ANTONIN 3, AN UP-TO-DATE TRANSPORTATION PLANNING MODEL FOR THE ILE-DE-FRANCE REGION

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Significance
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1. INTRODUCTION

ANTONIN is the transportation planning model for the Ile-de-France region in use by the STIF (Syndicat des Transports d'Ile-de-France) since the end of the 90's. STIF is the public transport authority in the Ile-de-France region (Paris region). Its role is to imagine, plan, organise, coordinate and fund the various forms of public transportation in the region.

Technically, ANTONIN is a passenger trip forecasting system designed to produce strategic tests on transport policies and analyses of the evolution of mobility due to evolution of population, travellers' behaviour and new public transport infrastructures. Since its inception, ANTONIN (ANalyse des Transports et de l'Organisation de Nouvelles INfrastructures) has produced numerous traffic forecasts for projects concerning all type of public transport modes (suburban railway lines, metro lines, tramway lines, bus on dedicated lanes, etcetera) and public transport schemes for the region as a whole.

ANTONIN is mainly based on a regional mobility survey (enquête globale transport EGT): EGT 1991 for the first version of ANTONIN, EGT2001 for its second version. In this paper we describe the update to version 3 of the model using the EGT2010 survey. Section 2 shows the overall context of transport in Ile-de-France and the need for accurate traffic forecasts. Section 3 depicts the operating structure of the new version of the ANTONIN model. Section 4 provides quantitative results demonstrating the effect of enhancements of the public transport framework or parking policies. We end this paper with our summary and conclusions for the new ANTONIN version.

2. CONTEXT

2.1. General overview of transport in Ile-de-France

On an average working day in Ile-de-France, more than 40 million trips are made – by walking, cycling, driving and using Public Transport. The main transport system consists of 5 Express Rail lines (RER), 8 suburban lines, 16 metro lines and 8 tramway lines: The bus network is very dense and contains more than 1500 lines all over the region.

Since 2000, the region has witnessed a continuous growth in the use of Public Transport, as is shown in Figure 1:
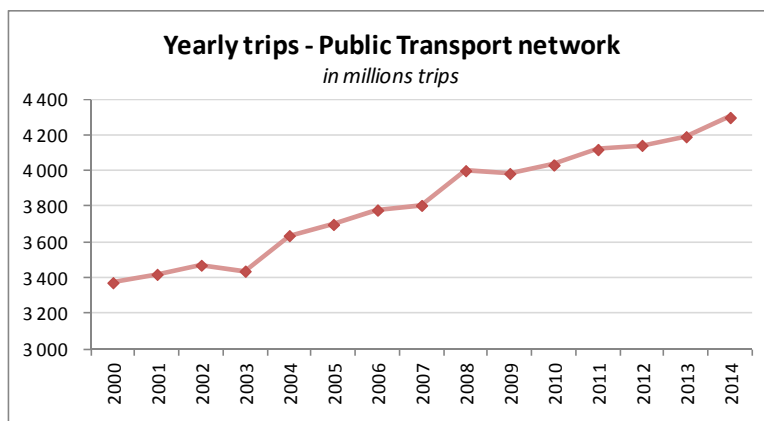
Figure 1 Annual number of public transport trips in the region (STIF, 2015)

Obviously, this continuous growth in Public Transport use calls for regular investments in the infrastructure. The Nouveau Grand Paris plan is a general Public Transport scheme designed to create a more reliable network and to promote the growth in Public Transport use. In addition to upgrading the existing network, it mainly consists of the Grand Paris Express project: by the year 2030, 4 new metro lines will be built and 2 lines extended, bringing 205 km of further automatic metro infrastructures.

2.2. Role of STIF

STIF is the mobility authority for the Île-de-France region. It defines and organizes all public transport services; it defines the fare policy (in particular the Navigo Pass), the contractual relations with operators (such as RATP, SNCF and private operators) and the financial balance of the whole system; it plans and monitors the extensions of the network; it defines the quality standards for intermodality and accessibility.

2.3. Main challenges for STIF in the coming years

The ANTONIN model brings support to decision making for two of the three main challenges identified for STIF in the coming years: getting prepared for Nouveau Grand Paris Express project and settling STIF as the authority for sustainable mobility in the region.

In the attempt of reducing GHG emissions by a factor of 4 in 2050, extensive efforts must be carried out to increase the use of shared transportation schemes. That relies not only on an extension or upgrading of the public transport system, but also on a more global consideration of transport facilities. STIF has become the authority of sustainable mobility which will confer some further responsibilities like car/bicycle sharing, carpooling or individual cycling.

For this purpose, STIF requires a transportation planning model capable of an accurate design/appraisal of public transport projects at a local scale and also capable of anticipating mobility changes in order to make reliable decisions for the future.

3.   ANTONIN, A COMPLETE METHODOLOGY FOR TRAFFIC FORECASTING

ANTONIN 3 is composed of a succession of demand models that are mainly derived from the regional household survey. But beyond the quality of the model, the quality of forecasts is also based on reliable databases for inputs, consistent and rigorous hypotheses and a general procedure in the use of the model by STIF modelling team, proven by several completed traffic forecasting studies.

3.1.   Structure and general principles of the model

The structure of ANTONIN is based on that of widely accepted disaggregated transport models. It uses multinomial logit models to predict the various choices made by travellers in the Ile-de-France region.

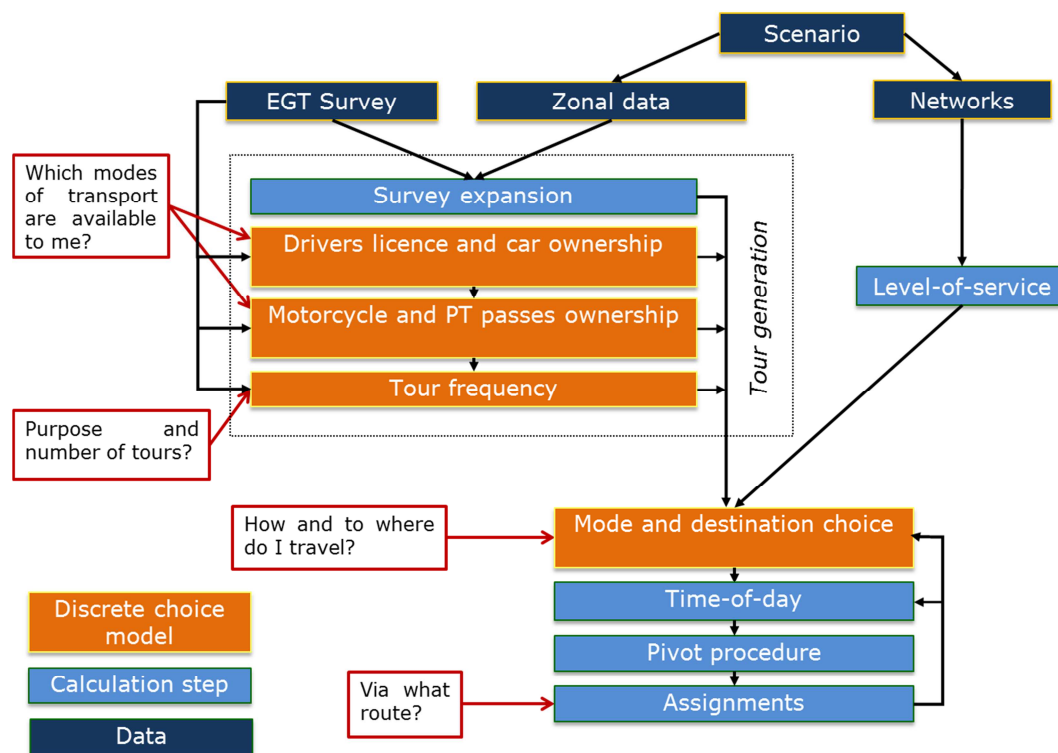The following figure depicts the modelling process of ANTONIN.

Figure 2 The modelling process of ANTONIN 3

The model uses the EGT survey and determines for each household and each member in that household probabilities of:

- Having a drivers licence

- Owning a car (or more in the household),

- Owning a motorcycle

- Having a public transport pass

- Making tours for certain purposes

These probabilities form the tour generation and are used as the starting dimensions for the choice of travel mode and destination of travel. After the application of the disaggregated mode-and-destination choice model, the transport patterns found are aggregately split to times-of-day, confronted with observed travel patterns in a pivoting procedure and subsequently assigned (capacity constrained) to networks for private car and Public Transport. A feedback loop is implemented to allow mode-and-destination choice and time-of-day choice to be dependent on the congestion and crowding levels found.

3.2. Calibration of the models and comparison to the previous version

Using the latest EGT2010, the various components of the model system were re-estimated and new features were incorporated in the updated ANTONIN model. These new features comprise for instance a new motorcycle model and the availability of motorcycle (and bicycle) as a travel mode in the model system.

In previous versions of ANTONIN, the Public Transport sub mode choice was modelled in the mode-destination choice model, but to allow more flexibility in the definition of the various components of Public Transport in the region, the Public Transport sub mode choice is now modelled at the assignment stage. However this gives more emphasis on the assignment so that a more consistent use of model parameters was required in the model system to avoid potential behavioural inconsistencies within the chain: level-of-service, mode-and-destination choice and Public Transport assignment. Therefore composite costs[1] are derived in the level-of-service module and used consistently in the model.

The implementation of the PT assignment has been improved by using parameters for the trade-off between in-vehicle time, waiting time, walking time, boarding time and transfers, that were based on logit estimation techniques. This was done by confronting the chosen PT route (as recorded in the EGT) with alternative routes and thus finding the best set of parameters that match the chosen route.

To implement the effect of crowding on PT route choice, comfort parameters were implemented from a value-of-comfort study (using Stated Preference techniques) carried out recently for the STIF. And feedback loops have been incorporated in ANTONIN to allow crowding and congestion to have an impact on mode-and-destination choice.

Given STIF's mission these improvements are important to address the issues that STIF encounters in modelling transport in Paris region.

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[1] An example demonstrating the composite cost calculation is given in the appendix.

3.3. Methodology put into practice

STIF has acquired for the last two decades a considerable experience in traffic modeling. Each year, it provides over 20 studies on various projects such as new/extensions of railway, metro or tramway or tram-train lines, bus rapid transit systems or bus restricted lanes, master plans for railway lines, restructuring of bus networks, interchange stations, cable car systems or river shuttles.

ANTONIN, like every transportation model, is based on a zonal representation of housing and work locations. ANTONIN consists by default of 1805 zones. For each study, this regional zoning is specifically refined to yield a realistic pattern of trips within the project area with respect to land use. On top of that, the level of public transport services and road networks are locally checked or completed.

Once this preliminary step is done, the study manager performs a careful calibration of the model so that the assigned PT network fits (as close as possible) to counts and surveys following a top-down process of checking: number of transfers from heavy (train) to light (bus) PT modes, number of boarding/alighting passengers and modal choice for access/egress by station, and origin-destination pattern along a line. This calibration is manually done (without the use of an automatic calibration tool) so that all calibration parameters are directly controlled by the project manager in order to meet the real issues of the project.

Once calibrated, the model is applied for future scenarios including increases of housings and works, extension of the public transport network and road policies (parking cost, speed limited area) to provide traffic forecasts. Sensitivity tests are commonly performed to overcome eventual lacks in calibration accuracies or to probe changes in mobility behaviors.

4. TESTING ANTONIN 3: THE IMPACT OF GRAND PARIS EXPRESS METRO

ANTONIN 3 is currently in a test phase before final validation; and therefore detailed model results are not yet ready for public release. However, we present in this paper some contrasted scenarios for 2030, in order to demonstrate the model's responses to a major modification of the public transport network.

4.1. Ile-de-France region in 2030 and the Grand Paris Express project

From now to 2030, population in Ile-de-France is expected to grow by 0.7% every year, and its jobs by 0.6%. Both population and employment grow faster outside Paris. Inside Paris, the population is expected to grow by 0.3% every year; the labour market will remain stable.
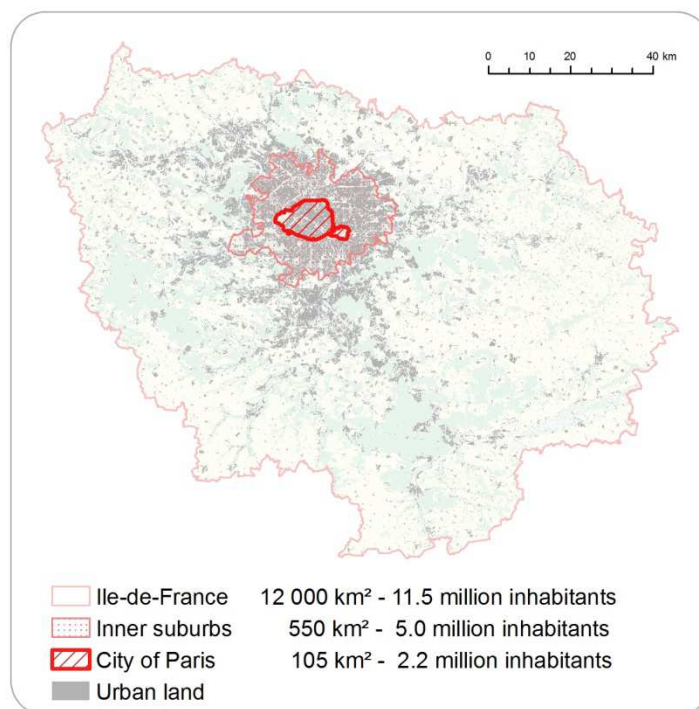
Figure 3 Population of Ile-de-France

Ile-de-France	12 000 km² - 11.5 million inhabitants
Inner suburbs	550 km² - 5.0 million inhabitants
City of Paris	105 km² - 2.2 million inhabitants
Urban land	

The Grand Paris Express project consists in realizing 205 km of new automatic metro lines, 68 new stations, with an expected traffic of 2 million passengers by 2030. It will contribute to a better accessibility especially in the inner suburbs.
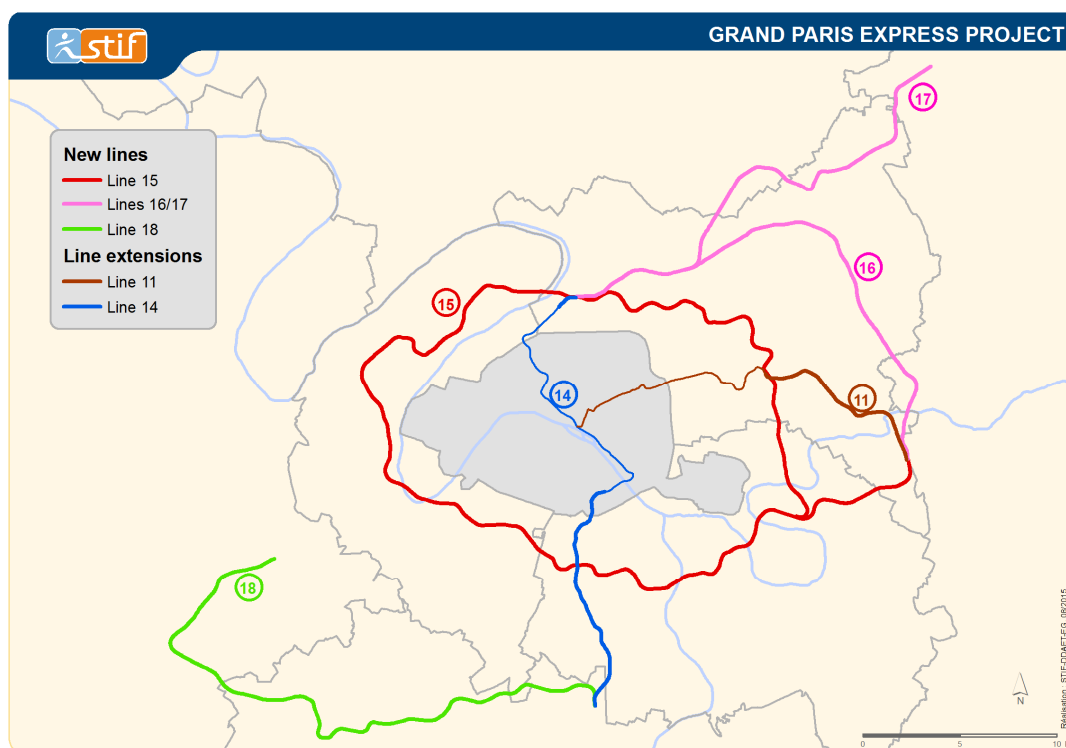

Figure 4 Grand Paris Express Project by 2030

4.2. Tested scenarios

We model four different scenarios in ANTONIN 3:

- REF : a reference scenario which depicts a realistic situation in 2030, but without the metro line extensions and creations of Grand Paris Express,

- LOW : REF scenario + metro lines of Grand Paris Express,

- MID1 : LOW scenario + parking restrictions on Grand Paris Express territory,

- MID2 : MID1 scenario + increase of bus frequency in the suburbs.

From REF to LOW scenarios: metro lines 11 and 14 are extended, metro lines 15 to 18 are created (vehicle-kilometers on metro network increase by 80%) and regional train network (RER and suburban trains) is consistently connected to the metro lines (vehicle-kilometers hence increase by 7%).

From LOW to MID1 scenarios: close to the new metro stations, parking policy is updated – with fares of about $2€_{2010}$ an hour depending on location (inner/outer suburbs).

From MID1 to MID2 scenarios: bus frequency is raised by 15% in the inner suburbs and by nearly 40% in the outer suburbs. This growth in frequency is similar to the frequency improvements realised between 2000 and 2010 in the region[2]. In the following, all results are given compared to REF scenario.

4.3. Households equipments and mobility

This paragraph shows the results of the possession and tour-frequency models.

In ANTONIN 3, accessibility given by Public Transport and parking restrictions affect households equipment, and the overall mobility (number of trips made) as is demonstrated in Figure 5:

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[2] Note that in this scenario, only existing buslines are adjusted. They are not yet fully adapted to the GPE network.
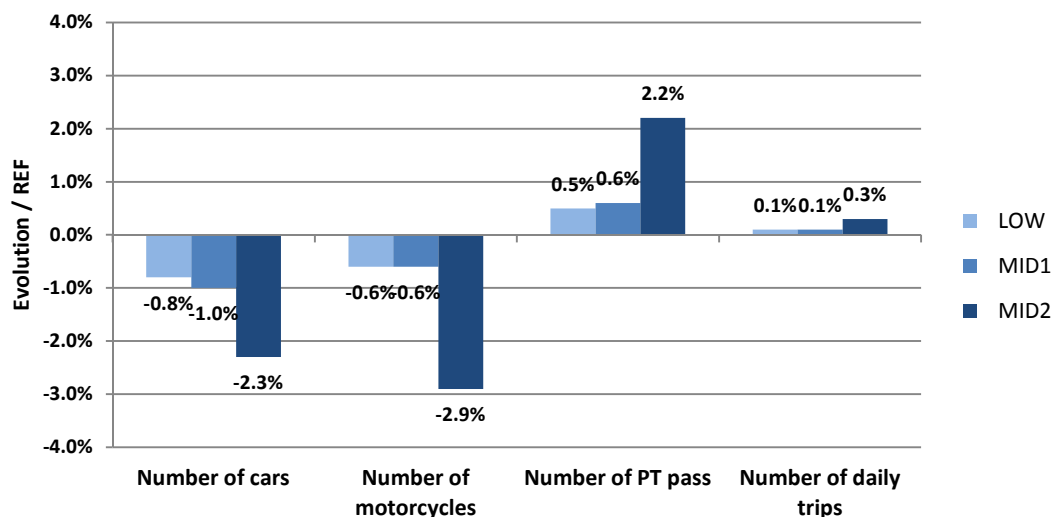
Figure 5 The effect of the scenarios on households equipment and mobility

As the model approximates the accessibility by the number of services available to the traveller, it is the development of bus services in the whole region that has the greatest impact.

4.4. Destination choice and modal shift

Disaggregated mode and destination choice models from ANTONIN 3 are defined for 12 different purposes – all of them using different individual characteristics or local amenities, but all based on level of services by mode: time and cost for individual motorized modes (car and motorized two-wheelers), distance for active modes (walk and bicycle) and the composite cost[3] of Public Transport (close to a logsum of PT routes).
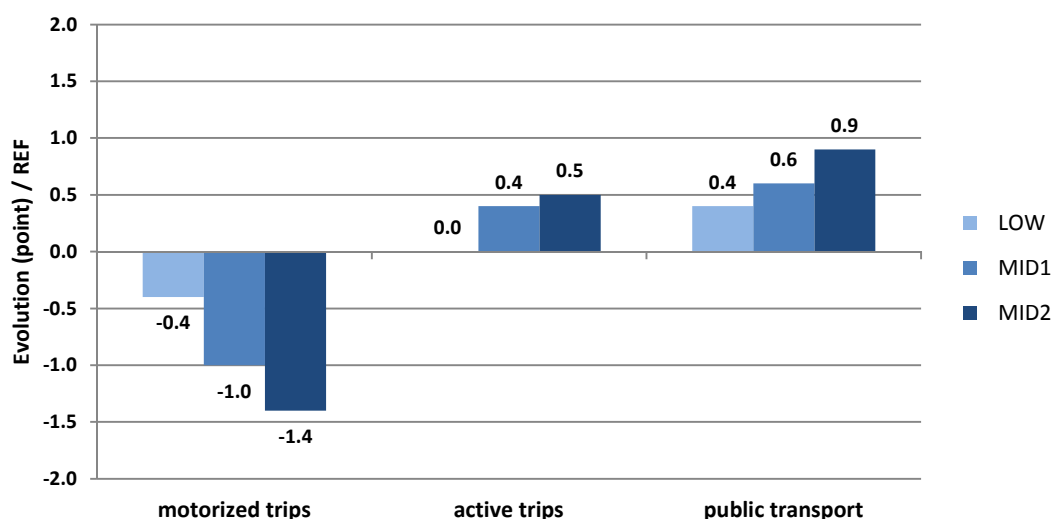

Figure 6 The effect of the scenarios on the variation in mode shares

Metro lines alone encourage modal shift from motorized trips to public transports (-0,4 pt). Hardening parking policies for accompanying the metro

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[3] See the appendix for more details

reinforce this effect (-0,6 pt), and also benefit to active modes. Bus lines, by improving access to major lines and especially the Grand Paris Express metro, also cause modal shift to public transport (-0,4 pt).

In MID2 scenario, bus lines are improved at a significant level; but although the magnitude is consistent, this scenario may underestimate the impact of bus offer as additional bus services are based on existing lines and are not (yet) adapted to new population and jobs, nor fully connected with the new public transport network (Grand Paris Express).
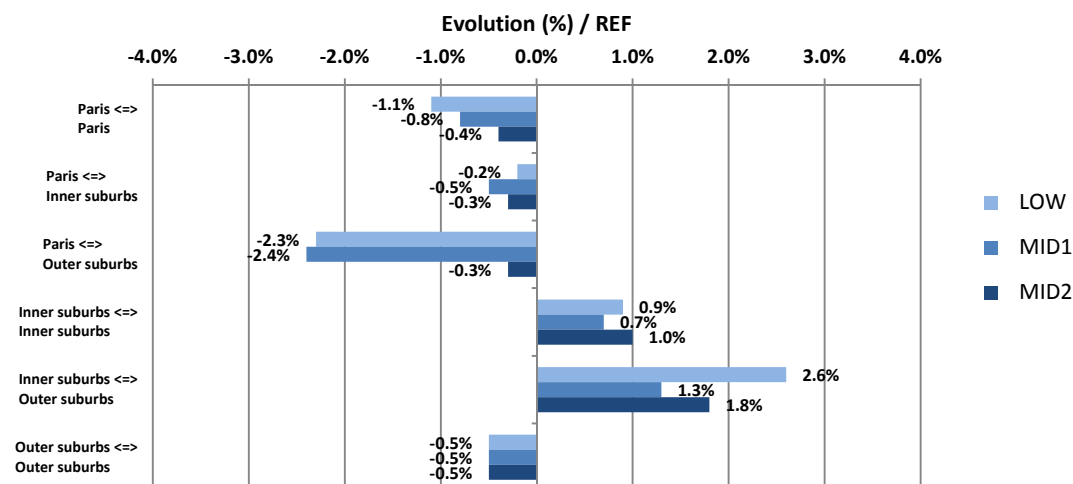

Figure 7: The effect of the scenarios on the number of daily trips (all modes)

Scenario LOW demonstrates that Grand Paris Express's metro lines provide better connectivity in the suburbs: trips within the inner suburbs and exchanges between inner and outer suburbs increase at the expense of other destinations – the polarization of trips towards Paris is reduced.

4.5. A reduced car use

The use of car decreases throughout the region. GPE, parking fares and rise in bus frequency have, when combined, significant impacts, particularly on trips involving inner suburbs, as is demonstrated in the next figure.
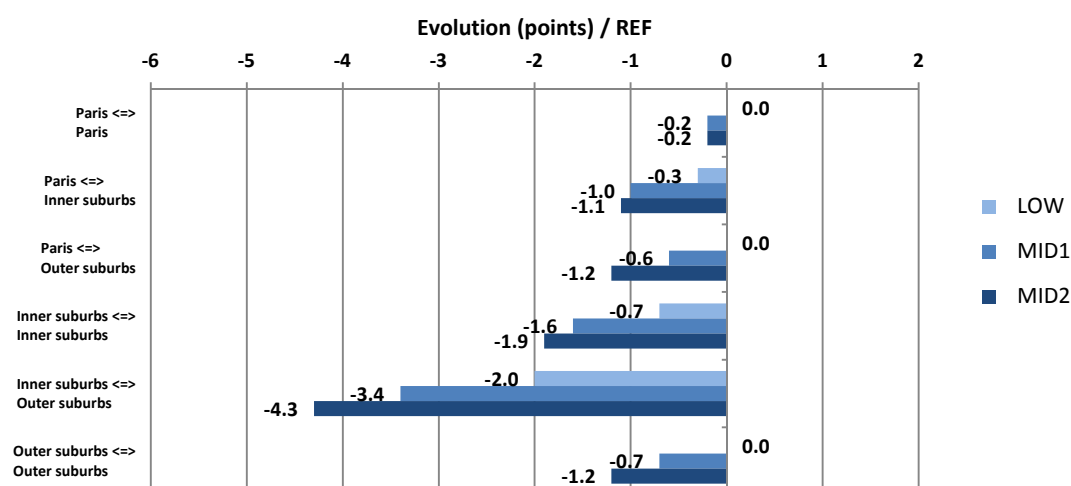
Evolution (points) / REF

-6   -5   -4   -3   -2   -1   0   1   2

Paris <=> Paris: 0.0, -0.2, -0.2

Paris <=> Inner suburbs: -0.3, -1.0, -1.1

Paris <=> Outer suburbs: 0.0, -0.6, -1.2

Inner suburbs <=> Inner suburbs: -0.7, -1.6, -1.9

Inner suburbs <=> Outer suburbs: -2.0, -3.4, -4.3

Outer suburbs <=> Outer suburbs: 0.0, -0.7, -1.2

Legend: LOW, MID1, MID2

Figure 8 The effect of the scenarios on the car driver mode share

In the peak period, we have analysed the effect of the scenarios on motorised trips and distance travelled. We have also looked more closely at the major GPE OD's. These GPE ODs are the major origin-destinations contributing to 80% of all trips using Grand Paris Express stations in the LOW scenario. These origin-destinations account for fewer than 10% of all PT trips.

Compared to REF / peak period	Whole region		Number of motorized trips on GPE ODs
	Number of motorized trips	Average distance of car driver trips	
LOW	-1.0%	stability	-1.8%
MID1	-2.6%	stability	-4.5%
MID2	-3.5%	-0.1%	-5.7%

Table 1 The effect of the scenarios on motorized trips and average distance

The table shows that the number of motorized trips is reduced for the region as a whole and (more substantially) for the GPE OD's. However the average distance travelled by car remains stable.

Other supporting measures, not tested in this paper, are likely to be adopted to further reduce car use – for instance, a reduction of road capacities available for cars, or speed limitations.

4.6. A more connected public transport system

ANTONIN 3 models Public Transport through two access modes (PT with walk or car access), and two user classes (people under 55 and people 55 and over). The assignment is implemented in one system, where all modes and lines contribute to the quality of service: proximity to PT network, travel time, frequency, transfers. The quality of service is important for the inhabitants of the region, and the results of the scenarios can be visualised for instance through the job accessibility:

In 2012, Ile-de-France's population is about 12 million inhabitants for 5.5 million jobs. The accessibility for these jobs is heterogeneous since the highest quarter of commuters may access almost 4 million jobs within an hour using Public Transport, while the lowest quarter has access to not more than a million jobs.

In 2030, Ile-de-France's population is expected to reach 13 million inhabitants and 6 million jobs, with a growing heterogeneity in accessibility if nothing would be done. In the Grand Paris Express' area, where housing concentration will grow, the accessibility may grow by half a million jobs within an hour as a result of the introduction of the GPE.
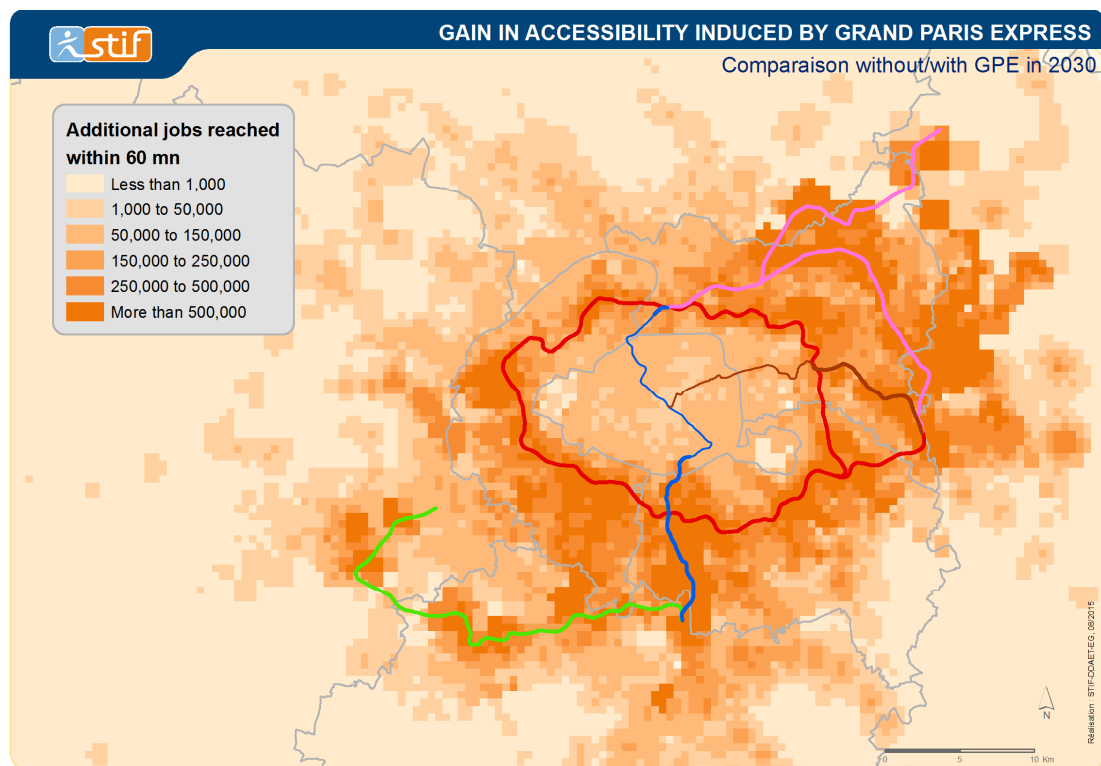

Figure 9 Accessibility gain

The effects of the three scenarios on the use of Public Transport are shown in the following table.

Compared to REF / peak period	Whole region		Number of PT trips on GPE ODs
	Number of PT trips	Passengers x km	
LOW	+0.8%	+3.5%	+6.9%
MID1	+1.5%	+4.4%	+7.7%
MID2	+2.9%	+6.8%	+9.1%

Table 2 The effect of the scenarios on Public Transport

At a regional scale, PT trips increase by the same order of magnitude as the car trips reduce. Within the ODs of the Grand Paris Express project however, the increase is twice as high.

Another difference concerning car use: the shortening of travel times induced by GPE through decreased headways on buses is counterbalanced by longer distances on public transports. Travellers can travel now longer distances within the same total time and thus tend to make longer trips (to destinations further away).
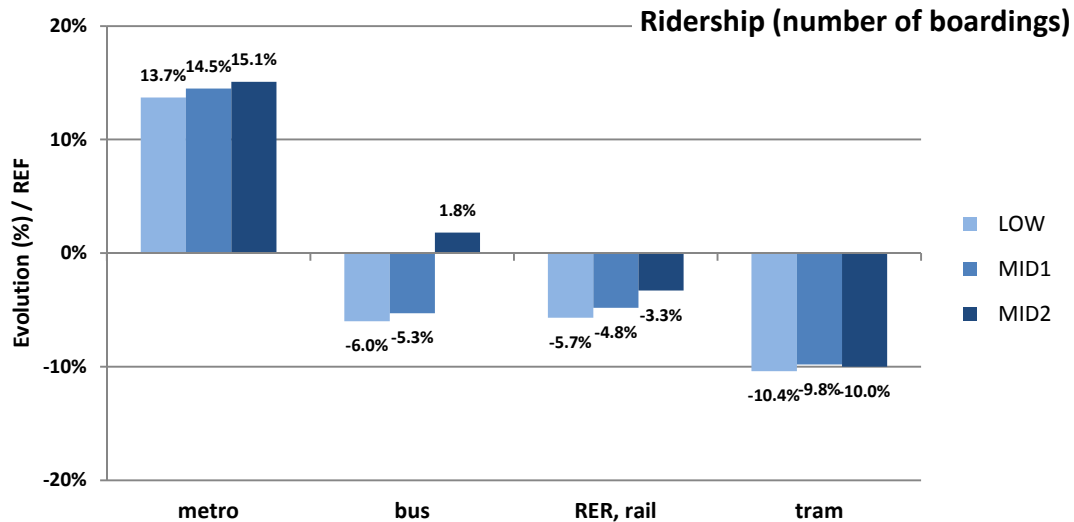

Figure 10 The effect of the scenarios on Public Transport Ridership

The introduction of the Grand Paris metro lines alleviates the PT lines inside Paris, by allowing a by-pass in the suburbs; the traffic close to metro stations increases but at a regional level, the other modes witness a decreased number of boardings.

In the MID2 scenario, improved service for buses allow a better access to the new metro network, although the increase in metro trips remains low. This strengthens the hypothesis that the overall traffic of the Grand Paris Express project may be underestimated by an incomplete definition of additional bus services, since additional feeder bus services have not been implemented (yet) in this scenario.

5.   SUMMARY AND CONCLUSIONS

In the Île-de-France region a continuous growth in the use of Public Transport is observed, which calls for tools to evaluate the various options in Public Transport development. ANTONIN is a decision support tool for the STIF to assist in these evaluations. The new version 3 has been made up-to-date to the most recently surveyed travellers' behaviour and improvements have been made to allow a wider variety of Public Transport modes to be modelled. The model application contains a consistently applied set of parameters which are based on available data for the region. Some initial tests of the model have been carried out yielding plausible results, the model is currently undergoing further tests for an operational use expected later this year.

APPENDIX: EXAMPLE OF COMPOSITE COSTS CALCULATION IN ANTONIN 3

Composite costs (similar to logsums) give an overall figure for the level-of-service between origin and destination. Composite costs comprise the generalised costs but include also the value of additional connections (even with a higher generalised cost) since the benefit of the extra connection is taken into account. The following example might illustrate this effect:
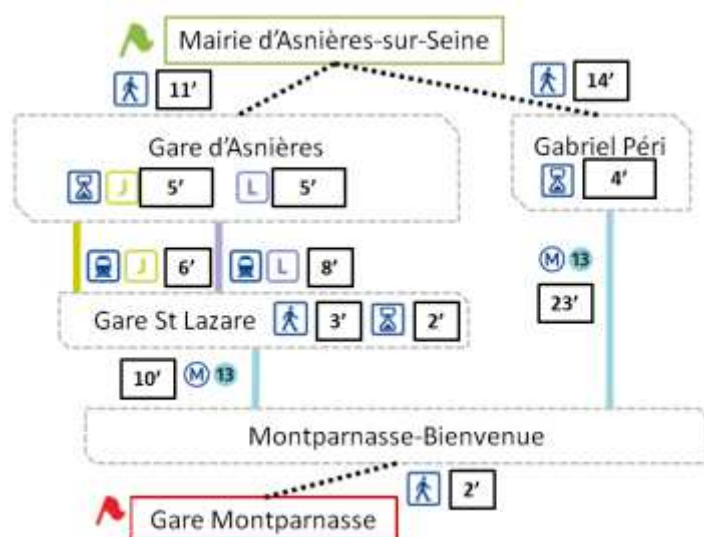
From Mairie d'Asnières-sur-Seine to Montparnasse-Bienvenue, three public transport routes are likely to be used:

Route	Real time	ANTONIN 3 generalized cost for userclass 1	Route probability in ANTONIN 3
Line J+M13	39 min	62.33 min	18.92%
Line L+M13	41 min	63.99 min	14.15%
M13	43 min	55.11 min	66.93%

If metro line 13 alone is in operation, the composite cost is 55.11 min. Allowing alternative routes by adding line J and L, even if these routes have higher generalized cost, improves the public transport system and the composite cost reflects this improvement as is given below:

Lines in operation	Number of possible routes	Composite cost
M13	1	55.11
M13 + J	2	53.69
M13 + J + L	3	52.82