10)
	4 out of 20 trains	25.3	(21)	25.3	(21)	25.3	(21)	25.3	(21)	33.9	(12)	33.9	(12)	33.9	(12)	33.9	(12)
	+ for each extra delayed train out of 20	5.4	(16)	5.4	(16)	5.4	(16)	5.4	(16)	7.2	(9)	7.2	(9)	7.2	(9)	7.2	(9)
Comfort level	Standing	4.9	(2)	14.0	(6)	4.9	(2)	14.0	(6)	6.5	(2)	18.7	(5)	6.5	(2)	18.7	(5)
	+ for each minute of traveltime	0.3	(4)	0.1	(2)	0.3	(4)	0.1	(2)	0.4	(4)	0.1	(2)	0.4	(4)	0.1	(2)
	Standing in a crowded environment	27.2	(14)	27.2	(14)	27.2	(14)	27.2	(14)	36.3	(9)	36.3	(9)	36.3	(9)	36.3	(9)
	+ for each minute of traveltime	0.2	(5)	0.2	(5)	0.2	(5)	0.2	(5)	0.3	(4)	0.3	(4)	0.3	(4)	0.3	(4)
Infor-mation level	Announcement of perturbation and cause	0.0	(*)	0.0	(*)	-4.4	(6)	-4.4	(6)	0.0	(*)	0.0	(*)	-5.9	(5)	-5.9	(5)
	+ for each shortly delayed train out of 20	-0.9	(3)	-0.9	(3)	0.0	(*)	0.0	(*)	-1.3	(3)	-1.3	(3)	0.0	(*)	0.0	(*)
	Announcement of perturbation, cause and size	-9.9	(10)	-9.9	(10)	-9.9	(10)	-9.9	(10)	-13.2	(7)	-13.2	(7)	-13.2	(7)	-13.2	(7)

Table 2 Results of the stated preference research, indicating for each segment how passengers value a certain quality level with respect to one minute of travel time and the corresponding t-ratios

valid excuse for arriving late at their work. So part of the disbenefit of being late could be transferred to the employer, which may explain this result.

The coefficients for **long delays** are higher: for commuting/education 6.7 minutes of travel time, for other purposes 8.9 minutes. Note that the actual frequency of such long delays is much lower than the frequency of the short delays, but that the expected duration of such a delay is considerably longer. The net effect, however, is that the utility of reducing longer delays is higher than that of reducing short delays.

Two other variables that were included in the SP experiments were comfort/crowdedness and information about delays. For **comfort** we found that not having a seat is equivalent to an additional 5-14 minutes of travel time: 5 on lines with good regularity, and 14 on lines with bad regularity. In addition to that, this value increases with the length of the journey. The disutility increases sharply when passengers have to stand in a crowded/packed train: this is valued as equivalent to a 27 minute increase in journey length.

For **information about delays** we found that providing extra information about the duration of delays is worth about 10 minutes of travel time. Note that the values for the information level are negative: this indicates that extra information about the size of the expected delay is valued equally to a *reduction* of the travel time.

The results that have been obtained here will be used in the practical tool and the application, which are both described in the next chapters.

6. PRACTICAL TOOL

Before a decision can be made to invest in a project aiming to improve punctuality, alternative projects improving the quality of suburban rail services to and from Paris need to be assessed. In order to facilitate objective decision-making, a robust operational methodology to appraise possible investments has been developed for STIF. This methodology enables a quantitative appraisal of the perceived value of all punctuality benefits to all passengers (both existing and new).

Methodology

This appraisal methodology consists of seven steps that are displayed in Figure 2.

First, in step 1, the project(s) to improve the quality of the service need(s) to be specified: what is the series of activities that will be carried out? What changes will be made? How will the service be improved?

Next, the impact of the project needs to be estimated, both in terms of the performance of the railway system (travel time, waiting time, level of punctuality; step 2) and in terms of the quality of the service (probability of having to stand, level of information provided to passengers; step 3). This information about the system performance before and after the project is the input to a Microsoft Excel tool that carries out the remaining steps.

Based on the results of the stated preference study, the daily impact of the project on passengers, expressed in equivalent minutes of travel time are calculated (step 4). This impact can be different for passengers in different market segments (based on their journey purposes).

Next, this impact is converted into monetary units, using an appropriate value of time (input by the user, see step 5). Because the level of service has changed, it is to be expected that this will also influence the number of passengers using this service. This change in demand is estimated using appropriate travel time elasticities (input by the user, see step 6). Finally, the total monetary benefits of the project are determined (step 7).

Punctuality appraisal tool

A Microsoft Excel spreadsheet was developed to perform all calculations in steps 4 to 7. The spreadsheet is made up of three sub-sheets: one for specification of the input; one for the coefficients that are used to calculate the impact on passengers in terms of equivalent minutes of travel time (the so-called “utility” coefficients); and one for presenting the output.

The punctuality appraisal tool only handles one train line at a time. If the project influences more than one line, the tool has to be run for each line separately, and the outcomes have to be added by the user (unless passengers can interchange between these lines, then a combined run has to be made). If the characteristics or the quality of the line change over the course of the day, then the tool has to be run for each time period separately.

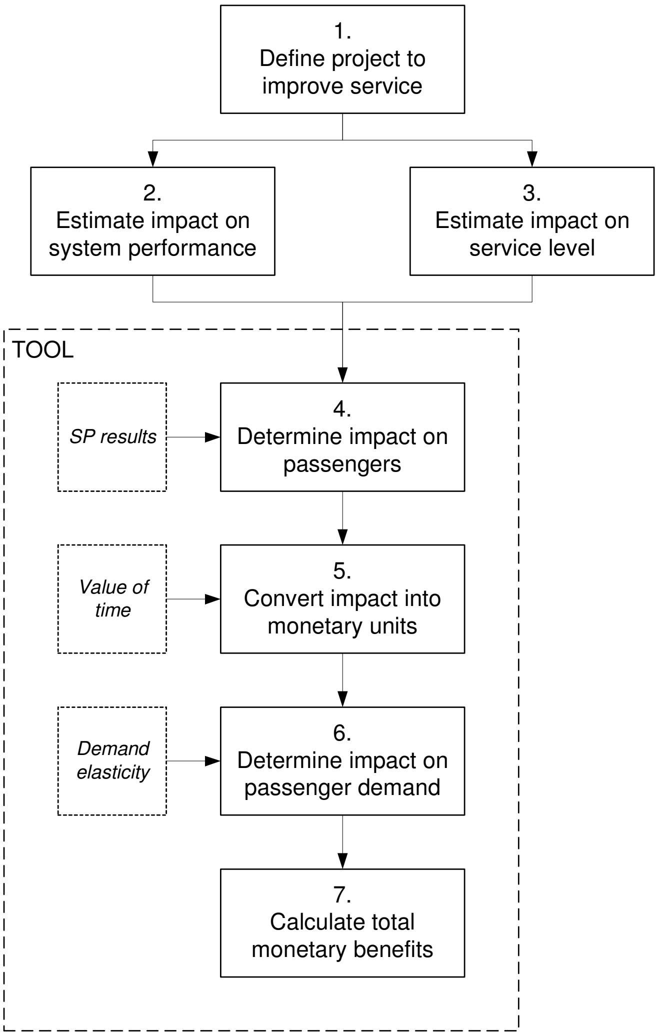

Figure 2 Outline of the methodology

Specification of the input

The stated preference research has shown that quality of service is perceived differently depending on certain characteristics of the trip, such as the direction of travel (travelling towards or from Paris), the existing regularity of service (good or bad) and the passenger's purpose of travel (commuting/education or other). Information is therefore required on each of these variables for input into the tool. An example input screen of the tool is displayed in Figure 3.

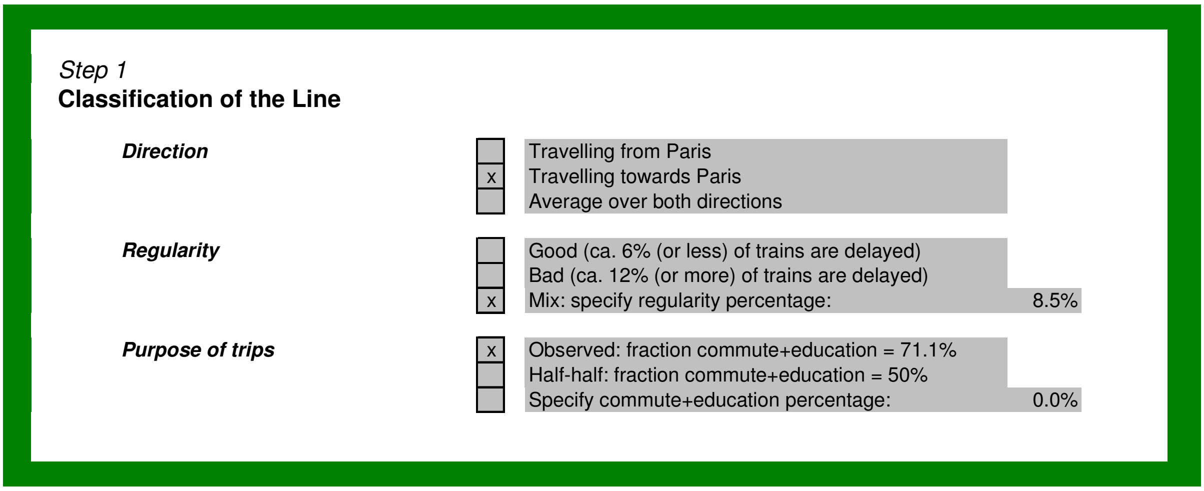

Figure 3 Input screen for the classification of the line

For the direction of the line the user must choose one of three options: travelling from Paris, travelling towards Paris or an average over both directions. Depending on their choice the corresponding utility coefficients that are used to calculate the impact of the project on the passengers are selected.

The stated preference research distinguished passengers on the basis of the existing regularity of the line on which they travelled. This regularity was classified “good” (i.e. the probability of experiencing a delay of more than 5 minutes was less than 9%), or “bad” (probability in excess of 9%). The average probability of delay on the good and bad lines was approximately 6% and 12%, respectively. The user must select the appropriate existing regularity level of the line for which they are conducting the appraisal on the input screen. So, if the probability of delay is currently less or equal to 6%, “good regularity” needs to be selected. If the probability of delay is more or equal to 12% “bad regularity” needs to be selected. To prevent sharp transitions for lines with a probability of delay between 6% and 12%, there is a mixed option. The user can specify the regularity percentage (= probability of delay). For values between 6% and 12% the utility coefficients transform linearly from their values for a line with a good regularity to their values for a line with a bad regularity.

The impact on a passenger of a change in service quality depends on their travel purpose, whether commute/education or other (note that business trips are included in “other”). In order to calculate the total impact over all passengers, the fraction of travellers with the purpose “commute/education” has to be specified on the input screen. The user can select a fixed fraction (either 71.1%, which is the percentage that was observed in the stated preference survey, or 50%) or they can specify any percentage that may be known from passenger surveys carried out for that line.

The next part of the input screen specifies the “Quality of Service” before and after the project. This can be completed in two ways: either in terms of a specification of average values per traveller (option one, see Figure 4), or in terms of the output of a train operation simulation model that is currently used by RFF (Réseau Ferré de France) (option two, see Figure 5).

Step 2
Quality of Service
Use table A (average per person) or table B (output of RFF model)

A: average per person	*Present*	*Future*	
Travel time			minutes
Short delays (5-15 min.)			(in %)
Long delays (15+ min.)			(in %)
Standing			(in %)
Standing, crowded			(in %)
Information level (1-3)			

1: announcement of perturbations
2: announcement of perturbations and their cause
3: announcement of perturbations, their cause and their size

Figure 4 Input screen for quality of service in terms of averages per person

B: output of RFF model	*Present*		*Future*	
	no perturb.	random scen.	no perturb.	random scen.
Number of passengers	19,905	19,929	19,848	19,874
of which have short delay	875	1,418	0	13
of which have long delay	0	0	0	0
Number of travel minutes	305,552	319,696	340,842	354,986
of which are standing		77,562		75,489
idem crowded env. > 3P/m²		376		444
Information level (1-3)	1		1	

1: announcement of perturbations
2: announcement of perturbations and their cause
3: announcement of perturbations, their cause and their size

Figure 5 Input screen for quality of service in terms of RFF model output

If the first option is used, the average travel and waiting time per traveller needs to be entered, both in the present situation and in the future situation after the project has been finished. Also, the probability of experiencing a short delay (between 5 and 15 minutes) and long delay (more than 15 minutes) has to be specified, as does the probability of having to stand (normal, i.e. in a non-crowded environment), as well as having to stand in a crowded environment. Finally, the level of information on delays needs to be specified both for the present and future situation.

If the second option is used, designed specifically for the RFF simulation tool, the number of passengers (total, experiencing short delays, experiencing long delays) has to be specified. The user should define over which time period this total is calculated: usually this should be a period of one hour. The number of passengers needs to be specified for four cases. Aside from the split between present and future, the numbers for an undisrupted situation (assuming all trains are running on schedule) and a random scenario (with disruptions occurring randomly with a pre-specified probability) need to be filled in.

Further, the user should specify the total amount of travel time that all passengers spend travelling in trains, as with the time spent travelling while standing, and the time spent travelling while standing with more than three persons per square metre (standing crowded). Finally, the scheduled frequency of the trains and the information level should be entered.

The third step of the input specification covers the remaining parameters, see Figure 6. In this input screen the number of passengers per day has to be specified, and the number of days per year. Note that these numbers should be specified for situations pertaining to the characteristics of the line and level of service that has been entered. If these characteristics are specified for a morning peak hour, the number of passengers per day should be limited to morning peak hours only, and the number of days per year should be limited to those days that have (on average) such a morning peak (i.e. no weekends or holiday periods).

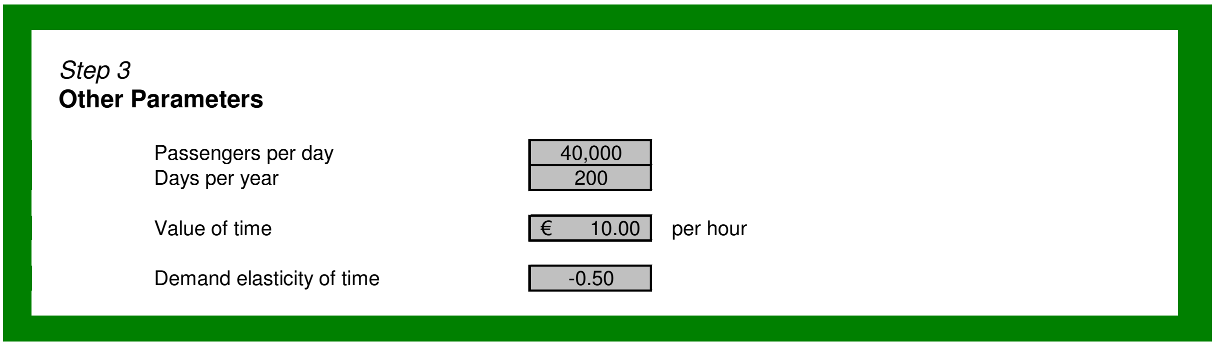

Figure 6 Input screen for the other parameters

This input screen also asks for the value of time that will be used for the monetarisation of the benefits. Finally, the demand elasticity of time needs to be specified in order for the tool to be able to calculate the impact on demand. If the user does not want to have benefits calculated for “new travellers” this elasticity can be set to zero.

Utility coefficients

The second sub-sheet in the Excel file contains the Stated preference findings (labelled the “UtilCoeff” sheet). This sub-sheet begins with a summary of the stated preference results expressed in terms of the utility coefficient for time. This means that the travel time coefficient is 1 by definition and all other coefficient express the weight of the coefficient relative to the time coefficient (see Table 2). This sheet also shows the utility coefficients for travellers for each purpose (commute/education and other) for the selected line type (see Figure 7).

		Commute / education	other
Traveltime	for each minute of traveltime	1.0	1.0
Short delays (between 5 and 15 minutes)	1 out of 20 trains	4.6	6.2
	2 out of 20 trains	9.2	12.3
	3 out of 20 trains	13.8	18.5
	4 out of 20 trains	18.0	24.1
	5 out of 20 trains	22.2	29.7
	6 out of 20 trains	26.4	35.3
	7 out of 20 trains	29.0	37.2
	+ for each extra delayed train out of 20	2.6	1.9
Long delays (more than 15 minutes)	1 out of 20 trains	6.7	8.9
	2 out of 20 trains	13.3	17.8
	3 out of 20 trains	20.0	26.7
	4 out of 20 trains	25.3	33.9
	+ for each extra delayed train out of 20	5.4	7.2
Comfort level	Standing	8.7	11.6
	+ for each minute of traveltime	0.2	0.3
	Standing in a crowded environment	27.2	36.3
	+ for each minute of traveltime	0.2	0.3
Infor-mation level	Announcement of perturbation and cause	-4.4	-5.9
	+ for each shortly delayed train out of 20	0.0	0.0
	Announcement of perturbation, cause and size	-9.9	-13.2

Figure 7 Results of the stated preference research for commute/education and other travel (utility coefficients divided by the travel time coefficient)

Output of the tool

The final sub-sheet in the Excel file contains the results, the output. The first table (Figure 8) contains the calculation of the improvement of service as perceived by travellers, expressed in minutes equivalent travel time. The structure of this table is similar to the structure of the stated preference results that was described before (Table 2). For each travel purpose and for both present and future situations, the total disutility of the service as perceived by the traveller is calculated. By taking the difference between future and present situations the improvement per person in equivalent travel time is determined.

Utility Calculation

	Present	Future	Utility (in equivalent travel minutes): Purpose = commute/education, Present	Purpose = commute/education, Future	Purpose = other, Present	Purpose = other, Future	Average over both purposes, Present	Average over both purposes, Future
Travel time	0:15:21	0:17:10	15.35	17.17	15.35	17.17	15.35	17.17
Short delay (5-15 min.)	2.7%	0.1%						
Contribution delayed trains 0-3 out of 20			2.50	0.06	3.35	0.08	2.75	0.07
Contribution delayed trains 4-6 out of 20			0.00	0.00	0.00	0.00	0.00	0.00
Contribution delayed trains 7+ out of 20			0.00	0.00	0.00	0.00	0.00	0.00
Total			2.50	0.06	3.35	0.08	2.75	0.07
Long delay (15+ min.)	0.0%	0.0%						
Contribution delayed trains 0-3 out of 20			0.00	0.00	0.00	0.00	0.00	0.00
Contribution delayed trains 4+ out of 20			0.00	0.00	0.00	0.00	0.00	0.00
Total			0.00	0.00	0.00	0.00	0.00	0.00
Standing	24.3%	21.3%						
Fixed contribution			2.11	1.85	2.82	2.47	2.31	2.03
Variable contribution with travel time			0.85	0.83	1.14	1.12	0.93	0.92
Total			2.96	2.68	3.96	3.59	3.25	2.94
Standing, crowded	0.1%	0.1%						
Fixed contribution			0.03	0.03	0.04	0.05	0.04	0.04
Variable contribution with travel time			0.00	0.00	0.00	0.01	0.00	0.00
Total			0.04	0.04	0.05	0.05	0.04	0.04
Information level	1	1						
Fixed contribution			0.00	0.00	0.00	0.00	0.00	0.00
Variable contribution with short delayed trains			0.00	0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00	0.00
Total			20.85	19.95	22.70	20.89	21.38	20.22
Difference (in minutes)			-0.89		-1.81		-1.16	
Difference (in h:mm:ss)			- 0:00:54		- 0:01:49		- 0:01:10	

Figure 8 Output sheet with the utility calculation for both present and future travellers for "commute/education", "other" or "mixed" travel purposes

This way of displaying the result is not very informative for a person who has no knowledge about utility functions. An alternative way to present the result is to look at an "average traveller" and list the modifications for him/her as a result of the project. Each modification is converted into a value in terms of equivalent travel time. The complete calculation for an average person is shown in Figure 9. [1]

[1] Note that the total of improvement in both Figure 8 and Figure 9 is the same: 1 minute and 10 seconds (1.16 minutes).

Average Person Calculation

	Present	Future		Delta (minutes)	Delta (h:mm:ss)
For an average person					
Travel time increases	0:15:21	0:17:10	=	1.82	+0:01:49
24.3% of his time he is standing and he has to stand longer			~	0.11	+0:00:07
0.1% of his time he is standing in a crowded environment and he has to stand longer			~	0.00	+0:00:00
Probability of having a short delay (5-15 min.) decreases	2.7%	0.1%	~	-2.68	-0:02:41
Probability of having a long delay (15+ min.) remains the same	0.0%	0.0%			
Probability of having to stand decreases	24.3%	21.3%	~	-0.41	-0:00:25
Probability of having to stand in a crowded environment increases	0.1%	0.1%	~	0.00	+0:00:00
Information level remains the same	1	1			
Total				-1.16	-0:01:10

Figure 9 Output sheet with results of the project in terms of equivalent travel time for an average traveller

The final part of the output sheet contains a summary of the total results per year, for all passengers in both directions together (Figure 10).

Year totals

		Purpose = commute / education	Purpose = other	Average	
Gain per passenger		0.89	1.81	1.16	in equivalent travel time minutes
Benefits per passenger		€ 0.15	€ 0.30	€ 0.19	in euro's
per day (40,000 passengers)				€ 7,725.23	
per year (200 days)				€ 1,545,046.34	
Passenger increase per day	1,084 (2.7%)				
Passenger increase per year	216,773				
Extra benefits due to new passengers				€ 20,932.79	
Total benefits				€ 1,565,979.14	

Figure 10 Output sheet with aggregated totals

7. APPLICATION TO THE “RER B NORD +” PROJECT

Context

RER B is a heavy rail line that serves the suburbs of Paris, and crosses the city from North to South. It is operated both by RATP and SNCF. RATP operates from the southern suburbs to Gare du Nord underground station (terminal station of Eurostar and Thalys), and SNCF operates from there to the northern suburbs, the so-called “RER B Nord”. The line is split into two branches in the northern part after the station of Aulnay-sous-Bois: one branch terminates at Charles de Gaulle Airport, the other one at Mitry-Claye (see Figure 11).

Figure 11 Part of the RER-B line (dark blue line) that is under consideration in this example

Several types of rail services are run on the common section of this line: some trains serve every station of the line, some trains are direct between Aulnay-sous-Bois and Gare du Nord, and some others serve only main intermediate stations. During peak hours the frequency is twenty trains per hour in the most crowded direction. The tracks of this part of the line are owned and maintained by RFF.

Issues

RER B Nord currently carries 245,000 passengers per day. Patronage of some stations is growing significantly, for instance the new station serving Stade de France.

The line suffers from poor punctuality. In 2003, the proportion of trains delayed by more than 5 minutes at their destination (which is the indicator of the contract STIF - SNCF) amounted to 10.8%. This figure is higher than the 2002 and 2001 statistics (7.9% and 8.5%) and is also higher than the average for all SNCF lines in 2003 (9.8%).

The delays could have various causes such as rolling stock failure, non-availability of staff, ill passengers, accidents, vandalism… However, the technical characteristics of the line have a worsening impact on service operation:

- There are four tracks, two in each direction. RER B trains share some portions of the rail tracks with other rail services: regional trains, interurban trains and freight trains. These trains have different speeds, priorities and operating constraints, which leads to conflicts in the use of infrastructure.
- In order to shift from one track to another, RER B trains may have to cross the opposite tracks and then insert between two other trains. The situation is worsened in some cases where there are only 3 tracks instead of 4. In this case, on the same track, trains can run alternatively in one direction and another.
- On the Charles de Gaulle branch, there is no installation that allows trains to change their direction, or installations that allow trains to overpass a stopped one. Any problem on this branch can lead to a total disruption of traffic.

Improvement proposed

In order to improve this situation, a project called "RER B Nord +" has been proposed jointly by SNCF and RATP, and was approved by the board of STIF in February 2005. This project consists of improving the overall quality of service for this line, including the stations, rolling stock, comfort, level of service, the interchanges and punctuality.

Different technical measures are proposed in order to improve the punctuality. RER B trains will run on two dedicated tracks, one for each direction. This will suppress all crossing conflicts and mixed use of infrastructure. Specific installations will be built on Charles de Gaulle branch, allowing trains to run in the opposite tracks so as to overpass a stopped train. Installations will also be built to allow the reversal of trains when the line is out of service beyond a certain point, in case of accident for example.

The consequence of the dedication of tracks is that the timetable must be changed because it is impossible to have direct and omnibus trains operating on the same tracks. Therefore, it has been decided to have only trains serving all the stations ("omnibus trains"). The number of trains per hour will remain the same on the whole (20 per hour) but the frequency at some stations will be much higher than today. Of course, travel time for travellers going from the terminal stations to Paris will be longer than today, but time losses will be less important than waiting time savings.

The total investment cost of the project amounts to 324 million € (all amounts are in € 2004). An initial cost benefit analysis has been conducted taking into account as benefits mainly the travel time savings due to the new service and the passengers*km shifted from private car to rail. Travel time savings have been estimated at 31 million Euro/year in 2010, savings from modal shift alone amount to 11 million Euro/year.

Appraisal of the punctuality benefits of the project

The initial cost benefit analysis of the project has already demonstrated its interest. However, the total benefits are actually higher when the punctuality improvements are taken into account (note that the results of the present study were not available at the moment when the initial cost-benefit analysis was carried out).

As we have seen in the previous chapter there are two options to estimate the punctuality benefits: (1) using more global estimates of the average effect per passenger, or (2) using the results from a detailed train operation simulation model, such as operated by RFF. In both cases the tool described can be used.

Input data

In order to apply the tool using option 2 it is necessary to collect different data both for the present and the future situations. :

- Number of passengers for each level of short delays (1 out of 20 trains, 2 out of 20 trains etc.)
- Number of passengers for each level of long delays
- Minutes spent travelling standing
- Minutes spent travelling standing in a crowded train
- Information level

Simulations on trains operation have been made by RFF and SNCF. They describe how external causes impact the theoretical timetable in the current situation and in the future situation for morning peak hours. In order to make a precise assessment, all origin to destination pairs must be considered separately.

At this point of the study, it has not been possible to collect all the required data for a complete assessment. However, to appreciate the savings due to enhancement of punctuality, a basic calculation can be done based on general statistics (option 1 approach).

Calculation

The inputs to the punctuality appraisal tool can be summarised as follows:

- Average over both directions
- Existing regularity level: 10.8% delays 5-15 min
- Commute and education: 84%
- Regularity level after project: 7.9% delays 5-15 min (value reached in 2002)
- 20,000 passengers per hour during peak hour for the most crowded direction
- 217 days per year
- Value of travel time 16.19 Euro per hour (for the year 2010)
- Demand elasticity of travel time 0.0 (we ignore new, induced demand here).

With these inputs, the assessment tool gives an equivalent time saving per trip of 2 minutes and 50 seconds. The results for one peak hour have to be expanded to one whole day and one whole year. We consider that morning peak hour is 2/3 of morning peak period and use the same values for the evening peak. This leads to 60,000 travellers per day who will benefit from the improvement of punctuality. In a year there are about 217 days with a similar peak hour travel pattern (excluding holidays and weekend-days).

Using the coefficient values found in the stated preference research the punctuality benefit of the RER B Nord+ project amounts to:

- Savings in equivalent travel time: 2 minutes and 50 seconds average per passenger

- Benefit for "existing" passengers: 9.9 Million Euro per year (in Euro 2004, using Value-of-Time for 2010)

The total annual benefit of 9.9 million Euro due to improved punctuality is about 32% of the value of the 31 million Euro benefit due to travel time reduction. Total benefits related to travel time plus punctuality improvements amount to 41 million Euro.

Use of the valuation method for other projects

The study reported here has shown the relevancy of appraising investments aiming at reducing unpunctuality in the case of RER B Nord (although we learned that we should have collected the required data earlier and more accurately).

Two other RER lines in Ile de France (lines C and D) suffer from high levels of unpunctuality. Projects aiming at improving regularity for these lines are currently being discussed. However, for these lines the timetables are unlikely to change substantially compared to the existing ones. As a consequence there is less benefit to be expected from waiting time and travel time reduction. The only improvement of the projects will therefore be due to the improvement of their punctuality. The results of the present study will be of great importance to justify these two projects.

The results can also be extended to contexts outside the Ile de France region. In the absence of any local empirical evidence the results obtained here can be used, as a first estimate. Of course it is desirable to conduct similar research, to test whether or not the local valuations are the same as those obtained in the Ile de France, and to modify the parameters if necessary.

8. SUMMARY AND CONCLUSIONS

In this paper we have described the results of a research project that aimed to provide a robust operational methodology to assess the perceived benefits of investments to improve punctuality of suburban rail services to and from Paris. An SP experiment has been conducted among 1,200 train users to obtain values of reliability. Also a simple tool was developed to quantify the benefits of specific projects. This was applied to the RER B Nord+ project.

With regard to the value of reliability, the research indicated that an improvement in punctuality, expressed as a 5% reduction in the number of trains 5-15 min delayed, was worth about 4.6 minutes of travel time for commuters/education.

Comfort appeared to be important, with particularly a clear dislike of the passengers of having to stand in very crowded trains (effect similar to an additional 27 minutes of travel time relative to travelling seated).

Information was also valued as worthwhile: explicit information about the duration of delays (in addition to information about the cause of delays) was valued similarly as a 10 minute reduction in travel time.

A case study carried out to estimate the potential benefits of a project aiming to improve punctuality of the RER B Nord line indicated that total annual benefits of 9.9 million Euro were expected, over and above the 31 million Euro benefits due to travel time savings. So taking punctuality into account added here about 32% to the travel time benefits alone.

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