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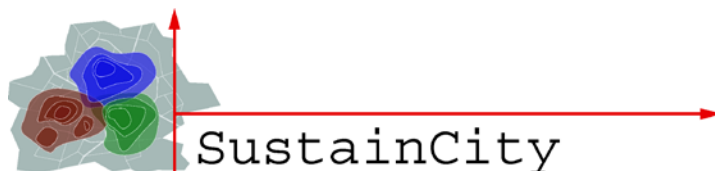
Calibration of METROPOLIS for Ile-de-France

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Contents

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Abstract

This paper summarizes the calibration procedure and the final results of calibration of the transport model METROPOLIS for Ile-de-France region. It also presents a brief description of the different sources of data available and their uses for modeling and calibration purposes.

Calibrations results were compared on both aggregate and disaggregate level with the field data obtained from different sources. The results suggest that METROPOLIS, which is a dynamic traffic simulator, can give precise prediction of the real traffic situation for Ile-de-France region.

Keywords

Dynamic model; Traffic simulation; METROPOLIS; Model Calibration

Preferred citation style

Executive Summary

This report is dedicated for calibration of the travel model METROPOLIS (de Palma & Marchal, 2002) (de Palma, Marchal, & Nesterov, 1997) for Ile-de-France network. Later this calibrated model will be coupled with UrbanSimE which is an Open Source urban simulation system designed by Paul Waddell (Waddell, 2002). A coupling idea has been discussed in work package 6 (Nicolai & Nagel, 2010). UrbanSimE has been developed with numerous collaborators in the University of Washington, to support metropolitan land use, transportation, and environmental planning. The software uses the inter-relation between land use, transportation, economy and environment to simulate urban development. For the first time it will work in tandem with a dynamic transport model.

The travel model METROPOLIS has a dynamic traffic simulator which uses mesoscopic approach of simulation where each vehicle is described individually by the simulator. The modeling of congestion on the links is carried out at the aggregate or macroscopic level. The disaggregate representation of demand allows to consider the heterogeneity of the population and trips. A small description of METROPOLIS simulation process has been described in Section 3.1 of this report.

The region Ile-de-France covers about 12000 sq. km embracing Paris and its suburbs. The region occupies 2% of the surface of France and represents 19% of the population, 22% of the jobs and 29% of the GDP of the country(de Palma, Motamedi, Picard, & Waddell, 2005). The road network is organized into a hierarchy which is densely interconnected and often congested. Over the region, 46% of trips are carried out by cars, 20% by public transport and 34% by other modes like walk and bike. Total number of trips generated inside the region estimated from the EGT travel survey 2001, was about 35.16 million per day and 36.9 million in 2005.

Calibration of METROPOLIS will be based on collected data of traffic flow and travel time, and aggregate measures of the network. The data for modeling and calibration have been collected from different sources. Available data and their sources will be discussed in details in the Section 2.6.

Ile-de-France network is coded with 1 289 internal zones in METROPOLIS, and 50 zones representing the entry/exit points of the region. The road network is coded by 43 858 links within them 4 462 are the connectors. Link length varies from 2m to 17km. This implies in-

troduction of a large number of short links to represent explicitly the turnings in crossings and all the ramps and loops in the interchanges.

The implementation of a dynamic traffic simulator needs driver behavioral parameters regarding departure time choice, mode choice and route choice. These parameters require estimation from specific survey dedicated to this purpose. For the case of Ile-de-France area a specific survey named MADDIF was conducted in the year 2000, where people were asked by phone about information's concerning their morning trips for the same day (de Palma & Fontan, 2000). During the estimation of behavioral parameters, the best results came from following classification of trips:

- Home to Work to Paris and Near Suburbs
- Home to Work to Outer Ring
- Other purposes

Results of the estimation are presented in Section 3.3 along with the distribution of desired arrival time for the selected three population categories.

As dynamic simulation of a large network like Ile-de-France requires long time, demand has been reduced to 10% to solve this issue. The roadway capacity has been adjusted to fit this demand (see the theoretical justification to do so in the paper by (Arnott, de Palma, & Lindsey, 1993)). The idea behind calibration of Ile-de-France network was to run the simulation with the initial data and compare the results with filed measurement. Traffic flow data has been collected for 606 different links and travel time data for 124 O-D pairs throughout the network. A time period of 6AM to 10AM has been selected for calibration. One key parameter has been calibrated at a time. The process could be lengthy but effective as the effect of a particular parameter over the network could be observed. The process has been described in details in Section 4.1.1.

Calibration result can be categorized as aggregate results and disaggregate results. Aggregate results are automatically produces from METROPOLIS after each simulation explaining the overall network performances. Disaggregate results are harder to obtain since they are not atomically produced. METROPOLIS keeps all its iteration results in a database which can be accessed by mysql. Some small queries can produce the required disaggregate data from the database.

Aggregate results consists of efficiency measure for the network such as, average travel time, travel cost, early/late schedule delay cost, free flow cost, speed, consumer surplus, level of congestion, vehicle kilometers, etc. In disaggregate level link flow on some selected links,

distribution of flows on those links and travel time for some selected O-D's have been collected. Also there are results which fall between these two categories; they are referred as semi-aggregate results. These results include: travel time and cost for different user types, distribution of simulated departure time, distribution of simulated arrival time, and isochrones of travel time from city center.

Proper field data is not available to compare all the aggregate measure of efficiencies from METROPOLIS. But the results seem reasonable by comparing some of them with the available results. For example, the average travel time from a regional static model MODU for Ile-de-France is 16.33 min and METROPOLIS predicts 18.2 min.

Similar comparison can be made for disaggregate results. The distribution of both departure time and arrival time fits with the observed field distribution. It indicates that the model can simulate the temporal distribution of flows and can predict the peak in right position. These are necessary for forecasting the temporal distribution of other parameters like congestion, speed, travel time etc. A correlation between the field and simulated traffic flow for 606 selected links showed that the model can capture 84.4% variability in the data, which is reasonable for a network of this size. Also the distribution of flow over time reflects the field condition precisely. Comparison of simulated and filed travel time for selected 124 O-D's also showed good result with a regression coefficient (R^2) of 84.3%.

Observing all these calibration results it can be concluded that the travel model of Ile-de-France is calibrated to a satisfactory level and ready to use for forecasting.

1 Introduction

The SustainCity project intends to implement an adapted framework of micro-simulation integrated land-use – transportation modeling for European cities. The objective of the Work Package 7 (WP7) is to test the new simulation tool UrbanSimE in at least three case studies i.e. Ile-de-France (IDF), Brussels and Zurich. UrbanSimE use the inter-relation between land use, transportation, economy and environment to simulate urban development. In order to improve the simulation results a transportation model will be coupled with UrbanSimE which will provide the accessibility measures after receiving demand from UrbanSimE. METROPOLIS has been selected as the transport model for Ile-de-France.

METROPOLIS is a dynamic mesoscopic model in which the transportation demand is presented in a microscopic manner. This disaggregates representation permits to consider the heterogeneity of the population and trips and integrate the model with the micro-simulation urban model. At the same time, the macroscopic representation of the transportation supply makes an important economy of the computational resources and running time of the model.

The first application of METROPOLIS to the Paris area is implemented during the years 2000 to 2002 at the University of Cergy-Pontoise in QUATUOR project (THEMA/TT&R. (1998 – 2002)). Another application has been done in the framework of the European project McICAM. The first calibration efforts focused on the aggregate and disaggregate level with respect to the data obtained from transportation survey (DREIF, 2005) and some traffic count data available at that date. The main objective was to provide aggregate socio- economic measures of effectiveness with a good predictive quality.

Recently METROPOLIS was used to predict the effect of congestion charging for Stockholm (Engelson, Kristoffersson, de Palma, Motamedi, & Saifuzzaman, 2012) and it confirms that, this software can predict the effect of road pricing quite accurately in terms of reduction of travel time, travel cost, congestion and improvement in speed.

This report is dedicated to the calibration of the travel model METROPOLIS for Ile-de-France network. Calibration of METROPOLIS will be based on some collected traffic flow and travel time data from filed and some aggregate measures of this network which has been collected from different sources. The data for modeling has been collected from different sources also. These sources of data will be discussed in details in the Section 2.6 which has been dedicated for data sources. Later this calibrated model will be coupled with the urban

model UrbanSimE[1]. An Idea of coupling the travel model with the urban model has been developed in the working paper 6 (WP6) (Nicolai & Nagel, 2010).

This report has been organized as follows: In section 2 a brief description of the study area, its population, employment and transport network has been presented along with a detail description of different types of data used in this study and their sources. The first part of section 3 deals with some important modeling features of METROPOLIS. In the second part modeling of IDF network in METROPOLIS has been discussed in details. Section 4 gives a brief description of the calibration procedure used for this study. Then different types of results of calibration have been analyzed with different sources of available data. Finally some conclusion has been drawn over the study in section 5.

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[1] Following the integration of METROPOLIS with UrbanSim and during the SimAURIF project (Nguyen-Luong, de Palma, Motamedi, Ouaras, & Picard, 2008); we have observed some imperfectness in the accessibility measures. The results of different location choice models have shown some inconsistency with expected role of the accessibility. So, we decided to improve the calibration method and data to obtain more realistic disaggregate results. This should be achieved by a better representation of the heterogeneity in the model inputs and parameters. This should provide us a better representation of the heterogeneity of the accessibility across the territory and the population.

2 Study area and its transportation system

2.1 Geography

Ile-de-France embraces Paris and its suburbs. It covers about 12 000 sq. km. Ile-de-France occupies 2% of the surface area of France and represents 19% of the population, 22% of the jobs and 29% of the GDP of the country(de Palma, Motamedi, Picard, & Waddell, 2005). There are 3 administrative institutions in Ile-de-France: 1 "région", 8 "départements" (counties) and 1300 "communes" (municipalities). In addition, the 3 counties around Paris are considered as close suburb or "inner ring" and the 5 counties far away from Paris as far suburb or "outer ring". There are some intermediate divisions between commune and department that are not officially well established. The city of Paris is divided into twenty arrondissements municipaux administrative districts, and over the region we have 48 arrondissements. Data from these arrondissements have been used in some of our analysis to calibrate the O-D matrix.

2.2 Population

According to the Census data in the year of 2008, the city of Paris has about 2.2 million inhabitants, on a regional total of 11.7 million. The population of Paris is estimated to not grow over the next 30 years but the total population will approximately grow about 0.3% yearly (this rate has been 0.4% for Paris and 0.7% for the region during the preceding 9 years). Regarding the suburbs, 46% of the population lives in the near suburbs and 54% in the outer ring. In each ring the population is approximately equal among the departments.

Out of Paris there are 38 communes with a population of more than 50 000, 31 of them are situated in the near suburbs and 7 in outer ring. These communes can be considered as poles of population over the region.

2.3 Employment

The total number of jobs is 5.6 million on 2008. That has grown by a rate of 1.2% per year during last 9 years. About 1.77 million jobs are concentrated on Paris and it has increased over the precedent years. The employments are equally distributed between near suburbs and

outer ring but there is a clear concentration in the two western departments Haut-de-Seine and Yvelines.

Outside of Paris, there are 8 communes with more than 50 000 employments. Three of them constitute the zone La Défense. Three others (Boulogne-Billancourt, Saint-Denis and Levallois-Peret) are immediate neighbors of Paris at West and North. Roissy at North-Est is where the great international airport is situated and Créteil is a great pole at South-East.

2.4 The road network

The road network is organized into a hierarchy that is densely interconnected and often congested. The express network of the region is composed of 590 km of motorways and 250 km of expressways, with a total of 4 500 lane-km. Road traffic flows attain the highest levels known all over the country. But thanks to the efficient road network, and despite the traditional rush-hour traffic jams, traffic conditions are on the whole remarkably good for a metropolis of this size. The average duration of a car trip is 19 minutes, and no more than 25 minutes for commuter trips by car (de Palma, Motamedi, Picard, & Waddell, 2005). The mode market shares for the home based work trips (2001) are: 50% Private cars, 36% Transit and 14% Bicycle/walk.

The public transportation network is diversified into:

- a main radial railway network, especially the RER lines (high speed train service between Paris and the suburbs)
- a subway network that provides comprehensive and timely service in the city centre
- a bus network to complement the rail services

2.5 Transportation Demand

Total number of trips generated inside the region was estimated about 35.16 million per day on 2001 and 36.9 million on 2005. It is projected to be 41.37 and 43.61 on 2025 and 2035 by the static model MODUS (DREIF, 2008). The geographical distribution of the trips among the three rings of the region is presented in **Table 1**. The generation and attraction of each ring is equilibrated. The daily trip generation rate with respect to the sum of population and employments is evenly distributed over the rings. About 82% of the total trips are observed within the same ring.

Travel demand is computed in three steps: internal trips, external trips and heavy vehicles. Volume of internal trips is computed based on regional travel survey and regional population and employment statistics. The external trips entering the region from outside or transiting the region are modeled based on a specific survey and traffic counts at the region's borders. Finally, the share of heavy vehicles is observed as uniformly distributed over the entire region. This share is approximated about 5%. Considering the equivalency factor equal 2, the total car traffic is multiplied by 1.1 to take into account the heavy vehicle traffic on the regional network.

Table 1   Distribution of the trips among the three rings (in millions)

| Origin	Destination			
	Paris	Near Suburbs	Outer Ring	Total
Paris	6.247	1.568	0.361	8.175
Near Suburbs	1.808	10.591	1.191	13.590
Outer Ring	0.494	1.383	13.249	15.125
Total	8.549	13.541	14.800	36.890

2.5.1   Trip purpose and timing

The trips are classified in 8 trip purpose categories. Trips purposes are originally identified by the trip origin and trip destination as Home, Workplace, Shop, Leisure or Personal affaire. Origin–destination couples are aggregated in 8 classes based on similarity in the behavior and equally distribution of trip frequency. **Table 2** presents trip purposes classes (1 to 8) based on trip origin and destination and **Figure 1** presents the trips frequency in each trip purpose class.

Table 2   Trip purpose 8 categories

Origin	Destination				
	Home	Work	Shopping	Leisure	Personal affairs.
Home		1	3	7	3
Work	2	5	5	5	5
Shopping	4	5	6	6	6
Leisure	8	5	6	6	6
Personal affairs	4	5	6	6	6

Figure 1   Distribution of trip purpose of 8 categories
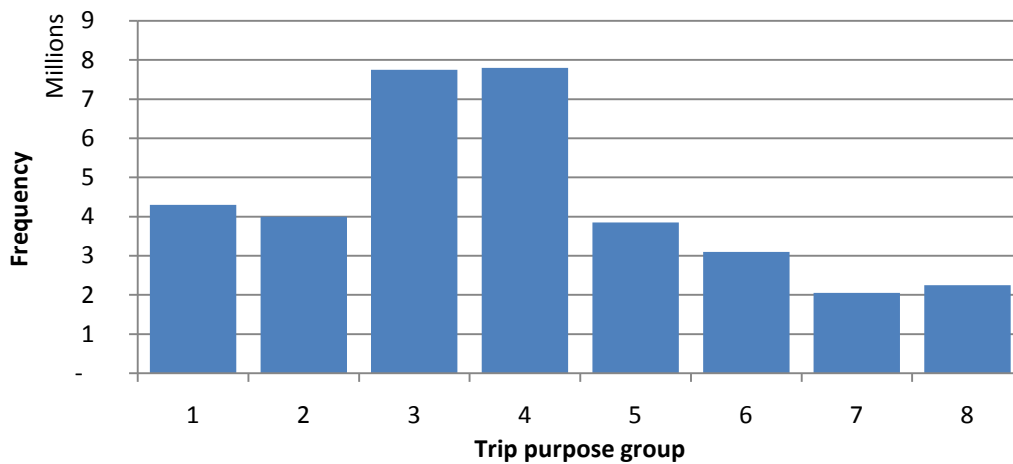
Source: (DREIF, 2008)

It is observed that the trips related to shopping are the most frequent one. Work related trips are in the next place. But this ranking would be different for motorized trips. About 4 million trips are for Home to work purpose the mostly happen during the morning period.

2.5.2   Mode share

Over the region, 46% of trips are carried out by cars, 20% by public transit system and 34% by other modes like walk and bike. The trip distance is the most important determinant of the mode share. Non-motorized modes are essentially used for short distances (less than 5 km). Part of public transit increases with distance but it is stabilized when the distance is greater than 5 km. F**igure 2** presents the modal shares with respect to the trip distance according to the travel survey 2001.

Figure 2   Market shares of different modes
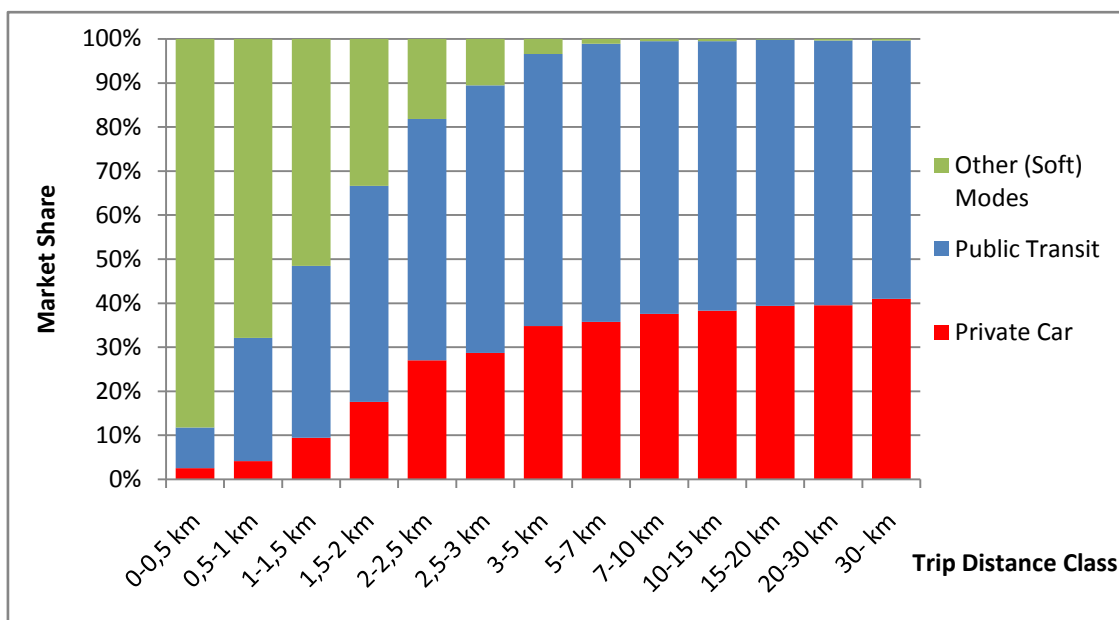
Source: (DREIF: Direction Régionale de l'Équipement d'Île-de-France, 2008)

2.6   Data representation

EGT: Travel survey

The regional travel survey (Enquête Globale de Transports, EGT) is the main source to esti-
mate the parameters of the regional travel demand models. It is conducted by several public
agencies on 1982, 1991, 1997, 2001 and 2010. On 1997 a partial survey has been conducted
but the results have not been reliable enough to be referenced. The results of the survey of
2010 are not yet available. The studies are based on the results of EGT2001 which consists of
the responses from 10 500 households. It represents 81 386 trips during the weekdays. The
survey provides the household and individual characteristics as well as the information about
the trip including trip purpose, departure time, arrival time, departure place and arrival place.
The geographical units are communes in a grid of 300 m side cells. For each trip the principal
mode used, some information about captivity to that mode and parking availability at destina-
tion are gathered.

Temporal distribution of trips

The travel survey provides start and end time of each trip. The temporal distribution is studied by two statistics: number of departures and number of ongoing trips during 15 minutes and one hour time slices. The actual number of departures is important to calibrate the departure time choice model in METROPOLIS. The number of ongoing trips is interested for a static equilibrium model and determining the peak hour.

Table 3 presents the numbers of departures and ongoing trips for the periods of 60 minutes begun at each quarter of hours during the morning peak period. The peak hour from the both number of departures and number of ongoing trips points of view is the period of 7:45 – 8:45 AM.

Table 3   Number of hourly departures and ongoing trips

Period		Number of	
		Departures	Ongoing trips
7h00	8h00	793 624	968 648
7h15	8h15	1 020 407	1 285 003
7h30	8h30	1 225 815	1 519 290
7h45	8h45	1 303 546	1 727 057
8h00	9h00	1 256 655	1 707 471
8h15	9h15	1 101 662	1 655 693
8h30	9h30	871 571	1 403 937
Source: EGT travel survey, 2001			

In Figure 3 a graph is presented showing the temporal distribution of departure and arrival numbers. A clear shift of the peaks from departure time to arrival time during the peak hours is observed from this graph. The peak for departure time is observed at 8:00 to 8:30 AM in the morning but the peak of arrival time is continuous over the period of 8:00 to 9:00 AM. The average of the arrival distribution showed about 16.5 min shift from the departure.

Figure 3   Temporal distribution of departure and arrival number of trips
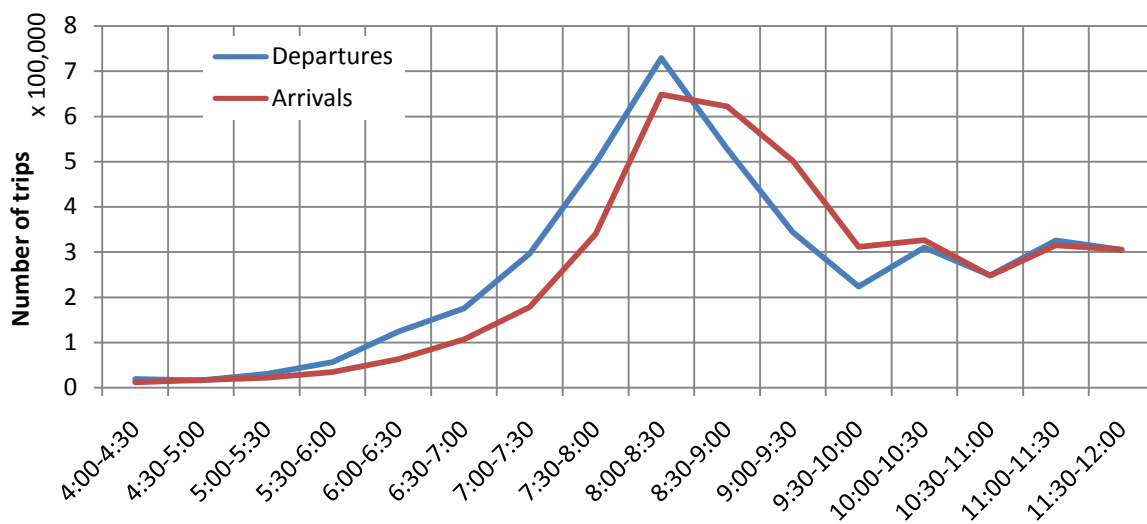
MADDIF

The dynamic transportation model needs some additional behavioral parameters than conventional static model. These parameters are essentially related to the departure time choice model. In the case of METROPOLIS, the required parameters are: value of time, the schedule delay penalties, distribution of desired arrival time and mode choice parameters in terms of value of time for public transport user and a constant that represents public transport penalty or fee. These parameters should be estimated by a stated and/or revealed preference surveys and need some interactive surveying method that is usually not included in travel surveys. For the case of Ile-de-France a specific survey was designed and conducted in 2000 under the project MADDIF (Multimotif Adaptée à la Dynamique des comportements de Déplacement en Ile-de-France), see (de Palma & Fontan, 2000) and Fontan, C. (2003). In that survey the respondents were asked by phone about information's concerning their morning trips for the same day. The survey was administered during May and June 2000. The phone calls have been processed from 5 to 8 PM. About 4230 individuals answered the questionnaire.

The survey had four different sections (De Palma, Fontan, Picard, 2003). In the first section the respondent was asked about his departure and arrival time and constraints, selected mode and its characteristics, network knowledge and use of information on trip conditions, etc. This part helps us to model departure time choice. The second part of the questionnaire was concerned with the tradeoffs between two choices involving different departure times and different travel times (and thus different arrival times). The third part was related to scenarios of

available modes and information. The last section was about the characteristics of the individuals and their household.

As the model has the capacity to consider several individual (trip) groups, during the estimation, it has been studied to find the best possible classification to represent optimally the population heterogeneity with acceptable quality of results. Classifications with respect to the geographical zones as origin or destination, to the trip purpose or the distance have been tried. The results will be discussed later in a dedicated section.

Traffic counts (DIRIF)

DIRIF (Direction Interdepartmental des Routes d'Ile-de-France) is a public organization responsible of operational management of the regional road network. It operates a network of traffic count stations constituted by several electromagnetic loops. The average hourly flow counts at each station is published. These stations are identified on the links of the coded network.

Data from some selected stations are used to compare the total peak hour flow (6AM-10AM) with metropolis peak hourly flow for the same duration and same points. It helped to calibrate the OD matrix and the departure time model of Metropolis.

Paris area transportation and infrastructure authority (DREIF)

MODUS model is developed by the Direction Régionale de l'Equipement d'Ile-de-France (DREIF) (Papinutti, 1998). It is a traditional 4-step multimodal travel model. MODUS model is one of the few regional transportation planning systems which uses the inter-zonal and intra-zonal equilibrium travel times, travel cost, to build up the transport attributes of the individual choice situation. It produces forecasts for the year 2009, 2025 and 2035. Both Morning and Evening peak periods were modeled but only Morning data was used for our study. The data from MODUS 2009 has been used for this study.

The zoning system proposed by MODUS has approximately 1305 zones and 36 600 links. But there were zones outside the study area; therefore, those zones were removed and the network was update for METROPOLIS accordingly. Also the travel time data for public transport (PT) has been taken from MODUS 2009 estimation. It will be used as an external input for METROPOLIS.

The number of travel obtained from the morning travel matrix in DREIF is 1 129 682 in total and 1 054 728 for areas within the region. The weighted average travel time obtained by the matrix of time and reported by the OD matrix DREIF is equal to 16.33 minutes.

Sytadin

Based on the online traffic counts provided by the stations network, the regional and operational roads authority (DIRIF) provides online estimations of average travel time among a set of points of interest on the freeway and highway network. The data are published on a website named Sytadin: http://www.sytadin.fr/. The data are updated in average every ten minutes.

The travel times are computed by a model that has been calibrated using field data obtained by probe cars. The traffic count stations provide online information to the model about the car flow and average flow speed every 6 minutes that permits to model to compute updated travel times.

As we have not access to the measured travel times, we have used these data as a good approximation of the travel time to calibrate the model. About 124 stretches among 20 points are selected to be observed. The data are gathered during at least 5 normal working days and the average travel times are computed for each stretch during the period 6 – 10 am.

Figure 4   Sytadin Network

Source: www.sytadin.fr

3 Modelling in METROPOLIS

METROPOLIS is a traffic planning software which uses dynamic simulations. METPOPO-LIS is based on simple economic principle, explained in originally in Vickrey,(1969). For a recent survey of dynamic model, i.e. model which describe congestion as a function of the time of the day, we refer the reader to de Palma and Fosgerau (2011). The software was developed in Geneva by André de Palma, Fabrice Marchal and Yurii Nesterov and later on applied at the University of Cergy-Pontoise by de Palma and Marchal. It includes a mesoscopic traffic simulator that can handle large networks, a graphical user interface (GUI) to visualize the data and a database to manage them. METROPOLIS GUI is coded in Java while the simulator core is coded in C/C++ (METROPOLIS 1.5 manual, (adpC SPRL, 2002)).

3.1 Features of METROPOLIS

METROPOLIS proposes an interactive environment that simulates vehicle traffic flow and congestion in urban areas. The core of the system is a dynamic simulator that integrates commuters' departure time and route choice behavior over large networks. Drivers are assumed to minimize a generalized travel cost function that depends on travel time and schedule delay (de Palma, Marchal, & Nesterov, 1997). The simulator uses event based simulation process; an event can be any change in the model environment: a vehicle entering a link or leaving a link, a driver taking a route decision or making a lane change, etc.

METROPOLIS describes the joint departure time and route choice decisions of drivers. Route choices are undertaken sequentially by drivers during the journey. The system is based on a disaggregated description of commuter behavior: Each commuter is characterized by specific parameter values, and at each moment his or her location on the network is known. A heuristic procedure describes a day-to-day adjustment process toward a stationary user equilibrium regime.

3.1.1 The cost function

Each traveler has a scheduling cost expressing his/her preferences concerning the timing of the trip. Travelers are assumed to have a preferred arrival time t* and they dislike arriving earlier or later at the destination. Travelers also prefer the trip to be as quick as possible.

The generalized cost function can be defined as:

$$C(t) = \alpha . tt_c(t) + \beta . \left[\left(t^* - \Delta/2 \right) - \left(t + tt_c(t) \right) \right]^+ + \gamma . \left[\left(t + tt_c(t) \right) - \left(t^* + \Delta/2 \right) \right]^+ ,$$

where, $Max(0, A) \equiv A^+$ .The first term in the above equation represents the travel time penalty; the second and third term represents early or late arrival penalty respectively. And

    $C(t)$: Generalized cost for car user whose departure time is t from the origin

    $tt_c(t)$: Travel time for a departure at t from the origin

    t^* : Desired arrival time at destination

    α : Value of time

    β : Unit penalty associated to early arrival

    γ : Unit penalty associated to late arrival

    Δ : Flexible time period without penalty

Typically, the user faces the following trade-off: either he arrives close to the desired arrival time and incurs a lot of congestion or he avoids the congestion and arrives too early or too late compared to his desired arrival time.

3.1.2   Supply Side

The congestion function

The model needs a congestion function to define the travel time over the links. METROPOLIS provides the possibility to introduce any relevant function with a flexible form based on the traffic flow and capacity of the links. The delay at intersections is considered in the link travel time and to obtain that either the capacity of the links or the maximum permitted speed of the vehicles should be modified. The usual forms of congestion function used in METROPOLIS are Bottleneck, Bureau of Public Roads (BPR) or DAVIS. In this study bottleneck function was used to describe congestion in the network.

3.1.3   Demand Side

In METROPOLIS the demand is represented at microscopic level and each trip can be simulated. The users' characteristics which are necessary for the modeling are presented below:

- Value of time
- Schedule delay penalty (early and late)
- Desired arrival/departure time distribution
- No penalty period
- Logit scale parameters
- Mode choice parameters
    - o   Value of time for Transit

o   Penalty or fee

The individual values are drawn from the given distribution. In simulation, each trip will be followed individually in its choices of mode, departure time and route choice (direction at each crossing).

Mode choice

Mode choice is described by a discrete choice model. The generalized cost associated to public transport (VB) is defined as:

$$V_B = \alpha_{PT} \cdot tt_{PT} + C_{PT},$$

Where,

α_{PT} = Value of time spent in public transport (PT)

tt_{PT} = Generalised travel time in PT

C_{PT} = Fixed penalty associated to PT.

The mode choice could be modeled either in short run or long run choice. In long run, the user chooses the mode considering the average maximum expected utility (logsum) offered by the car network in comparison with the other modes. In short run the user chooses her mode after choosing her departure time and consider the car utility at that precise time.

Departure time choice and route choice

Car users have to select their departure time. The choice of departure time for public transportation is not described by the model, since the public transportation travel times are external inputs to METROPOLIS. The departure time choice model for car is a continuous logit model, either deterministic or stochastic. In the deterministic version the individual selects the departure time that minimizes the generalized cost function. In the stochastic version used in METROPOLIS, the *P(t) dt* probability of choice of the departure interval [*t, t+dt*] is given by a continuous model logit:

$$P(t)dt = (1 / A) * \exp(-C(t)/\mu^T)dt,$$

where, the parameter $\mu > 0$ measures the heterogeneity of the departure time choice, and *A* is the accessibility which can be defined as, $A = \mu^T ln \int_{T_0}^{T_1} \exp(-C(u)/\mu^T)du.$

METROPOLIS uses a model of route choice based on point-to-point dynamic travel times. The user selects the dynamic shortest path from the origin node to the destination node. The

decision will be based on the real time situation of the immediate link and memorized information about the rest of the network up to the destination.

Learning model

The software uses a learning process where users acquire knowledge about their travel and use this information to modify their trip for the next day. It should be noted that one is day corresponds to one iteration in METROPOLIS. This process operates as follows:

- The first day, the users have a naive knowledge: they make the assumption that there is no congestion in the network. The users start their journey relatively late and all attempting to arrive at their preferred time by using the fastest route. The congestion caused by this concentration phenomenon is very high.

- Learning from the experience, second day they start their journey either much earlier or later and select longer routes. Consequently, the congestion is reduced but the arrivals are too far away from the schedule time.

- The process continues until it reaches a stable state. The users acquire information about their experienced route and after each iteration, the collected information's are either stored as historical travel data or update the previous data.

The process can be illustrated by following equation

$$X_{d+1}^{H} = f\left(X_{d}^{H}, X_{d}^{S} \right),$$

where,

X_{d}^{H} : The historical information acquired on day d

X_{d}^{S} : Represents the traffic conditions effectively simulated/incurred on day d.

Several functions *f(.)* are available. METROPOLIS uses Exponential, Linear, Quadratic or Genetic function for learning process.

3.2 Network representation of Ile-de-France in METROPOLIS

The Ile-de-France network is coded with 1289 internal zones. 50 zones represent the entry/exit points of the region with the exteriors in public or road transportation system (including the international airports and inter-regional train stations). Paris arrondissements and great communes have been divided in several zones. Rural communes at the outer ring have been aggregated into greater zones.

The road network is coded by 43 857 links within them 4 462 are the connectors. This coding has been aimed to provide a detailed model able to produce detailed information about the traffic flows necessary for engineering studies on the transportation infrastructures. This implies introduction of a large number of short links to represent explicitly the turnings in crossings and all the ramps and loops in the interchanges.

The length of the links

A descriptive statistics about the link lengths has been presented in **Table 4** below along with a histogram showing the distribution of the link length in **Figure 5**:

Table 4   Descriptive statistics of link length used in METROPOLIS Network

Statistic	Value		Percentile	Value
Sample size	39395		Min	2
Range	17052		5%	23
Mean	532.77		10%	33
Variance	1.00E+06		25% (Q1)	62
Std. Deviation	1004.9		50% (Median)	218
Coef. of Variation	1.8862		75% (Q3)	559
Std. Error	5.0629		90%	1207.4
Skewness	5.0614		95%	2087
Excess Kurtosis	36.991		Max	17054

The link length varies between 2 m to 17.05 km. A descriptive statistics shows that 25% links have a length equal to or lower than 61 meter whereas only 5% links have length higher than 2.4km. In the context of dynamic assignment model like METROPOLIS, congestion can be concentrated on these short links that makes more difficult the interpretation of the results. A frequency distribution of the overall lengths of the links will show more precise data about the links length as presented in Figure 5. The distribution can be described by Weibull distribution with shape parameter $\alpha = 0.8188$, scale parameter $\beta = 346.6$ and location parameter $\gamma = 2.0$.

Figure 5   Distribution of link length (32 897 no of links)

Length (m)
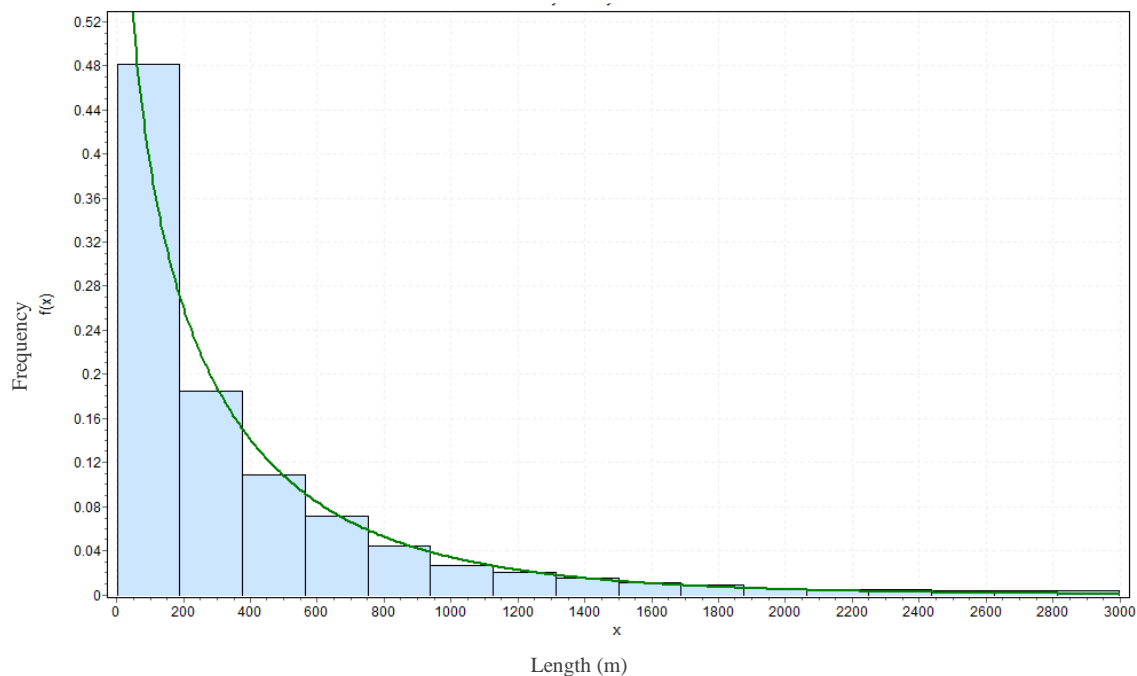
Capacity and Speed

A descriptive statistics of link capacity and link speed are shown in **Table 5** and **Table 6** respectively. A frequency distribution of link speed is also presented in **Figure 6**.

Table 5   Descriptive statistics of link capacity (veh/hr/lane)

Statistic	Value		Percentile	Value
Sample size	39395		Min	100
Range	1400		5%	700
Mean	1090,2		10%	900
Variance	65094		25% (Q1)	900
Std. Deviation	255,13		50% (Median)	1050
Coef. of Variation	0,23402		75% (Q3)	1333,3
Std. Error	1,2854		90%	1500
Skewness	0,1597		95%	1500
Excess Kurtosis	-0,77594		Max	1500

Table 6   Descriptive statistics of link speed (km/hr)

Statistic	Value		Percentile	Value
Sample size	39395		Min	6
Range	124		5%	26
Mean	53.247		10%	30
Variance	456.72		25% (Q1)	40
Std. Deviation	21.371		50% (Median)	50
Coef. of Variation	0.40136		75% (Q3)	60
Std. Error	0.10767		90%	90
Skewness	1.0864		95%	91
Excess Kurtosis	1.0906		Max	130

Figure 6   Distribution of link speed
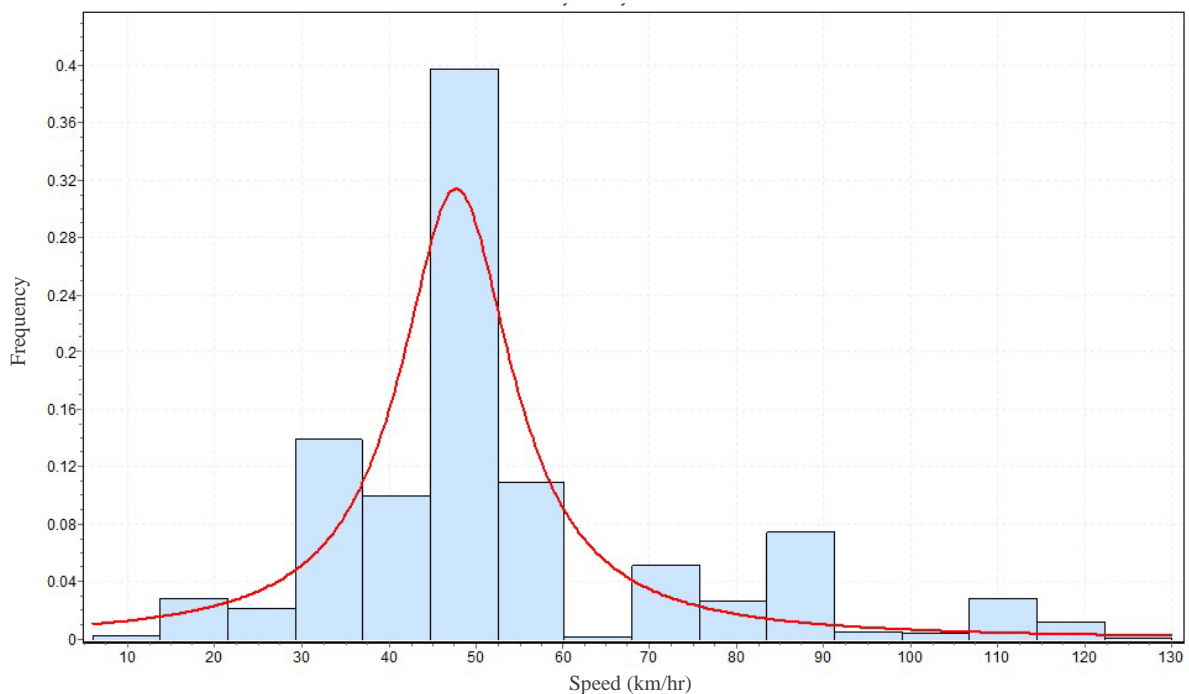
The fitted line in this **Figure 6** is from Cauchy distribution. The bottleneck in METROPOLIS can be created by decreasing the capacity or decreasing the speed or both. IDF network in METROPOLIS has used the capacity and speed from a previously calibrated static model named MODUS which has been described in the previous section 2.6. **Figure 6** show that large number of links has a desired speed of 50Km/hr. These are mostly collector roads, intermediate roads, ring roads and ramps.

The normal links (out of connectors) are classified in 15 types with regard to their functionality and their location in urban zone. In addition, the capacities and free flow speeds have been individually adjusted to calibrate the MODUS model. Final calibrated values are used for this study. Small description of these link types are presented in the Appendix **Table A1**:

3.3 Behavioral parameters

The implementation of a dynamic simulator of travel requires the estimation of behavioral parameters specific to the study area. As it was discussed earlier, dynamic modeling in ME-TROPOLIS requires estimating some parameters for departure time choice, mode choice and route choice[2]. It concerns the parameters of the generalized cost function like α, β, γ, logit scale parameter of the departure time choice model μ and the desired arrival time distribution, t*. A no penalty period of 10 min has been selected. In next section a brief discussion about the relation among the behavioral parameters obtained for different categories of the trips will be discussed. The data used for this estimation has been described previously in the report in the section 2.6 under the subsection named MADDIF.

3.3.1 Estimation of α, β and γ

Estimating the schedule delay penalties for all the population (de Palma, Delattre, Marchal, Mekkaoui, & Motamedi, 2002), the β/α and γ/α are obtained as 0.51 and 0.81 respectively. β and γ are estimated parameters for arriving early and late. Dividing them by α normalizes the estimation, therefore, β/α and γ/α represents the flexibility of arriving early or late. The estimation of the total population shows that $\beta/\alpha > \gamma/\alpha$ which tells us that people of Ile-de-France prefers to arrive early than late, which totally make sense. But it is not wise to model with only one population sample, because the model may not show the true heterogeneity among the people. Therefore the population was classified in different samples depending on some certain criteria.

Different classification scheme was proposed i.e. with respect to residence area, purpose of trips, length of the trip and destination of trips. The most significant classification was jointly based on trip purpose and destination by merging Paris and near suburbs in a group. The detail results of these estimations based on different classifications are presented in the report of QUATUOR (de Palma, Delattre, Marchal, Mekkaoui, & Motamedi, 2002), interested users

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[2] Deterministic route choice will be used in this study and mode choice will be introduced later.

are suggested to read that report. In this report only the estimation result based on the final classifications is presented. The final classification is as follows:

- Home to Work to Paris and Near Suburbs
- Home to Work to Outer Ring
- Other purposes

The result of final estimation is presented in **Table 7**.

Table 7   Behavioral parameters by O-D region

	Simple size	$\boldsymbol{\alpha}$	β	Γ	$\boldsymbol{\beta}/\alpha$	γ/α
Work to Paris and Near Suburbs	648	0.081 (0.015)	0.038 (0.007)	0.047 ⑤ (0.023)	0.469	0.580
Work to Outer Ring	509	0.130 (0.022)	0.084 (0.013)	0.175 ⑤ (0.045)	0.646	1.346
Other purposes	544	0.089 (0.019)	0.036 (0.008)	0.073 ⑤ (0.03)	0.404	0.820

Legend: ⑤ significant between 1% and 5%, Without any symbol : significant at less than 1%

Source: Final report of QUATUOR project (de Palma, Delattre, Marchal, Mekkaoui, & Motamedi, 2002)

The estimation samples included respondents declaring a precise desired arrival time. In the estimations, the significance of a no penalty time window at the arrival is testes and it is obtained as null.

In these estimations the logit scale parameter μ is normalized to 1. If one removes the assumption $\mu = 1$, previous estimates of dynamic parameters will be equivalent to α/μ, β/μ and γ/μ. For example, in the case of work-related travel to Paris and its inner suburbs were: $\alpha/\mu = 0.081$, $\beta/\mu = 0.038$ and $\gamma/\mu = 0.047$. The scale parameter μ can be obtained through a recent estimate of the value time, α, obtained for the population of the study area.

Following the econometric work done from the EGT 1998, motorists of the Ile-de-France have value of time α equals 85F/H (see (de Palma & Fontan, 2001)) i.e. $\alpha = 12.96$ Euros per Hour. So a simple calculation will provide that $\mu = 2.67$, $\beta = 6.09$ and $\gamma = 7.53$. Now the values are consistent with METROPOLIS specification. The final values of behavioral parameters according to METROPOLIS specification are presented in the following **Table 8**:

Table 8   Behavioral parameters for METROPOLIS estimated for three O-D classes

	Simple size	α (Euro/hr)	B (Euro/hr)	γ (Euro/hr)	M
Work to Paris and Near Suburbs	648	12.96	6.09	7.53	2.67
Work to Outer Ring	509	12.96	8.36	17.43	1.66
Other purposes	544	12.96	5.24	10.64	2.43

### 3.3.2   Desired arrival time

The distribution of desired arrival time for the same trip categories are also needed for dynamic modeling. The distributions are presented in **Figure 7** as a combination of normal flows fitted by a kernel. In this figure the labels are in French; 'Densité' means density, Observée stands for observed distribution and Normale stands for fitted normal distribution and 'Résultat du mélange' refers to result of mixing of two graph.

The distribution parameters are presented in **Table 9**.

Table 9   Parameters of the fitted normal distribution in Figure 7

	Type of Distribution	Parameter of distribution	
		Mean	St. Dev.(minutes)
Work to Paris and Near Suburbs	Normal	8:29	60
Work to Outer Ring	Normal	8:24	50
Other purposes Group 1 (46%)	Normal	8:54	54
Group 2 (54%)	Normal	10:49	53

Figure 7   Distribution of arrival time for three different O-D pairs

O-D pair: Work to Paris and Near Suburbs

O-D pair: Work to Outer Ring

O-D pair: Work to Outer Ring
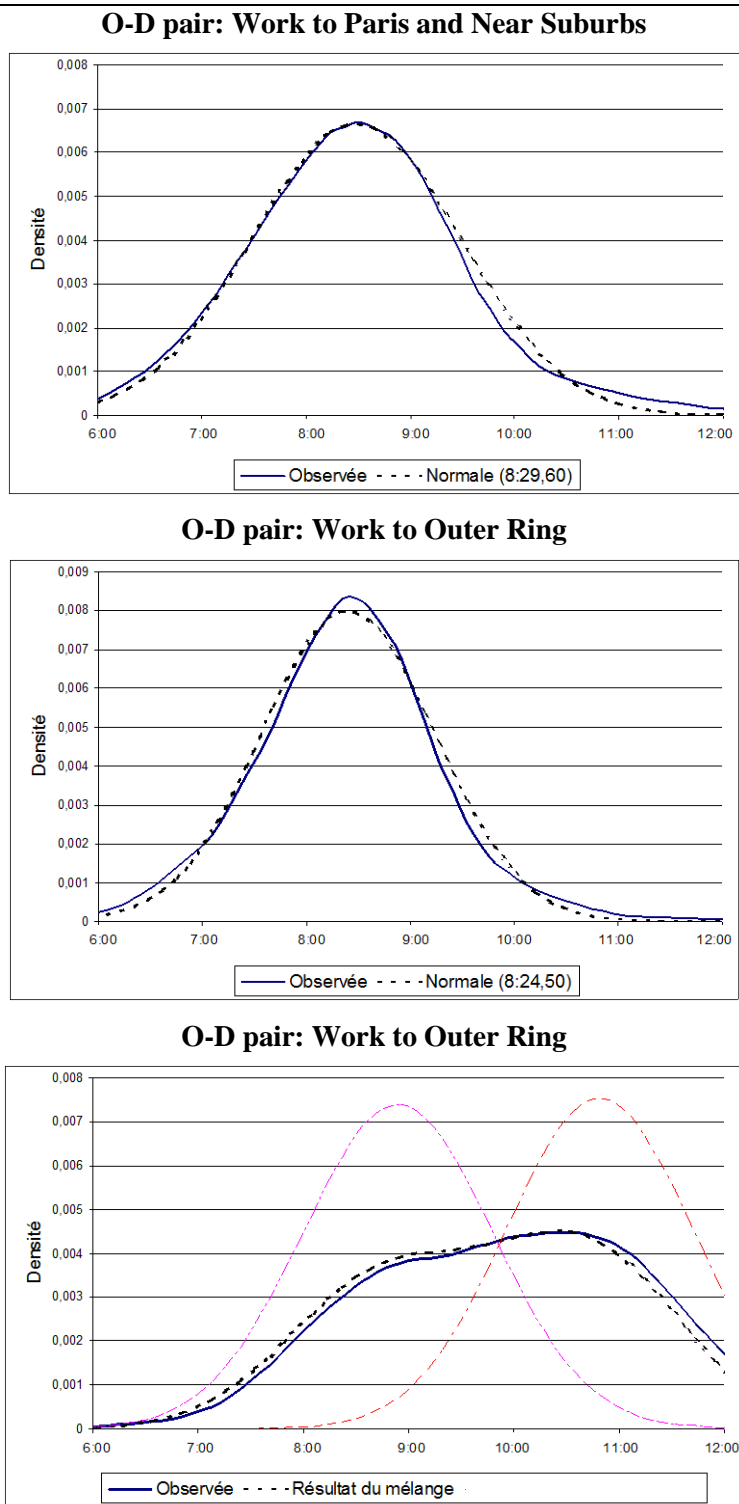
Source: QUATOUR report (de Palma, Delattre, Marchal, Mekkaoui, & Motamedi, 2002)

3.4   O-D Matrix

Our simulations in METROPOLIS use an OD matrix for the morning commute. As the exact matrix for desired morning period is not available, the matrix of rush hour is extended to the simulated period by multiplying it with a factor. This factor is obtained by trial and error procedures of several simulations and comparing the simulated flow with the observed flow to have the best results. The geographical distribution of travel varies with time and to reflect this, it is necessary to differentiate the multiplicative factor depending on the origins and destinations. The total number of O-D pairs being several hundred thousand, it is necessary to aggregate them.

An aggregation is possible by the districts. The districts are defined in terms of links between the town center (sub-prefecture) and peripheral municipalities. That is to say that the division is based on a concept of accessibility and transport between the towns. The following map shows the relationship between network structure, the districts and the centers of trip generation. According to this map, each district encircles a centre of trip generation; therefore, we believe that the districts can be a good aggregation to apply the deformation coefficients of the matrix.

Figure 8   Trip generation from different zones of Ile-de-France network
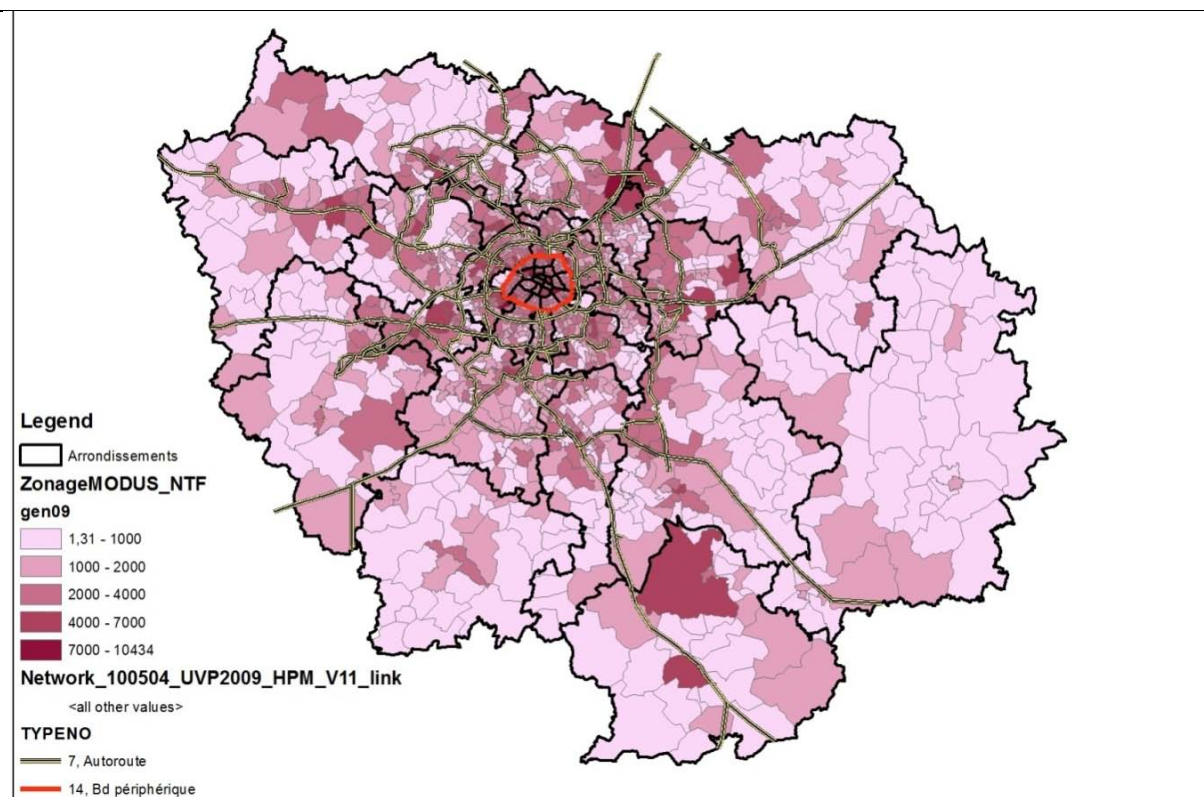
Source: Map produced by Kiarash Motamedy using the data from DREIF

4 Calibration of Paris Network in Metropolis

4.1 Methodology of Calibration

Calibration of a large network like Ile-de-France requires a lot of time and dedication. Also the computer in which the simulation will run has to be a good one. To reduce the runtime the demand has been reduced to 10% of the original travel demand. So the capacity of the network was also divided by ten to reflect the original picture. To test the assumption of reducing the capacity by the same factor as to reduce the flow, some pre simulation was set on the popular "Sioux Falls" network. The simulated conditions are: full flow with full capacity and 10% flow with 10% capacity. No significant difference is observed among the results of these two simulations. The summary results are showed in a tabular form below in **Table 10**. So the assumption is valid and the simulation could be run with 10% flow.

Table 10   Descriptive statistics of Link Capacity (Veh/hr/lane)

Network: Sioux Falls		Morning commute (full flow)	Morning commute (10% flow)
Num. of users	[-]	57240	5724
Travel time	[min.]	21.16	20.90
Travel cost	[€]	5.19	5.10
Schedule delay cost	[€]	1.66	1.62
Free flow cost	[€]	2.80	2.80
Consumer surplus	[€]	-5.68	-5.61
Late delay	[min.]	6.92	6.50
Early delay	[min.]	25.42	25.50
Congestion	[%]	26.03	24.46
Mileage	[10^6 km]	0.77	0.077
Speed	[km/h]	38.14	38.43

Stepwise calibration

The idea behind calibration of Ile-de-France network was to build the model with available data, run simulation, modify one parameter at a time, re-run the simulation and continue this loop until the results are good enough with comparison of some field measurements. A time

period of 6 AM to 10 AM has been selected for calibration. The process can be described by the following 5-step procedure:

Step 1: **Model construction.** The model has been built with the available data from different sources: The network was taken from the static model MODUS. The behavioral parameters for the dynamic model METROPOLIS has been estimated previously in the project QUATOUR. The same estimation was used here with the same distribution of preferred arrival time. The congestion function was the standard bottleneck function.

Step 2: **First run and comparison with field data.** The base model was run with 10% of the original demand. The result of the first run i.e. base situation was compared with the collected field observations. The filed observations are: hourly traffic flow in 606 selected links throughout the network, travel time for 124 different O-D pairs, distribution of departure time and arrival time and some aggregate measures.

Step 3: **Adjusting demand.** The comparison of simulated link flow with observed flow indicates the need of increasing the demand. It should be noted that, departure time is modeled by METROPOLIS itself. Due to the stochastic nature of the model, some people modify their departure time and starts early or late to reduce their travel cost. Early or late departure from the desired time of travel results some decrease in demand inside the period of 6:00 AM to 10:00 AM. To compensate this loss the demand has been increased by a factor 'n'. Several simulations were executed to find the correct value of 'n', and finally a value of 1.2 was selected.

Step 4: **Adjusting PAT distribution.** The distribution of departure time was compared with the distribution from survey data. The simulated distribution of departure time did not fit with the survey distribution. The reason could be the stochastic nature of the departure time model of METROPOLIS or due to the estimated behavioral parameters. The distribution was adjusted by calibrating the Preferred Arrival Time (PAT) distribution parameters. The calibrated parameters of the PAT distribution are presented in **Table 11**.

Step 5: **Check travel time.** The O-D travel time in 124 selected O-D's was compared with observed travel time data for same O-D's. The simulated travel time was a bit higher than observed. To adjust it, the capacity of the links was increased slightly. Finally only 2% increase in capacity gave us satisfactory result for O-D travel time.

Step 6: Checking other parameters and finalize the result. The other parameters like distribution of link flows, distribution of arrival time, network average travel time, etc. were compared with confirmed data. Simulation results for all these categories were found acceptable with respect to the available data. Therefore the calibration process was stopped here and the final results of calibration were produced.

The calibration steps have been described by a flow chart in **Figure 9**:

Figure 9   A Flow chart describing calibration procedure
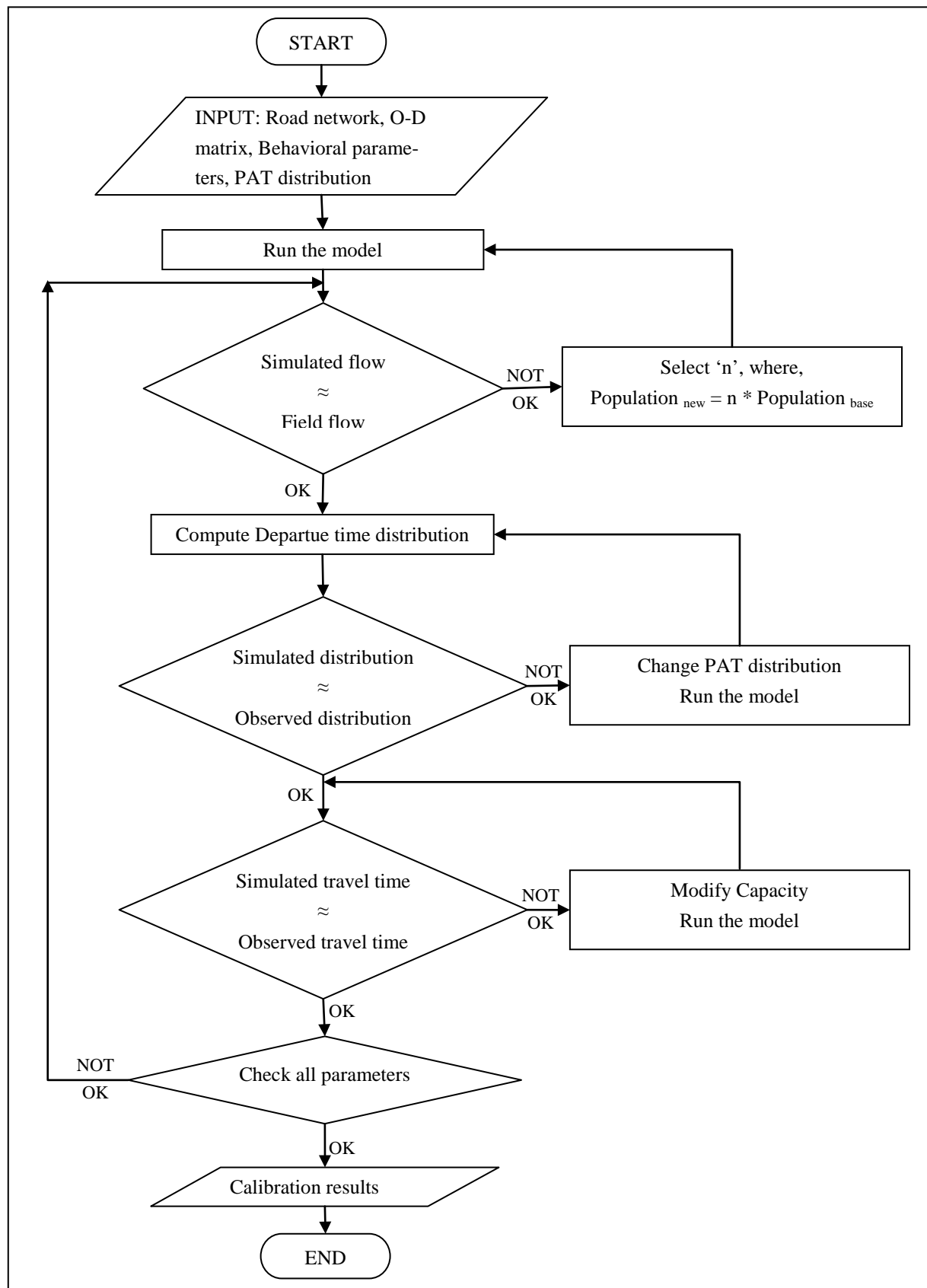
4.2   Calibration results

It is out of scope of this report to include the results of each calibration steps. Therefore the results of the final calibrated model are provided only. As it was mentioned in different steps in Section 4.1.1, to obtain the final calibrated model the population was increased by 20% and the overall link capacity was increased by 2%. Also the parameters of the Preferred Arrival Time (PAT) distributions were modified to adjust the departure time distribution as shown in **Table 11**:

Table 11   Modified parameters of PAT distribution

	Type of Distribution	Parameter of distribution	
		Mean	St. Dev.(minutes)
Work to Paris and Near Suburbs	Normal	8:29 AM	45
Work to Outer Ring	Normal	8:24 AM	35
Other purposes Group 1 (30%)	Normal	8:59 AM	54
Group 2 (35%)	Normal	10:34 AM	53
Group 3 (35%)	Uniform	12:00 PM	35

The Calibration results can be categorized into two types: aggregate results and disaggregate results. Aggregate results are automatically produces from METROPOLIS after each simulation showing the overall network performances. Disaggregate results are hard to obtain as they are not atomically produced. All the iteration results are stored in the database of METROPOLIS. Disaggregate data can be obtained in each link level and user level. Some small query can produce the exact output from the database. For this study the selected disaggregate results are:

- flows on some selected links
- Distribution of flows on those selected links
- Travel time for some selected O-D

Also there are other results which fall between these two categories. They will be called as semi-aggregate results in this report. This category includes the followings:

- Travel time and cost for different user types
- Distribution of simulated departure time
- Distribution of simulated arrival time

4.2.1 Aggregated results

Simulation Measure of Efficiency

Table 12   Parameters of distribution (modified)

	Unit	Result
Average travel time	min	18.20
Average travel cost	€	6.21
Schedule delay cost	€	2.27
Free flow cost	€	2.61
Consumer surplus (per user)	€	-11.72
Average delay (late)	min	16.63
Average delay (early)	min	28.50
Early ratio	%	58.40
On time ratio	%	18.64
Late ratio	%	22.97
Congestion [3]	%	45.17
Mileage	10^6 km	7.23
Average speed	km/hr	49.28

It is not so simple to comment on the results of the aggregate MOE's, because usually field data are not so available to compare. The regional static model MODUS predicts that for Ile-de-France network the weighted average travel time in the morning peak period (7-9 AM) is 16.33 minutes. But the Regional survey (EGT 2001) showed the average car trip is about 19 min long for Ile-de-France region. The simulation suggests an average travel time for the simulation period (6-10 AM) is 18.2 min which falls between the result of MODUS model and the survey data.

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[3]Congestion (C) is defined as the ratio of the actual travel time (TT) to the free-flow travel time (TT_0): $C = (TT-TT_0)/TT_0$.

4.2.2   Semi-aggregate results

Travel time and cost for different user types

The users are divided into three user groups as discussed in Section 3.3. The behavioral parameters are different. It would be noteworthy to observe their average travel time and travel costs. This information's are collected from METROPOLIS and presented in the **Table 13**:

Table 13   Travel time by user types

	Average travel time (min)	Average travel cost (Euro)
Work to Paris and Near Suburbs	18.08	6.97
Work to Outer Ring	21.46	6.35
Other purposes		
Group 1	18.57	6.61
Group 2	15.8	5.43
Group 3	15.66	5.34

It is observed from the table that, although the distance travelled for the first user group i.e. Work to Paris and Near Suburbs is small, their cost is higher than the second group who has to cover large distance to go to work. The reason behind is could be high congestion in the city centre during morning peak hour. 'Other purposes' group has been divided to three separate user groups having the same user behavioral parameters but only the distribution of Preferred Arrival Time (PAT) is different. Group 1, 2 and 3 has average PAT at 8:59 AM, 10:34 AM and 12:00 PM respectively (See **Table 11**). So group 1 should have higher travel time and cost than the other two, because the people belongs to this group travels mostly in the peak period. From **Table 13** it is noticed that the travel time and cost for group 1 is higher than other two groups in this category of users. The model supports our prediction.

Arrival and Departure time distribution

The regional survey EGT 2001 provides data about number of departures and arrivals in specific time periods. METROPOLIS also produces the distribution of departure and arrival time for each simulation. Therefore, it would be remarkable to compare these distributions. It will also disclose us how good the software can represent the departure and arrival time distribution. **Figure 10** and **Figure 11** will present the distribution of departure time and arrival time respectively with field and simulation data.
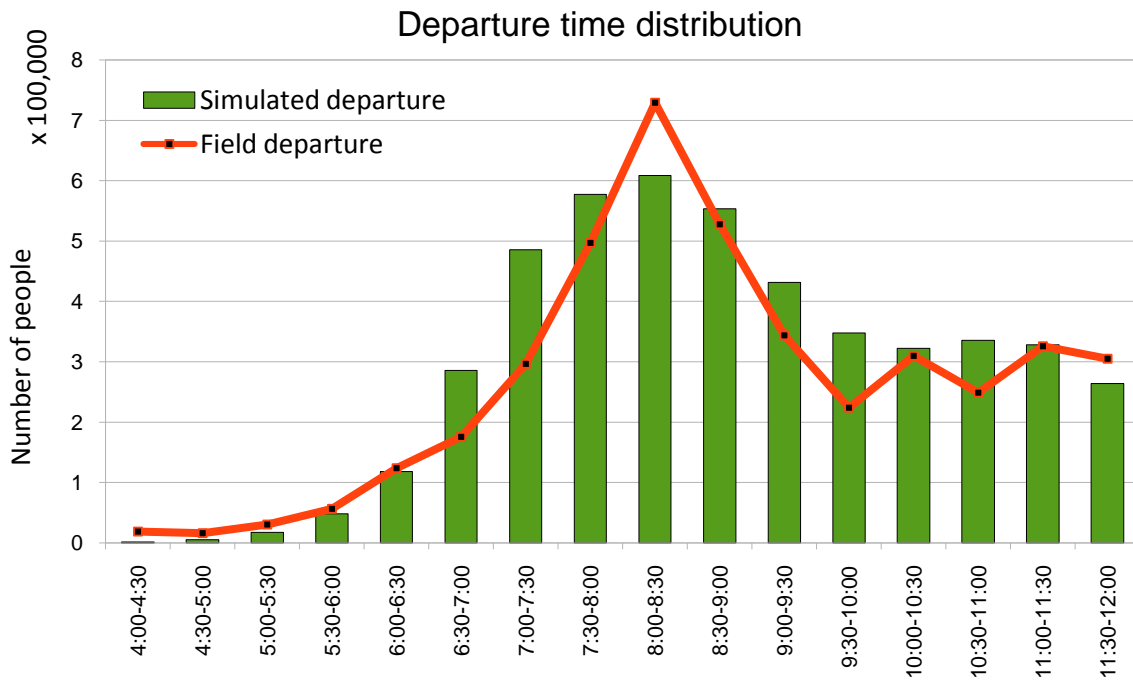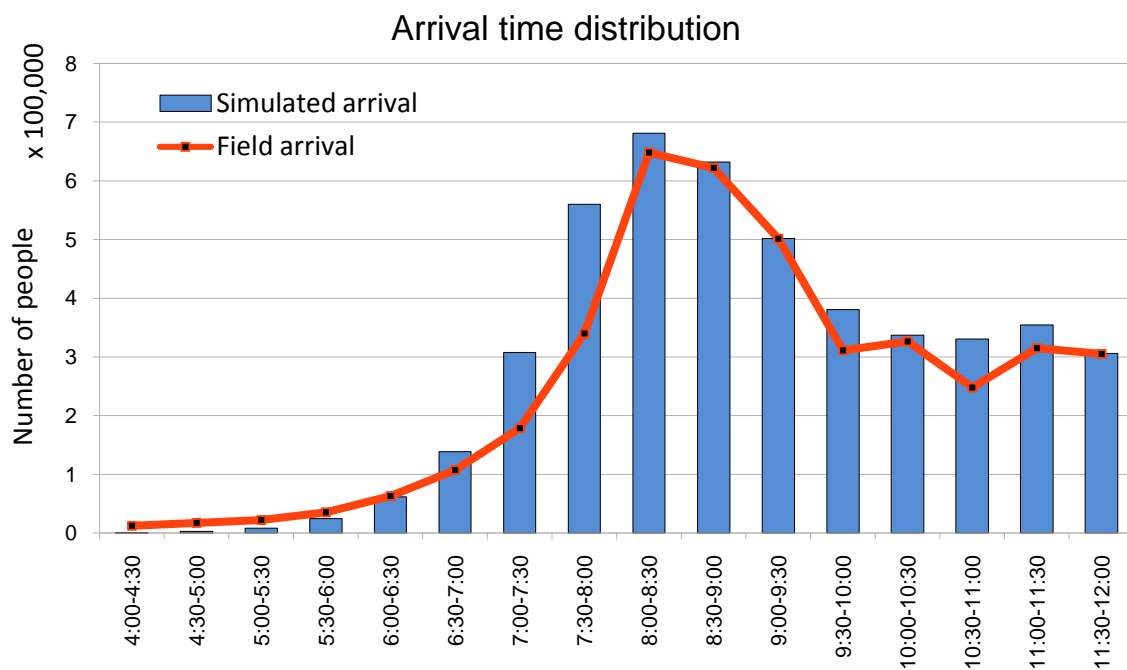
Figure 10   Distribution of Departure time

Departure time distribution

Figure 11   Distribution of Arrival time

Arrival time distribution

Last two figures suggest that, the calibrated network predicts almost similar picture compared to the field observation for both the cases of departure and arrival time distribution. The peak of the distribution is appeared in exactly the same position as observed from the field data. It is very important to have the peak because in this position the network is having the critical problems. These figures ensures us that other parameters like congestion, travel time or speed may be underestimated or overestimated by the software but their temporal distribution should be same as in the field.

Travel time from city centre (Chatlet)

It is possible to observe the travel time of different destination from one origin in a map. This type of map is known as isochrone map. In **Figure 12 and 13** two isochrone maps are produce to show the average travel time to different destination from the same city centre Chatlet, at the time period of 8-9 AM and for the whole simulation period (6-10 AM) respectively. In these figure the term CC refers to the City Centre.

Figure 12 Isochrones from city centre (Chatelet) for 8-9 AM
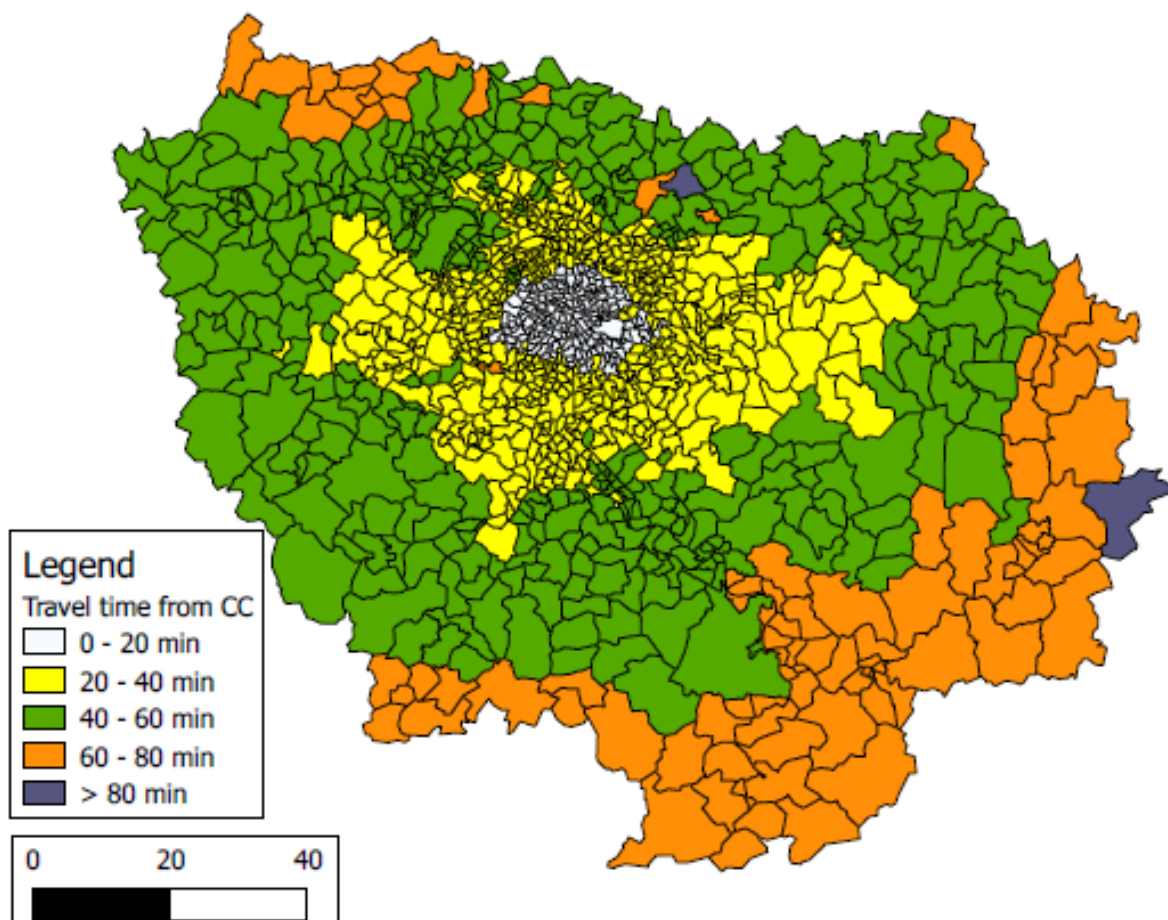
Figure 13   Isochrones from city centre (Chatelet) for morning period (6-10AM)
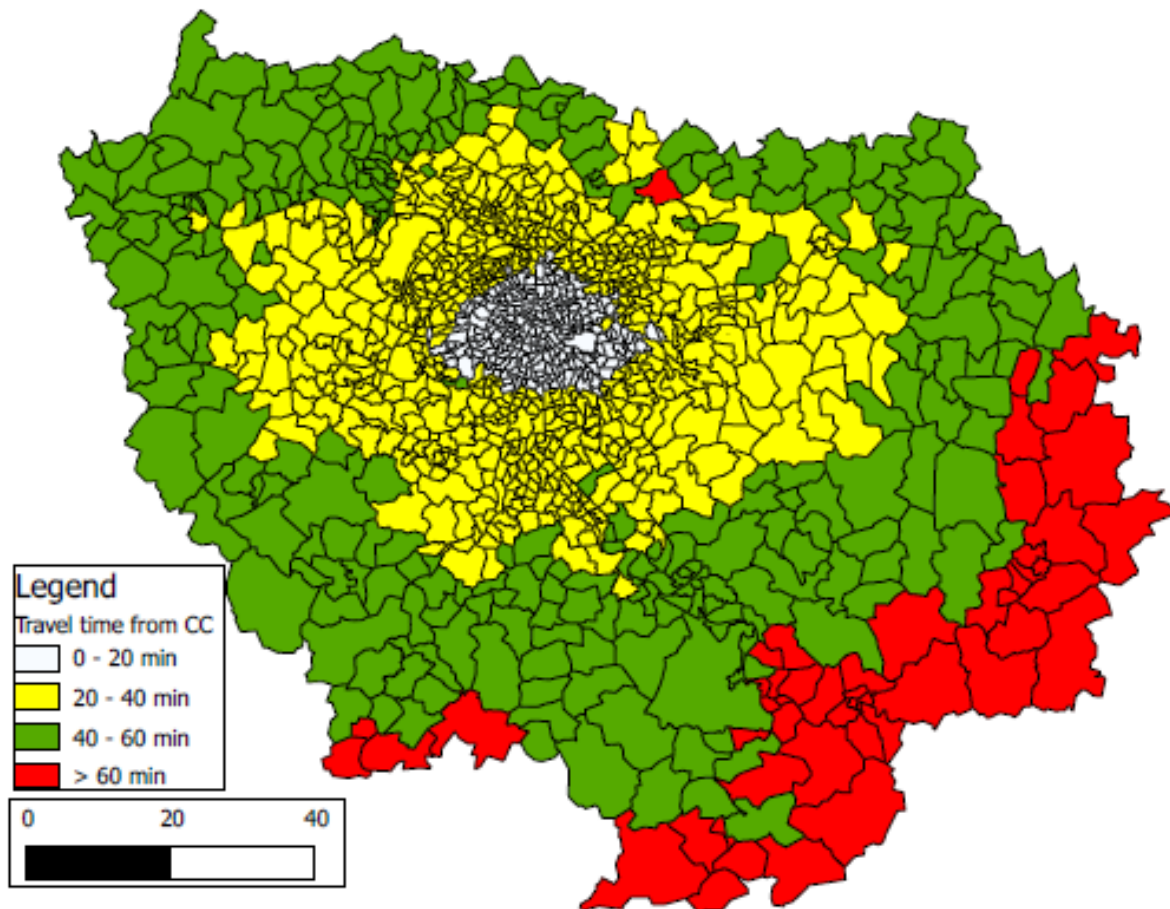
It is observed from **Figure 12 and 13** that the travel time is increased during the peak period. It is obvious from the fact that increased flow causes more congestion in the peak period. This peak hour can be identified from the arrival time distribution as 8:00 to 9:00 AM.

At this point a conclusion could be made that, the model results for the calibrated Ile-de-France network are reasonable. But to know how close the model predicts the real situation, the results should be compared in disaggregate level with the real field data available for comparison. It will be achieved in the next section.

4.2.3   Disaggregated results

Simulated vs field flow

It is always a good measure to compare the traffic flow in some selected links with the filed observation. In this study 606 links are located in different places of the network whose traf-

fic flow is known from traffic counts made by DIRIF (Direction Interdepartmental des Routes d'Ile-de-France). Traffic counts are available for every hour in the morning period (6:00 AM – 12:00 PM) in those links. So the temporal distribution of flow could also be compared. The positions of these links are highlighted in **Figure 14**.

Figure 14   Position of 606 calibration links (marked as blue color)
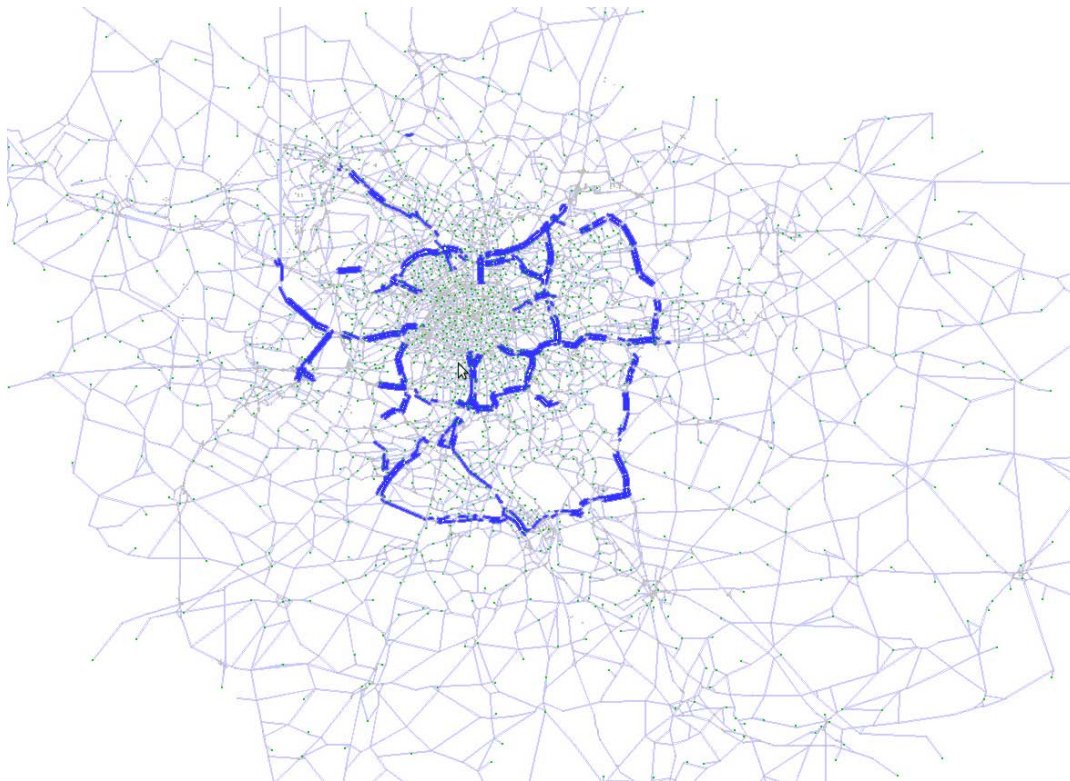
The traffic flow and their distribution have been recorded for these links from the simulation. The relation between the field flow and simulated flow is presented in **Figure 15** in the form of a scatter plot. The average hourly flow for all the 606 calibration links has been used to produce this scatter plot.

Figure 15   Field vs Simulated Flow fitted with a linear trend line (606 observations)
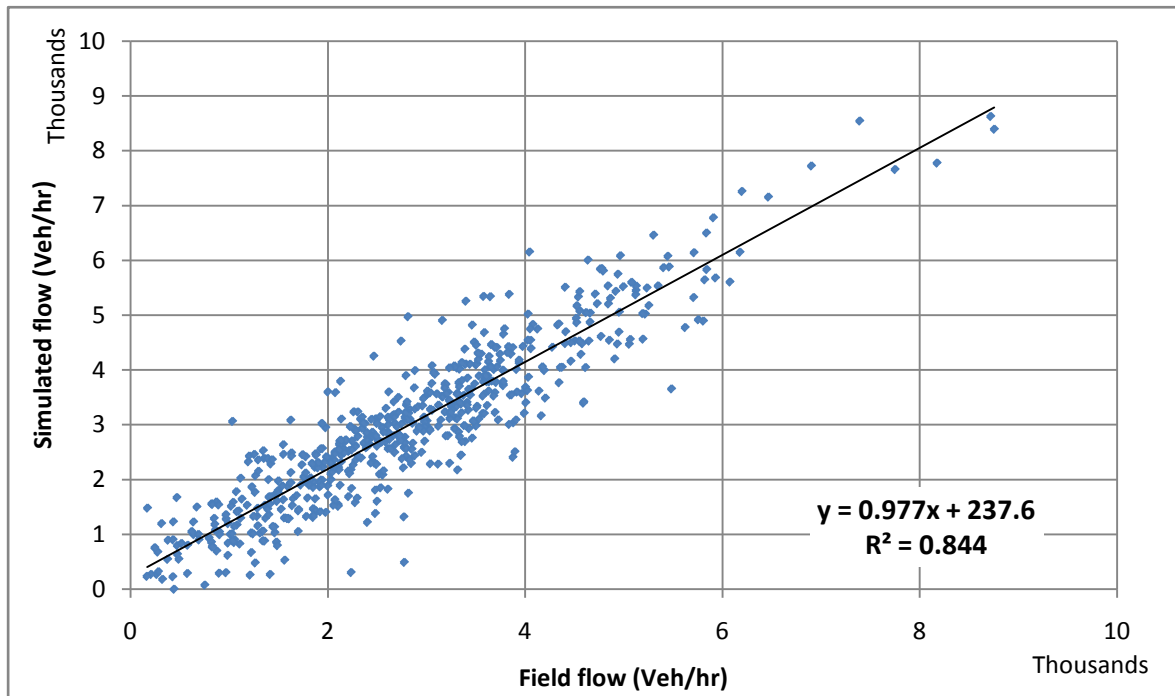
The scatter plot shows a good relation between field and simulated flow. The R^2 value of 0.844 suggests that our simulation can capture about 84.4% variability in the original data. For a large network like Ile-de-France, this value is quite acceptable. The temporal distribution of traffic flow in these links is presented in Figure 16. The distribution is selected for the period of 6:00 AM to 12:00 PM. For this distribution average of hourly traffic flow in the selected 606 links are used.

Figure 16   Distribution of average hourly flow of 606 selected links
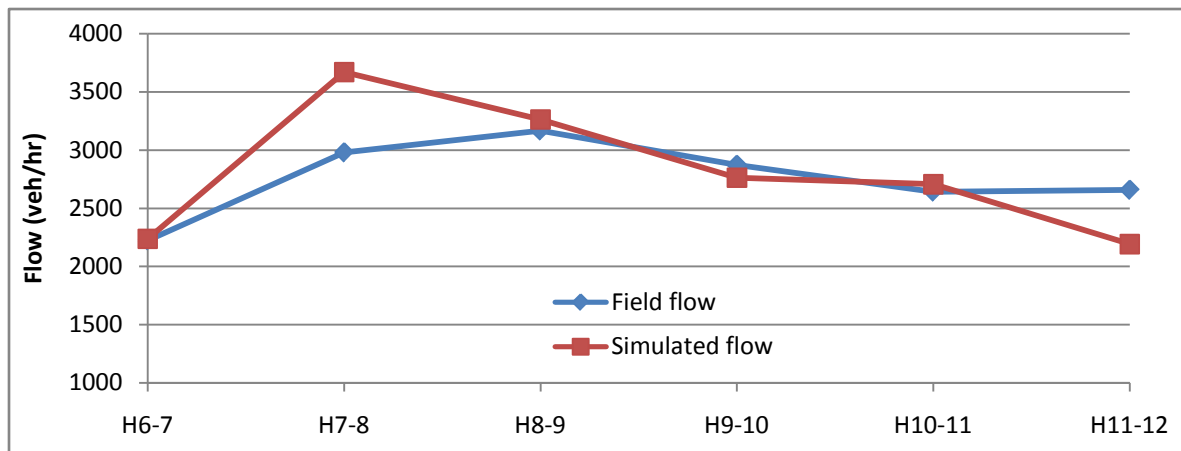
Figure 16 show that, the distribution of simulated average hourly flow of the selected links matches with the distribution of field flow. No peak was observed from the flow counts, but a sharp peak is noticed from the travel survey for departure and arrival time distribution as shown in **Figure 3, 10 and 11.** It could happen due to different sources of the data: DIRIF for traffic counts and EGT2001 for travel survey. As the input demand has this peak in the distribution, it is obvious that a peak should appear around 8:00 AM. In spite of this difference, the other points of the distribution are very close to the field. It should be noted that our concerning period for calibration is from 6:00 AM to 10:00 AM. Inside this period the distribution matches perfectly except one point where the peak occurs.

Field Vs Simulated Travel time

O-D travel time is another important measure for calibration. In this study about 124 O-D pairs comprising a 31 origin/destination points are selected for comparison. The field travel time for these O-D's are collected from web based real time travel time data (from the website www.sytadin.fr). The positions of O/D's are showed as green dot in the following **Figure 17**. The travel time is collected in different hours in the morning period (6:00 AM to 10:00 AM) and for different days of the week. It was then averaged over the morning period and over the week. Simulated average travel time data for the same 124 O-D pairs are calculated for the morning period and compared with the collected field travel time data. The comparison is presented in the form of scatter plot in **Figure 18**.

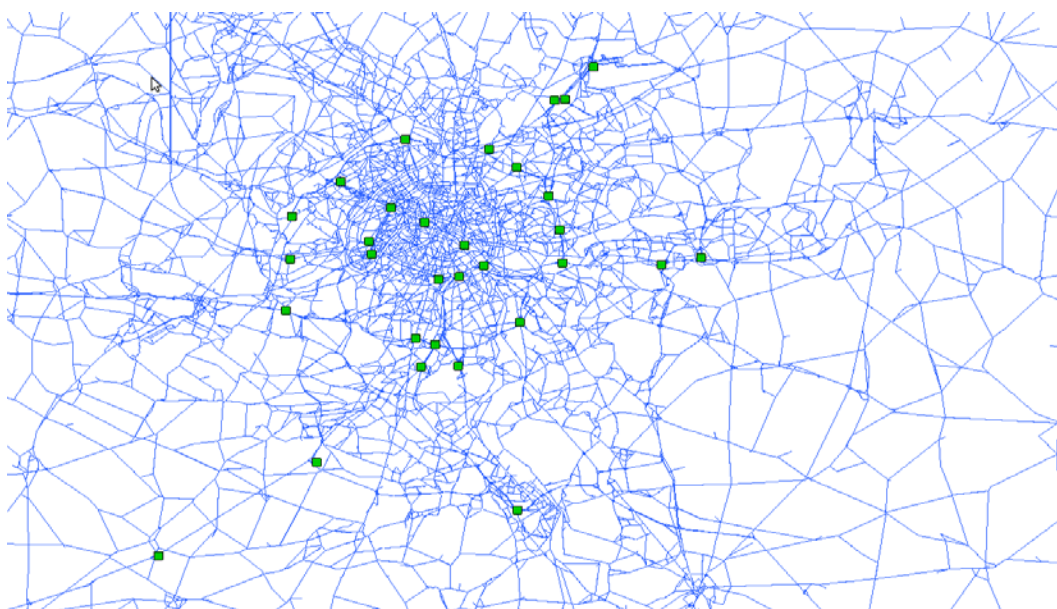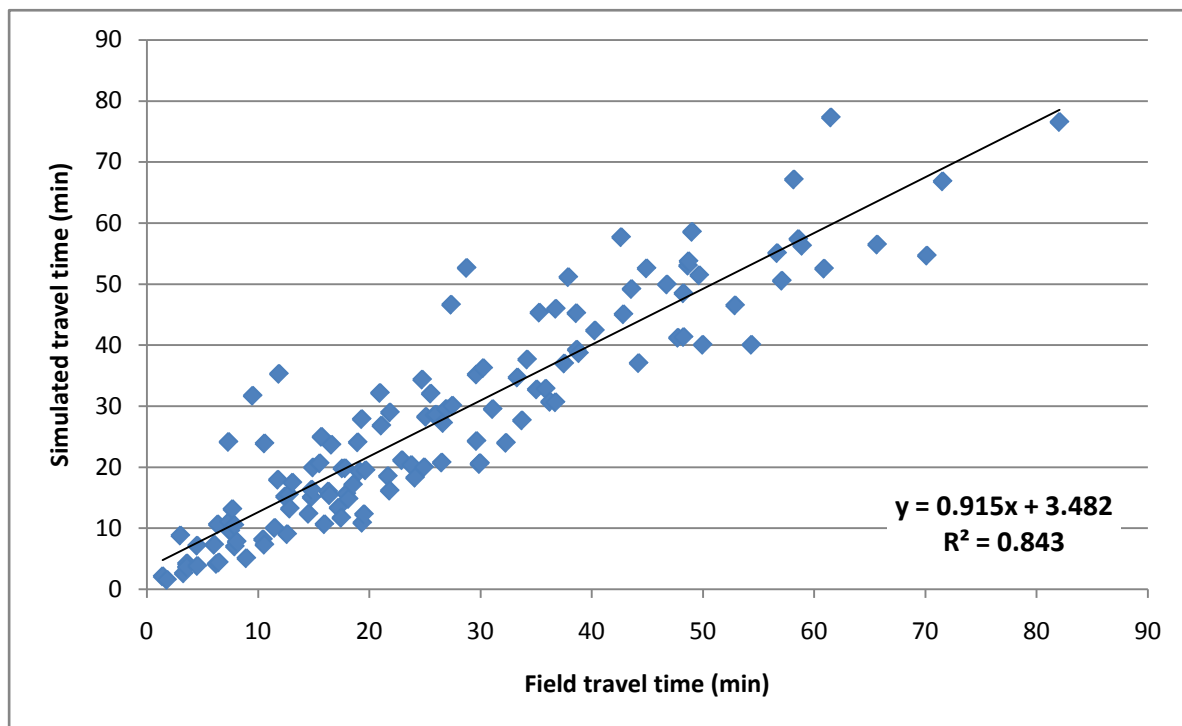Figure 17   Field Vs Simulated travel time (31 O-D points)

Figure 18   Field Vs Simulated travel time

The scatter plot in **Figure 18** shows a good relation between field and simulated flow. A value of 0.843 for R^2 suggests that the simulation can capture about 84.3% variability in the original data.

5 Conclusion

In this study the travel model named METROPOLIS has been calibrated for Ile-de-France region with the help of survey data and field observations. Only morning period has been simulated under this study. The data used for modeling and calibration comes from different sources which have been discussed briefly in a dedicated section. Calibration results are categorized in three types: aggregate results, semi-aggregate results and disaggregate results.

Aggregate results are compared with another static regional model MODUS. Due to the absence of another dynamic model for Ile-de-France region, it is not possible to compare all the aggregate results. It is worth mentioning here that, recently METROPOLIS was used for modeling of congestion charging for Stockholm road network and the results were compared with another dynamic model SILVESTER (Kristoffersson & Engelson, 2008) and available field data. It was proved that calibrated METROPOLIS model is capable of producing very good aggregate and disaggregates results which are almost similar to the real situation (Engelson, Kristoffersson, de Palma, Motamedi & Saifuzzaman, 2012).

Semi-aggregate results and disaggregate results are compared with survey data and collected field data respectively. The comparison shows that the differences between the simulation results and field results are very small. Some key points of comparison are:

  a) Distribution of departure time and arrival time fits perfectly with the available survey distribution of departure and arrival time,
  b) Peak of the distribution (both departure and arrival time) are observed at right place,
  c) Simulated average hourly flow in 606 selected links showed high correlation with average field flow on those links,
  d) Simulated travel time in 124 selected O-D's shows high correlation with field travel time for those O-D's.

After observing all these results and comparisons, it can be concluded that METROPOLIS model is well calibrated and gives good prediction about the real traffic situation for Ile-de-France region.

When mode share was introduced in this model, 51.3% share of car users is observed from the model. The mode market shares for the home based work trips calculated from the survey EGT 2001 were: 50% Private cars, 36% Transit and 14% Bicycle/walk.

Later this calibrated travel model will be coupled with the urban model. Some idea for integration has been developed under Work package 6 (WP6) (Nicolai & Nagel, 2010). The integration of the two models will be discussed in another paper.

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Appendix

Table A1   Descriptive statistics of different types of Links

Region	Outer ring				Near Suburbs	La defense	Paris	Outer ring	Paris	Paris	Near Sub-urbs					Overall
Road Type	Collectors	Intermediary roads	Arterials	Freeways	Intermediary roads	Ring road	Ring road	interface roads	Inner ring	Urban Roads	Collectors	Other collectors	Express-ways	Ramps	Others	
Type ID	3	5	6	7	12	13	14	18	19	20	21	25	26	27	30	2
Count of Links	12956	7667	3427	2478	1912	29	270	34	211	3914	4278	6	378	1831	4	39395
% of Links	32,89%	19,46%	8,70%	6,29%	4,85%	0,07%	0,69%	0,09%	0,54%	9,94%	10,86%	0,02%	0,96%	4,65%	0,01%	
Average length	0,582	0,742	0,749	0,673	0,278	0,130	0,258	4,286	0,301	0,208	0,279	0,211	0,612	0,256	0,793	0,533
Min of length	0,003	0,002	0,006	0,006	0,006	0,023	0,006	1,091	0,013	0,006	0,006	0,153	0,006	0,012	0,121	0,002
Max of length	11,820	13,324	13,330	17,054	2,178	0,554	1,250	9,010	1,052	2,096	2,857	0,297	10,270	3,112	1,499	17,054
Average of speed	50	56	65	100	53	58	72	50	40	33	38	66	76	54	80	53
Min of speed	10	6	19	19	10	40	19	50	30	15	10	66	19	15	70	6
Max of speed	130	120	130	130	94	75	80	50	53	339	100	66	120	130	90	339
Average capacity	1221	1275	1935	4848	1993	5372	6807	100	2031	1734	1250	700	3719	1756	7375	1707
Min of capacity	100	300	600	1200	700	3600	2600	100	1000	200	500	700	900	500	4400	100
Max of capacity	5500	5400	6000	10400	6200	8000	9000	100	4000	50000	6300	700	50000	8400	9900	50000
Average Number of lanes	1,20	1,12	1,71	3,64	1,77	3,93	5,01	1,00	1,75	1,58	1,24	1,00	2,77	1,35	5,25	1,51
Min N. of lanes	1	1	1	1	1	3	2	1	1	1	1	1	1	1	3	1
Max N. of lanes	4	4	4	7	5	6	6	1	3	34	5	1	34	6	7	34