4788 60

CALIBRATION, VALIDATION AND APPLICATION OF A NETWORK EQUILIBRIUM MODEL FOR THE MONTREAL REGION

QMTRA

CANQ
TR
TTP
191
EX.1

1986-11-25

CALIBRATION, VALIDATION AND APPLICATION

OF A

NETWORK EQUILIBRIUM MODEL FOR THE MONTREAL REGION

by:

Michael Florian,

Centre de recherche sur les Transports,
Université de Montréal,
Montréal, Québec, Canada;

and

Pierre Tremblay,

Direction de l'administration et des systèmes d'information,
Direction générale du transport terrestre des personnes,
Ministère des transports du Québec,
1410 Stanley, Montréal, Québec, Canada.

Invited paper presented at the

ORSA/TIMS Joint National Meeting

Miami, Florida - October 1986

CALIBRATION, VALIDATION AND APPLICATION

OF A

NETWORK EQUILIBRIUM MODEL FOR THE MONTREAL REGION

ABSTRACT

We report in this paper the methodology and results obtained with the use of the network equilibrium model implemented in the EMME/2 system to model the road network of the Greater Montreal region. The model is characterized by its dimensions; the network has 700 zones, 6000 nodes and 18,000 links.

We give a detailed account of the data sources and procedures used to obtain the origin/destination matrix, the coding of the network and the calibration of the volume/delays functions. We present next the validation of the assignment model and conclude with the presentation of three applications of the model, with graphical output from EMME/2 system.

1. INTRODUCTION

The coordination of the development and the efficient operation of the ground transportation networks and infrastructures are the principal preoccupations of the "Direction générale du transport terrestre des personnes", within the Ministry of Transportation of Québec (MTQ). The MTQ has the task of planning, managing and maintening the main road network, including all the autoroutes, expressways and regional routes which serve the municipalities of the province. The MTQ also has the task of strategic planning of the main public transit infrastructure, which it subsidizes to a large extent.

For the purpose of carrying out planning studies and analyses at the strategic level in the Montreal region, the MTQ has acquired a variety of modeling tools for urban transportation planning, with particular emphasis on mode choice, auto assignment and transit assignment. In 1976, it started using UTPS [1] for planning in the Montreal region. Since 1982, the MTQ has also been using EMME/2 [2], which was installed on its IBM mainframe; a collaboration was established as well with the Centre de recherche sur les Transports, which developped the EMME/2 system.

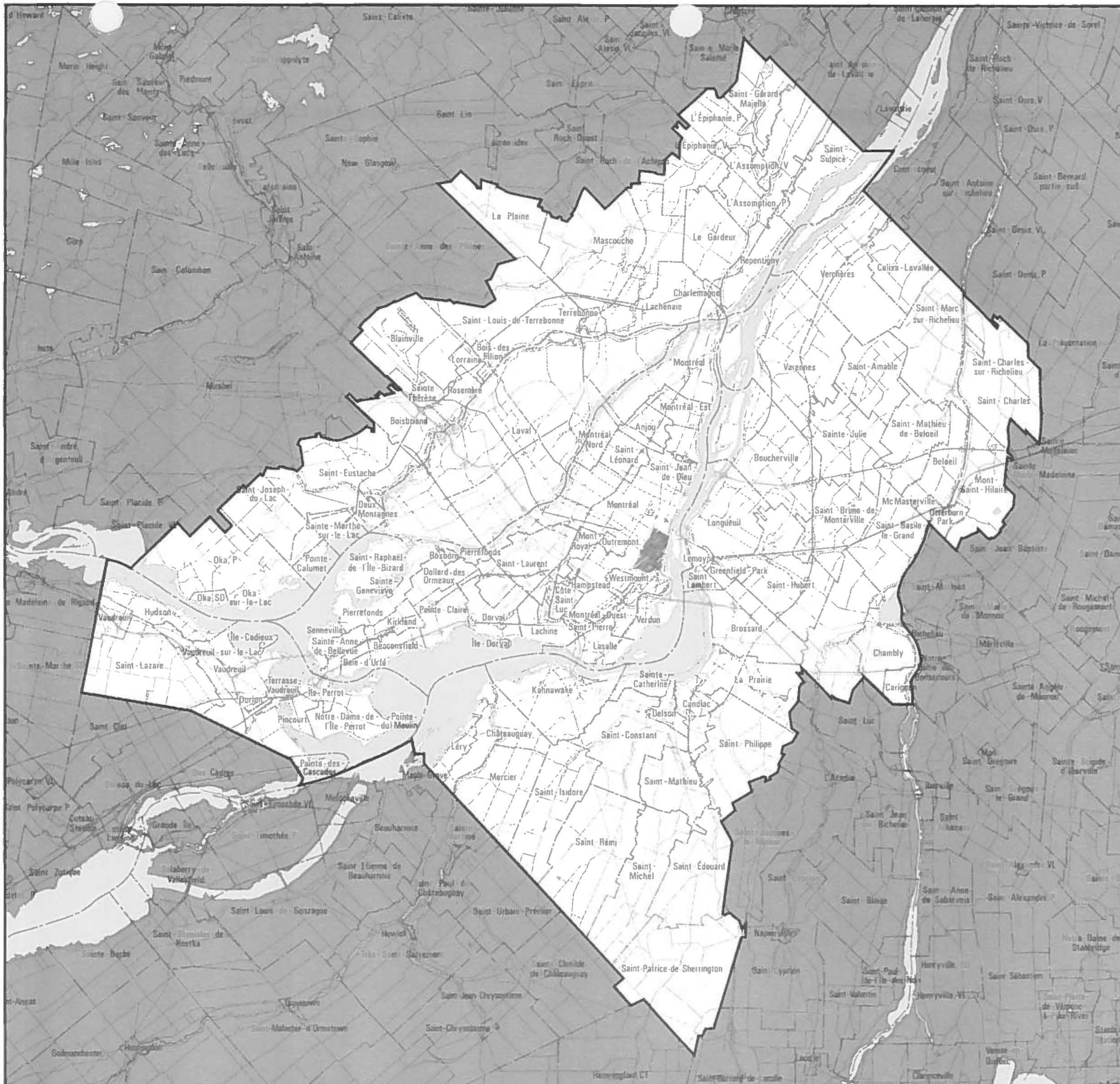
The purpose of this paper is to present the methodology and results obtained with the use of EMME/2 to model the road network of the Greater Montreal region. In particular, the results obtained by using the equilibrium assignment on this network are described in detail.

The paper is organized as follows. First we describe some socio-economic and transportation infrastructure characteristics of the Greater Montreal region. We then give a detailed account of the data sources and procedures used to obtain the origin/ destination matrix, the coding of the network and the calibration of the volume/delay functions. We present next the validation of the assignment model and conclude with the description of three applications of the model.

2. THE GREATER MONTREAL REGION

The Greater Montreal region (see Figure 1) spans an area of more than 3340 sq. km. which contains 107 municipalities. The population of nearly three million persons inhabit more than one million households. The average household is 2.7 persons and the ownership averages 0.97 car per household. The center business district of Montreal (see map) attracts more than 23% of the 1.1 million work trips done, each day, within the whole region.

The road network of the region (see Figure 2) is largely rectangular and is characterized by the presence of 22 bridges



Gouvernement du Québec
Ministère des Transports
Direction générale du transport terrestre des personnes

Figure 1

The Greater Montreal Region

Study Area

Center Business District

N

0 1 5 10 15 20km

octobre 1986

that connect the islands of Montreal and Laval with the rest of the territory. These bridges carry a significant amount of road traffic since the economic activities are concentrated in the core of the island of Montreal while the other parts of the region are largely residential suburbs.

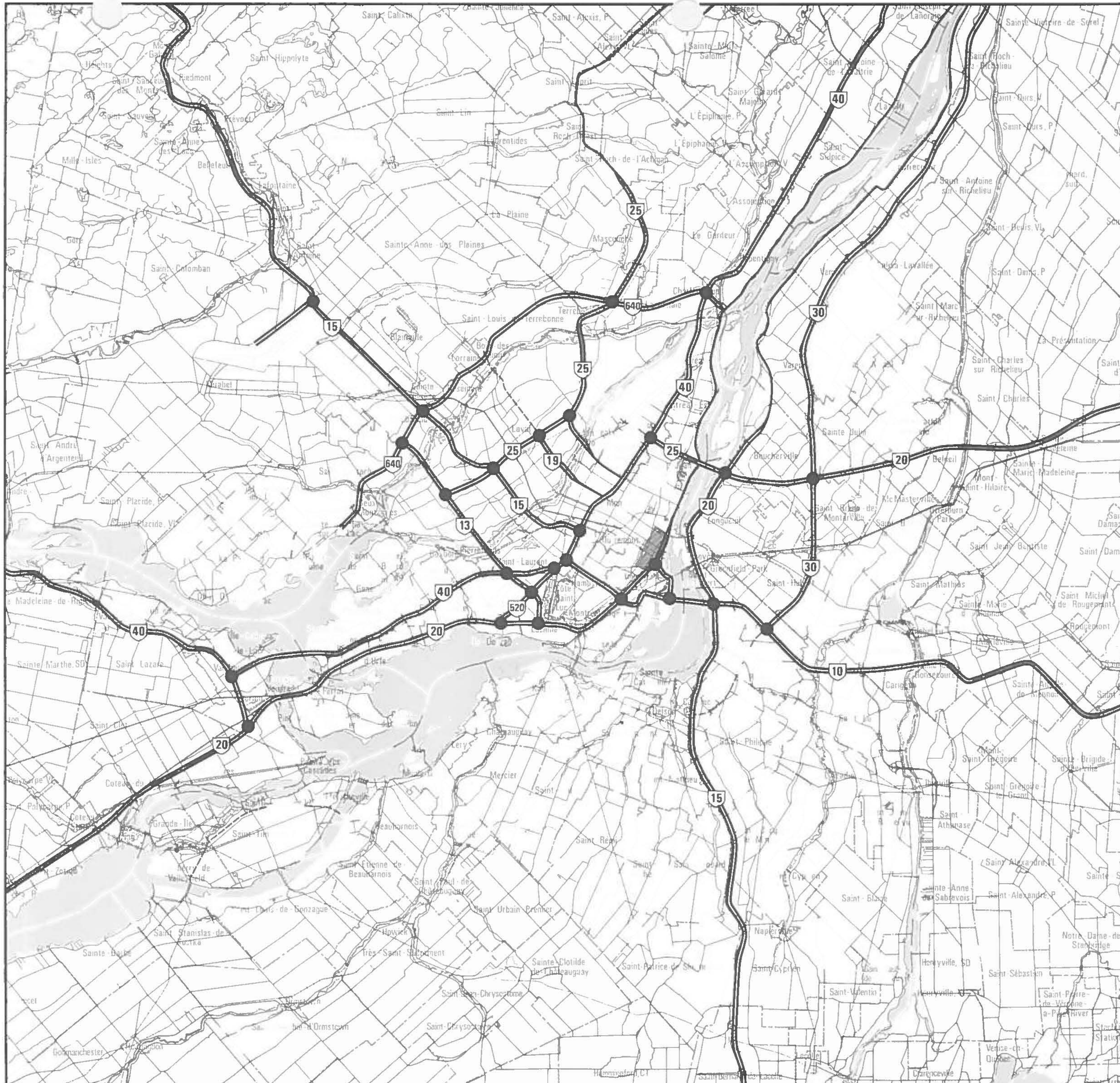
3. THE TRANSPORTATION DEMAND

The transportation systems modeling activities in the Greater Montreal region are based on extensive origin/destination surveys, carried out every four years, since 1970, by the S.T.C.U.M. (Société de transport de la Communauté urbaine de Montréal), which is the main transit property of the region [3]. These are household based surveys, carried out by telephone; in 1982, the sampling rate was 5.4% in the central part of the territory and 9% for the peripheral parts of the region. This sample corresponds to 75,000 households, with a total of 208,000 persons reached. The resulting database contains approximately 492,000 trip records.

Given the quality of the origin/destination survey, the origin/destination matrices are obtained directly from the sample, by applying the appropriate expansion factors, rather than resort to models of trip generation, distribution and mode choice. Nevertheless, such models will be developed in the near future, by using disaggregate methods based on the data available from the O-D survey.

It is worthwhile to point out that the use of data from an origin/destination survey to obtain an auto origin/destination matrix poses certain restrictions, which may have a major impact on the results of the prediction of flows in the network. First, a certain sampling error is associated with the survey and the sampling method (interview, coding of replies, entering the data in computer readable form, validation, etc...). Second, the survey does not sample any trip of "commercial" nature (truck traffic, delivery vehicles) which are generally not home based; also, the survey does not sample any trips with origin outside the territory. The resulting auto origin/destination matrix will thus underestimate the auto trips, with the most important effects noted in the peripheral sectors of the region.

One of the largest difficulties of modeling the demand for the a.m. peak hour is that the "peak" itself is a phenomenon that varies in space and with time. Since the assignment models are static but congestion levels vary within the peak, depending on which time period is analyzed, it is necessary to define a demand matrix which best reflects the peak hour flows. In our case, the starting time of each sampled trip is known; thus the temporal distribution of demand is known, but only at the origin of the trips.



Gouvernement du Québec
Ministère des Transports
Direction générale du transport terrestre des personnes

Figure 2

The main road network

er Business District

N

It is difficult to justify the definition of an origin/ destination matrix based only on trips that start within a given hour, since the spatial distribution of trips will be necessarily biased. Therefore, it was decided to include in the demand matrix all trips that occur during the morning peak period, which is considered to be from 6 to 9 a.m. When this matrix is used for simulating flows, an adjustment factor is applied to estimate the hourly flows, in order to compare them to the links hourly capacity. In the current situation, the ajustment factor was globally determined to be 0.4 by comparing peak hour counts to those for the morning peak period of three hours.

4. THE ROAD NETWORK

Several preliminary considerations were taken into account before coding the model of the road network. The base network was chosen to be at a sufficient level of detail in order to be able to support the transit lines, since the final aim is to carry out bi-modal assignments. On the other hand, the data base had to satisfy the needs of the three systems in use (EMME/2, MADITUC [4] and UTPS), since applications were foreseen for each; the same system of nodes and links would permit interfacing of data and results. Since in UTPS the number of links incident at a node cannot exceed four, this restriction was observed even though it is not a restriction in EMME/2. Also, the fact that the shortest path computation used in UTPS does not systematically prevent "U" turns at nodes, implied sometimes the duplication of nodes at intersections, which is not necessary in EMME/2.

For the purpose of scenario analysis, the model is based on a subdivision of the region in 700 zones (see Figure 3), based on the 1500 zones system used in the O-D survey. This is a reasonable compromise between the execution times and the detail of the results obtained, given that the interest is region-wide planning. The road network model has 699 centroids, 5972 regular nodes and 18,815 directionnal links (Table 1), which represent more than 13,000 km, not including the public transit exclusive right-of-way facilities. The coded network also has 187 turning movements restrictions of which 81% represent forbidden turns. It should be emphasized that most of the freeway ramps are coded explicitely, so that penalized turns are necessary only when major intersections have particular geometry or forbidden left-hand turns during the AM peak period.

The construction of a network of this size represents a considerable task of data collection, preparation and entry work. The network was geocoded very efficiently by using a specially written set of programs which permitted the coding of the nodes and links directly from a micro-computer, linked to a digitizing table. The total work required for data collection and coding

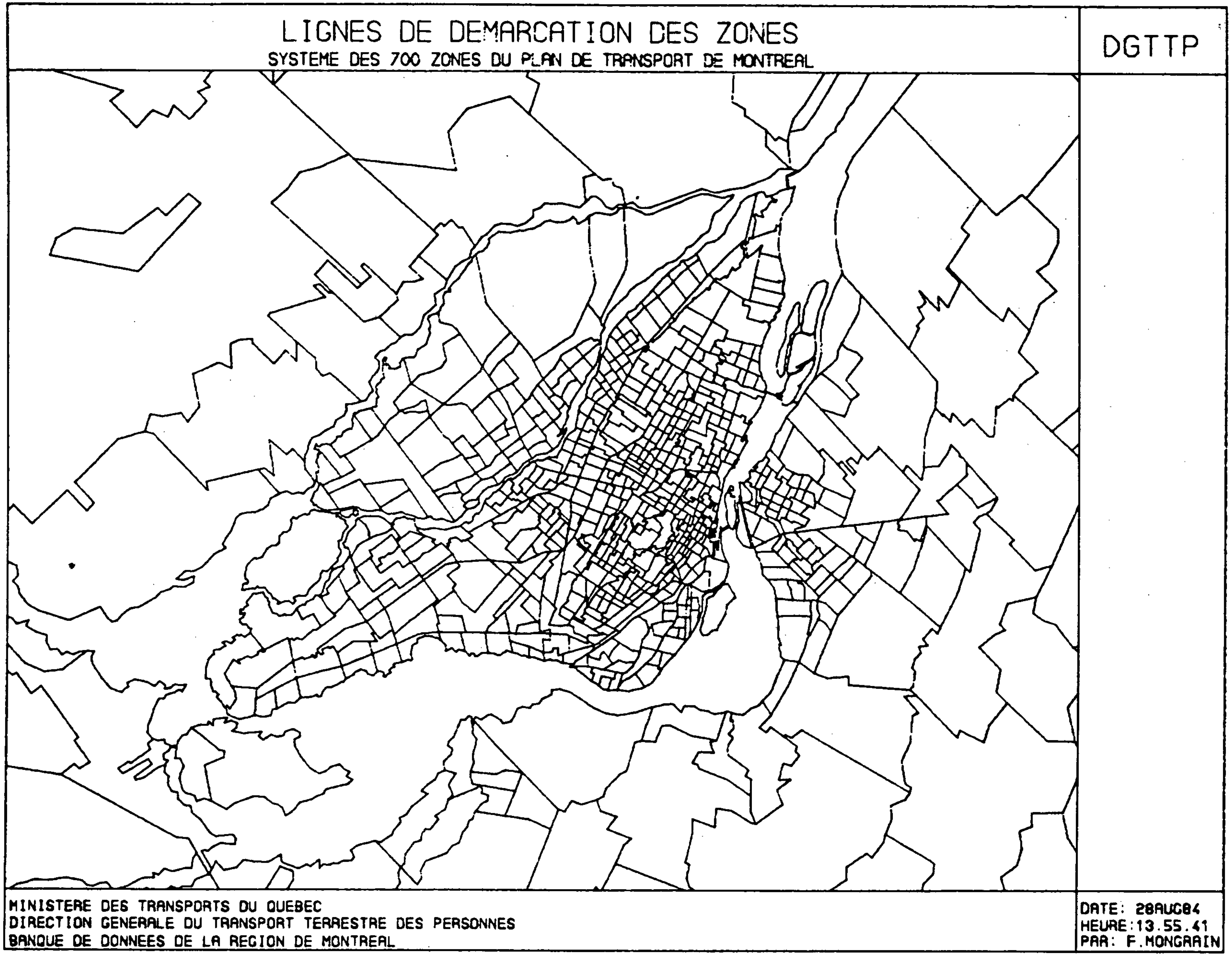


Figure 3
The zonal system

represented approximately one year-person; the basic validation and the corrections required about four month-person of work, spread over a one year period.

Table 1

Link classification

Facility type	number of links
Exclusive transit	783
Autoroute	565
Expressway	283
Major arterial	3 169
Minor arterial	2 659
Collector	4 835
Local	5 739
Ramp (autoroute)	756
Toll plaza	26

5. THE VOLUME/DELAY FUNCTIONS

The modeling of congestion on the links of the road network is achieved by using a set of volume/delay functions which are part of the data base.

In order to calibrate these functions, in parallel with the origin/destination survey, measurements of travel times, by using the "floating car" method, were carried out simultaneously with measurements of observed volumes. For each of 27 predefined routes, traffic counts were obtained by 15 minutes time slices and the observed travel times during the corresponding 15 minutes time intervals were associated with the corresponding traffic count. Each predefined route was traveled continuously by a car during the morning peak period (6 am to 9 am), resulting in multiple observations of travel time and traffic counts on the selected links.

The functional form selected for the volume/delay functions is:

$$s_a(v_a) = \alpha v_a + t_o \, (1 + \beta((v_a/c_a l_a)^{\gamma}))$$

where s_a is the estimated travel time per km, v_a is the volume on link a, t_o is the free flow travel time in min/km, c_a

is the practical capacity of the link in veh/hr/lane and l_a is the number of lanes of the link; α, β, ξ are parameters that are calibrated.

Since the congested part of the volume/delay functions models in part the congestion phenomenon and in part acts as a penalty for flows much over capacity, there are many ways to choose the parameter ξ. If ξ is chosen too high, say between 8 and 20, the functions are quite steep and the assignment algorithm used (see next section) may converge slowly. After some analysis of the data and trial uses of the assignment algorithm, it was decided to use values of ξ around 4, β was fixed at 0.15 and c_a was defined to be 75% of the link capacity at level of service "C", as used in the UROAD program, of UTPS. Also, α was chosen to be greater than zero but small, in order to better fit the observed data in light congestion conditions.

The data analysis resulted in the calibration of a series of volume/delay curves, of which 17 are currently used (see Figure 4). At first, all links were assigned "a priori" to one of these categories, based on their facility type and area type (Table 2). During the calibration of the assignment model, some links were reassigned from one category to another, based on a more detailed analysis of the model.

It should be noted that function FD13 is used for the toll links, where a systematic 2 minutes penalty is added to the standard form of the function. The FD14 and FD15 curves are used for access links, where penalties are added for parking and walk times.

Table 2

A priori assignation of volume/delay functions

Area type	Facility type 1	2	3	4	5	6	7	8	9	c
CBD	1	3	6	8	11	12	2	13	5	14
Commercial	1	3	7	8	10	12	2	13	5	15
Industrial	1	3	6	9	8	12	2	13	5	15
Residential	1	3	4	6	11	12	2	13	5	15
Rural	1	3	19	18	8	12	2	13	5	15

1 : Freeway
2 : Expressway
3 : Major arterial
4 : Minor arterial
5 : Collector
6 : Local street
7 : Freeway ramp
8 : Toll plaza
9 : Arterial bridges
c : Centroid connectors

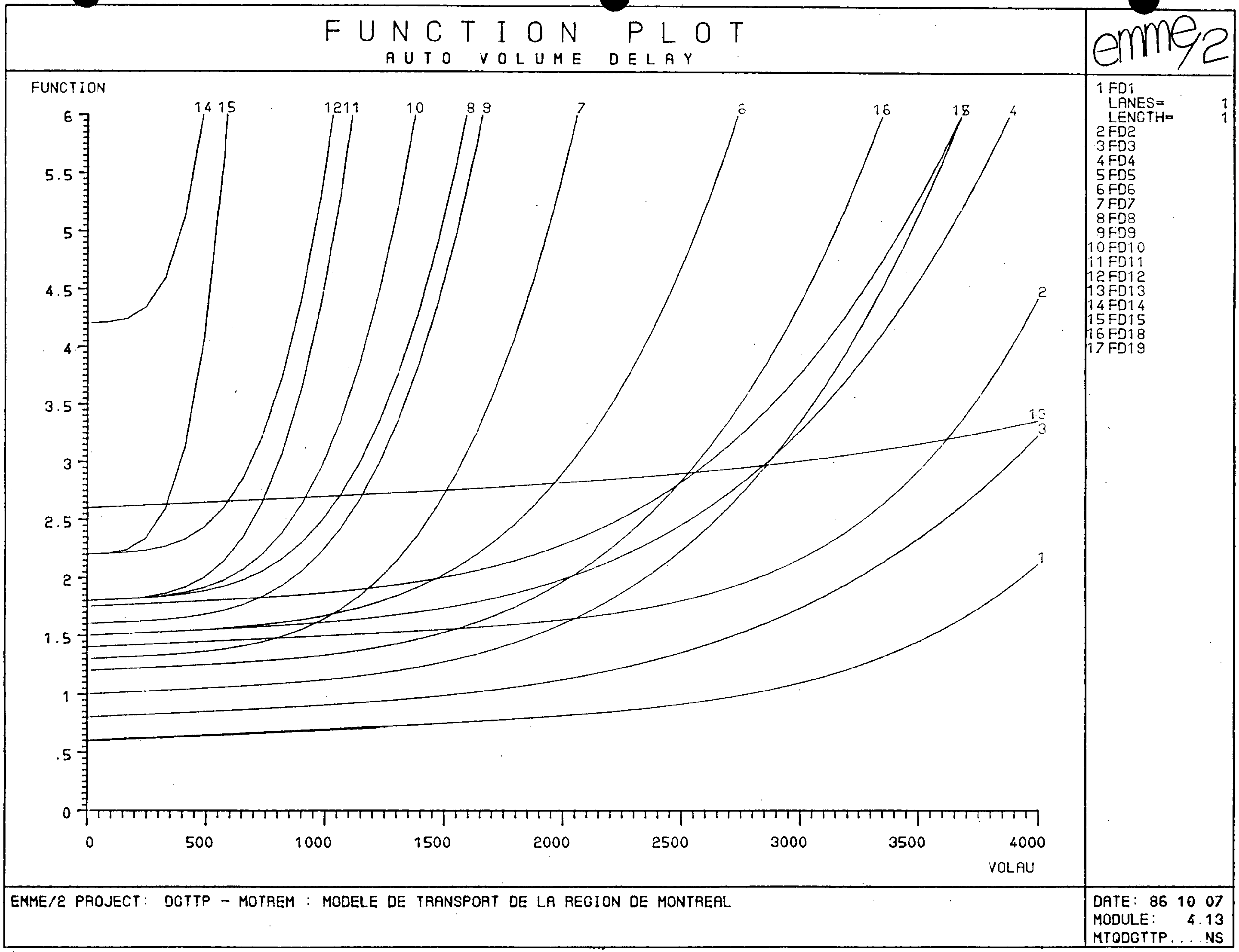

FUNCTION PLOT
AUTO VOLUME DELAY
emme/2
FUNCTION
VOLAU
1 FD1
LANES= 1
LENGTH= 1
2 FD2
3 FD3
4 FD4
5 FD5
6 FD6
7 FD7
8 FD8
9 FD9
10 FD10
11 FD11
12 FD12
13 FD13
14 FD14
15 FD15
16 FD18
17 FD19
EMME/2 PROJECT: DGTTP - MOTREM : MODELE DE TRANSPORT DE LA REGION DE MONTREAL
DATE: 86 10 07
MODULE: 4.13
MTQDGTTP....NS

Figure 4

6. THE MODEL

The model used is the fixed demand network equilibrium model, as implemented in EMME/2 which may be formulated as:

$$\text{Min} \sum_{a\epsilon A} \int_0^{v_a} s_a(x)dx + \sum_{i\epsilon P} \sum_{a_i\epsilon A_i^-} \sum_{a_i\epsilon A_i^+} \int_0^{v_{a_1a_2}} p_{a_1a_2}(x)dx \qquad (1)$$

$$\text{subject to :} \quad \sum_{k\epsilon K_i} h_k = g_d \ , \quad d\epsilon D \qquad (2)$$

$$h_k \geqslant 0, \ k\epsilon K_d, \ d\epsilon D \qquad (3)$$

$$\text{and} \quad v_a = \sum_{d\epsilon D} \sum_{k\epsilon K_d} \delta_{ak} \, h_k, \quad a\epsilon A \qquad (4)$$

$$v_{a_1a_2} = \sum_{d\epsilon D} \sum_{k\epsilon K_d} \delta_{a_1a_2k} \, h_k \ , \quad a_1a_2\epsilon P \qquad (5)$$

The notation used is the following :

a is a link belonging to the set of links A, $A \subset N \times N$, where

N is the set of nodes of the network

A_i^+ is the set of outgoing links at node i, $i\epsilon N$

A_i^- is the set of incoming lings at node i, $i\epsilon N$

a_1a_2 is a turn belonging to the set of turns P, $P \subset N$

$p_{a_1a_2}(v_{a_1a_2})$ is the penalty cost function on turn a^1a^2

d is an origin/desgination pair belonging to the set of O/D pairs D

g_d is the demand for O/D pair d, $d\epsilon D$

h_k is the flow on patk k

$$\delta_{ak} = \begin{cases} 1 & \text{if } a\epsilon k \\ 0 & \text{otherwise} \end{cases} \quad \text{and} \quad \delta_{a_1a_2k} = \begin{cases} 1 & \text{if } a_1a_2\epsilon k \\ 0 & \text{otherwise.} \end{cases}$$

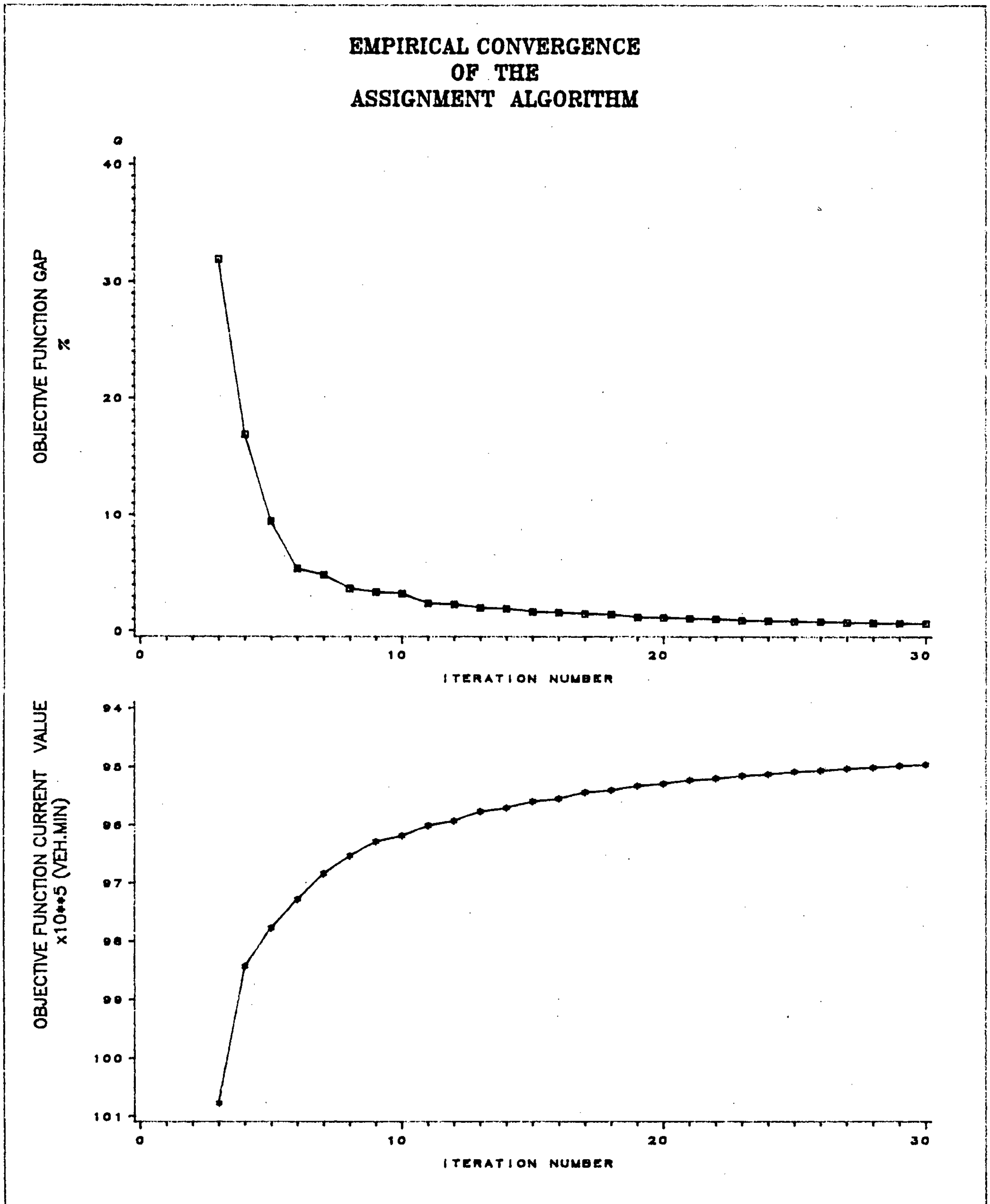
The solution algorithm implemented in EMME/2 is a version of the linear approximation algorithm of Frank and Wolfe [5]. The details of the implementation are described by Spiess [6]. The computations are initiated with an all-or-nothing solution, based on the free-flow travel times and are terminated after a prescribed maximum number of iterations or when a prescribed value of the "gap" is reached. For the problem of [min $F(x)$, $x \in \Omega$], where $F(x)$ is a convex fonction and is a compact set, the relative gap is defined as:

$$100 \, |\Delta F(x^k)(y^k - x^k) \, / \, F(x^k)|,$$

where x^k is the current solution and y^k is the solution of the linear approximation problem at iteration k.

Figure 5 gives the value of the objective function and the relative gap as a function of the number of iterations carried out for the Montreal network. A solution with a gap of 1% or less is sufficiently close to optimality and this is reached after 22 iterations. The time per iteration on the IBM 3090-200 of the MTQ is approximately 172 seconds; as is well known, the algorithm exhibits slow convergence in the vicinity of the optimal solution and a future version of the equilibrium assignment of EMME/2 will incorporate both a better starting solution and the PARTAN variant of the linear approximation method, as described by Florian, Guelat and Spiess [7].

Figure 5


EMPIRICAL CONVERGENCE
OF THE
ASSIGNMENT ALGORITHM
OBJECTIVE FUNCTION GAP
%
0
10
20
30
40
0
10
20
30
ITERATION NUMBER
OBJECTIVE FUNCTION CURRENT VALUE
x10**5 (VEH.MIN)
94
95
96
97
98
99
100
101
0
10
20
30
ITERATION NUMBER

7. CALIBRATION AND VALIDATION OF THE MODEL

The calibration and validation of an equilibrium assignment model on a network of this size is a task that is never truly completed. As the model is used to evaluate scenarios in particular areas it is possible to further refine the model and improve the quality of the flow simulations. At present, 40 successive assignments were carried out and analyzed, and the results presented in this paper give the current state of the model. It is nevertheless suitable to discuss the sources of difficulty in the calibration and validation of the model. These are as follows:

- The demand matrix; this is a principal source of difference between predicted and observed flows, since it is subject to the bias of the origin/destination survey and also does not include any trip of "commercial" nature, as mentioned before in section 3. Other sources of problem may be linked to the zonal subdivision and its adequacy with respect to the network representation; in certain cases it is not possible to modify the zonal subdivision since it is tied with the O/D survey. Last, but not least, the intra-zonal trips, which are not assigned on the network, may result in underestimation of the predicted flows in large peripheral zones.

- The traffic counts; the data related to counts are sometimes difficult to use if the counts are not obtained in a systematic way, which is economically not feasible. In general, counts are performed throughout the year and are carried out by different organisations with different classification of vehicle types, different time periods covered and different time intervals used to report the data. At times the counters have unreported mechanical or electrical breakdowns and the exact location of the counter may not be perfectly known (before or after an autoroute ramp). Some of these details are important but not always available.

- The temporal aspect of congestion effects; as mentioned before, the peak flows move in space and time during a three hour period and a static model based on volume/delay curves to model congestion is an approximation of the congestion phenomenon.

- The assignment of volume/delay functions to links; it is practically impossible, when dealing with more than 18,000 links, to make entirely appropriate choices of the volume/delay functions, given the great diversity of local conditions which can influence the performance of a link independently from its physical characteristics.

Nevertheless, a regional model, such as the one described in this paper, is workable if the accuracys of the predicted flows are well characterized. In order to achieve this, data from 501 counts that were controlled was used to calibrate and validate the model. The localization of these counts was organized to produce 25 screen lines and 4 cordons. In addition, a survey of travel times during the peak was carried out upon the staff of two large employers; the data from this survey makes it possible to produce isochrones for accessing these two destinations and these were used in the calibration process.

The data from 201 traffic counts distinguish between truck and car traffic. This data was used to estimate the proportion of trucks traffic for the rest of the stations. A simple relationship was estimated from these 201 observation which is:

$$\text{No. of trucks} = \exp^{(-0.3923 + 0.7238 \ln(\text{Total traffic}))}$$

and has an r^2 of 0.60 . By using this relationship we can estimate the number of private cars out of the total observed traffic and the volume/delay curves are adjusted slightly to reduce the practical capacity available for cars. While this analysis is approximate, given the small amount of data available, it compensates partly for the absence of any information on "commercial" trips in the origin/destination matrix.

In order to analyze the predicted flows vs. observed flows, the following statistical measures are computed by utility programs developed for this purpose (see also Nuzzolo [8]):

- Difference between Means (DM): $DM\ \% = (v_m - \hat{v}_m)/\hat{v}_m$

  where $v_m = \sum_a v_a / n$ is the average predicted flow,

  $\hat{v}_m = \sum_a \hat{v}_a / n$ is the average observed flow, and

  n is the number of links with observed flows.

- Root Mean Squared Error (RMSE): $RMSE = \sqrt{[\sum (v_a - \hat{v}_a)^2 / n]}$

- Root Mean Squared Error %: $RMSE\ \% = RMSE / \hat{v}_m$

- Weighted RMSE (W_tRMSE): $W_t RMSE\ \% = RMSE\ \% * (\%\ \text{total flow})$

Under the assumption that the bias is null, RMSE is a sample estimate of the standard deviation of the distribution of prediction error. Even though this assumption is unlikely to be satisfied, the RMSE and RMSE% may be used to compute confidence limits for the predicted flows.

COMPARISON OF PREDICTED VS. OBSERVED VOLUMES
A.M. PEAK PERIOD

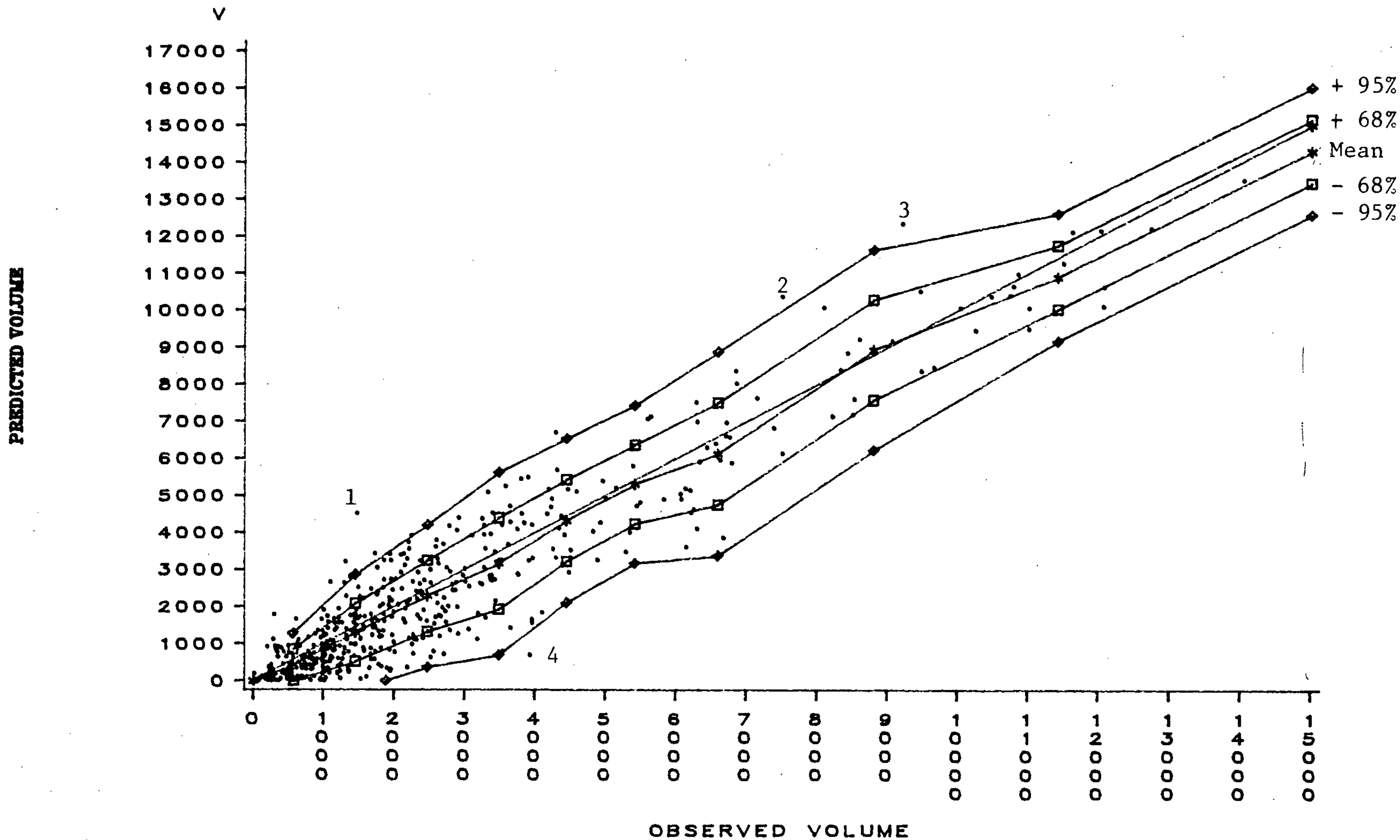


Figure 6

Figure 6 gives a scatter diagram of predicted flows obtained at the most recent stage of the calibration, vs. observed flows for the 501 counts that were used for the calibration. The 68% and 95% intervals of confidence and a piecewise linear function that connects that mean predicted value for each flow class are drawn as well. Some outlyers, numbered from 1 to 4, may be commented as follows:

(1) This is due to a problem with the zonal subdivision at Dorval airport; the employees of the airport may access their place of work by two entrances that are several kilometers apart, but the network contains only one access link for that zone, to the passenger terminal, which is oversimulated.

(2) This is due to a flow diversion between the Trans-Canada autoroute (A-40) and the parallel service road near the Decarie interchange; this problem may be rectified by a more detailed coding of the Decarie interchange.

(3) This is an overestimation of the flow in the Ville-Marie autoroute (A-20) which accesses the CBD; this problem may be rectified by reducing the capacity of this link, which is part of a tunnel, and inducing a diversion of the flows on the many parallel arterial roads to it.

(4) This is an underestimation on a major arterial route which competes with many minor parallel arterial routes; this problem may also be rectified by changing the volume/delay function of this link.

These comments highlight the difficulties of calibrating and validating a large scale network model. In our case, the technical choices to be made are based on a relatively small number of observations and hence, systematic choices are often difficult to implement.

Table 3 gives a summary of the results; the volumes classes refer to the total flow on a given link, for the whole peak period (6 am to 9 am).

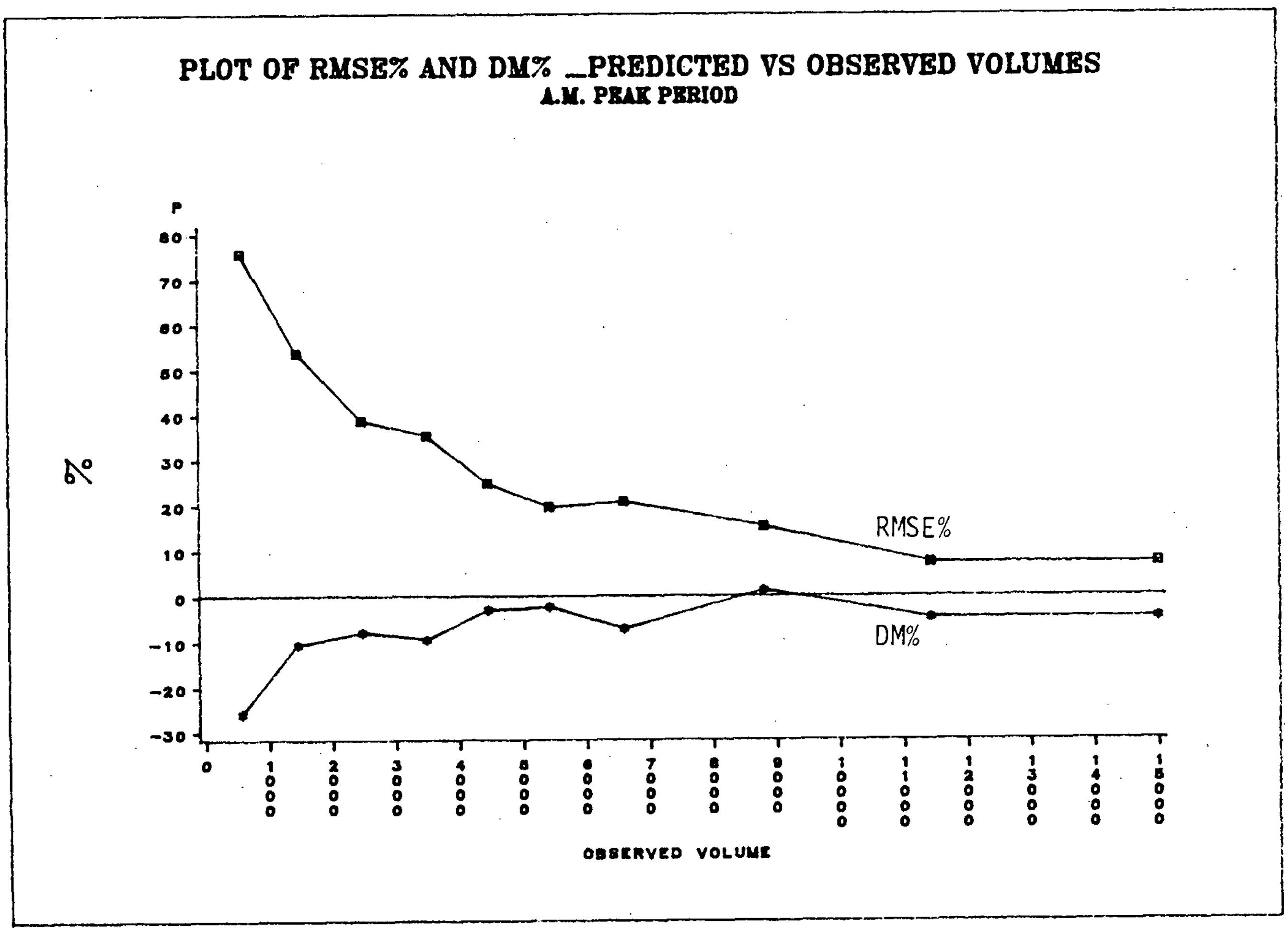
In spite of all the above considerations of sources of error, it is easy to remark, by inspecting Table 3, that the quality of the predicted flows is better for larger volumes. Figure 7 gives the relation between the error of estimation and the values of the observed flows, for the classes used in Table 3. Our model has a bias towards underestimating the observed flows, which is to be expected, and this is particularly noticeable for links with low volumes. The slight overestimation for the flow class [8,000 - 10,000] is due to two outlyers, explained earlier, which cause this deformation of the general properties of the model. It is worthwhile to point out that the coefficient of variation of the prediction errors decreases with increasing flow values.

TABLE 3

ANALYSIS OF PREDICTED VS. OBSERVED VOLUMES
AM Peak Period

Flow Class	n	Avg. Obs.	Avg. Prd.	DM %	RMSE	RMSE %	%Tot. Flow	W_t % RMSE
0-1000	135	564	419	-25.7	428	75.9	6.1	4.6
1000-2000	156	1452	1299	-10.5	781	53.8	18.0	9.7
2000-3000	78	2472	2280	-7.8	959	38.8	15.3	6.0
3000-4000	49	3485	3157	-9.4	1233	35.4	13.6	4.8
4000-5000	20	4447	4317	-2.9	1106	24.9	7.1	1.8
5000-6000	11	5418	5299	-2.2	1065	19.7	4.7	0.9
6000-8000	25	6597	6128	-7.1	1376	20.9	13.1	2.7
8000-10000	12	8800	8927	1.4	1351	15.4	8.4	1.3
10000- +	15	11421	10884	-4.7	860	7.5	13.6	1.0
GLOBAL	501	2508	2315	-7.7	875	34.9	100.0	32.8

Figure 7



The links that carry the highest volumes are usually major facilities, which have generally little competition from parallel facilities for attracting traffic; the links that carry lower volumes are affected more by parallel facilities and by the choices made in the modeling, such as the subdivision of zones and the location of centroid connectors.

The above conclusions are verified by the statistics shown in Table 4, where the links are stratified by facility types. In order to complete the analysis of the results, the same statistics were computed for a stratification of the links by "flow per lane" classes (Table 5). The same general properties of the predicted flows are apparent, with the exception that the underestimation of the flows now varies in a narrower range.

TABLE 4

ANALYSIS OF PREDICTED VS. OBSERVED VOLUMES
BY FACILITY TYPE
A.M. Peak Period

Facility type	n	Avg. Obs.	Avg. Prd.	DM %	RMSE	RMSE %	%Tot. flow	W_t % RMSE
Freeway	91	5105	5021	-1.6	1003	19.6	37.0	7.3
Expressway	59	3590	3400	-5.3	982	27.4	16.9	4.6
Major arterial	156	2311	2183	-5.5	924	40.0	28.7	11.5
Minor arterial	98	1338	1183	-11.6	713	53.3	10.4	5.6
Local/Collect.	97	913	474	-48.1	731	80.1	7.0	5.6
GLOBAL	501	2508	2315	-7.7	875	34.9	100.0	34.6

TABLE 5

ANALYSIS OF PREDICTED VS. OBSERVED VOLUMES BY LANE, BY FLOW CLASS
A.M. Peak Period

Flow Class	N	Avg. Obs.	Avg. Prd.	DM %	RMSE	RMSE %	%tot flow	W_t % RMSE
0- 500	143	298	253	-15.1	222	74.5	7.8	5.8
500-1000	161	722	648	-10.2	374	51.8	21.3	11.1
1000-1500	95	1215	1046	-13.9	479	39.5	21.2	8.4
1500-2000	26	1745	1553	-11.0	662	37.9	8.3	3.2
2000-2500	26	2238	1970	-12.0	606	27.1	10.7	2.9
2500-3000	14	2703	2617	-3.2	532	19.7	6.9	1.4
3000-3500	17	3229	2902	-10.1	574	17.8	10.1	1.8
3500-4000	12	3718	3628	-2.4	485	13.1	8.2	1.1
4000- +	7	4215	3892	-7.7	597	14.2	5.4	0.8
GLOBAL	501	1087	975	-10.3	415	38.2	100.0	36.3

8. APPLICATIONS OF THE MODEL

We describe briefly, in this section, three applications made with the regional model that we presented before. The first is the measurement of the impact of closing a lane on a bridge that is part of a heavily used arterial road; the second is the study of a corridor linking the Island of Montreal to a suburb which is relatively far from the city center on the north shore; the third is a study for the economic justification of building a new interchange for an expressway which was to be updated and implied the crossing of a railway in order to provide a new inter-municipal access.

The Pont-Viau bridge renovation

The first application involved the creation of a scenario in which one lane was removed from the Pont-Viau bridge, between Laval and Montreal. Figure 8 gives the comparison of flows for this scenario and the existing situation. We can notice increases of flow on parallel bridges and a reallocation of the flow and the nearby collectors.

An analysis of the time differences revealed a paradoxical result: when we calculated the variation of travel times between the two scenarios by trip production zone, we found that some zones far from the bridge showed significant differences in vehicle-minutes traveled (see Figure 9). These differences are explained by the fact that the flows obtained are not "perfect" equilibrium flows and small differences in travel time represent important differences in vehicle-minutes since the flows produced by these big peripheral zones are high. Figure 10 shows the same map, where a treshold of 3% was applied to the minimum variation in travel time to be included in the analysis. The way to attenuate such problems is to be very careful in the coding of centroid connectors and the local street links, giving them sufficient capacity to accomodate the relatively high volumes they have to feed to the major facilities. These problematic links can be found by careful inspection of all facilities that have a predicted speed of less than 5 or 10 km/hr.

The analysis was completed by using the predicted flows as an input to dynamic traffic simulation programs, which model explicitly the queuing phenomena on the bridge, and can yield more accurate estimates of travel times during the peak period.

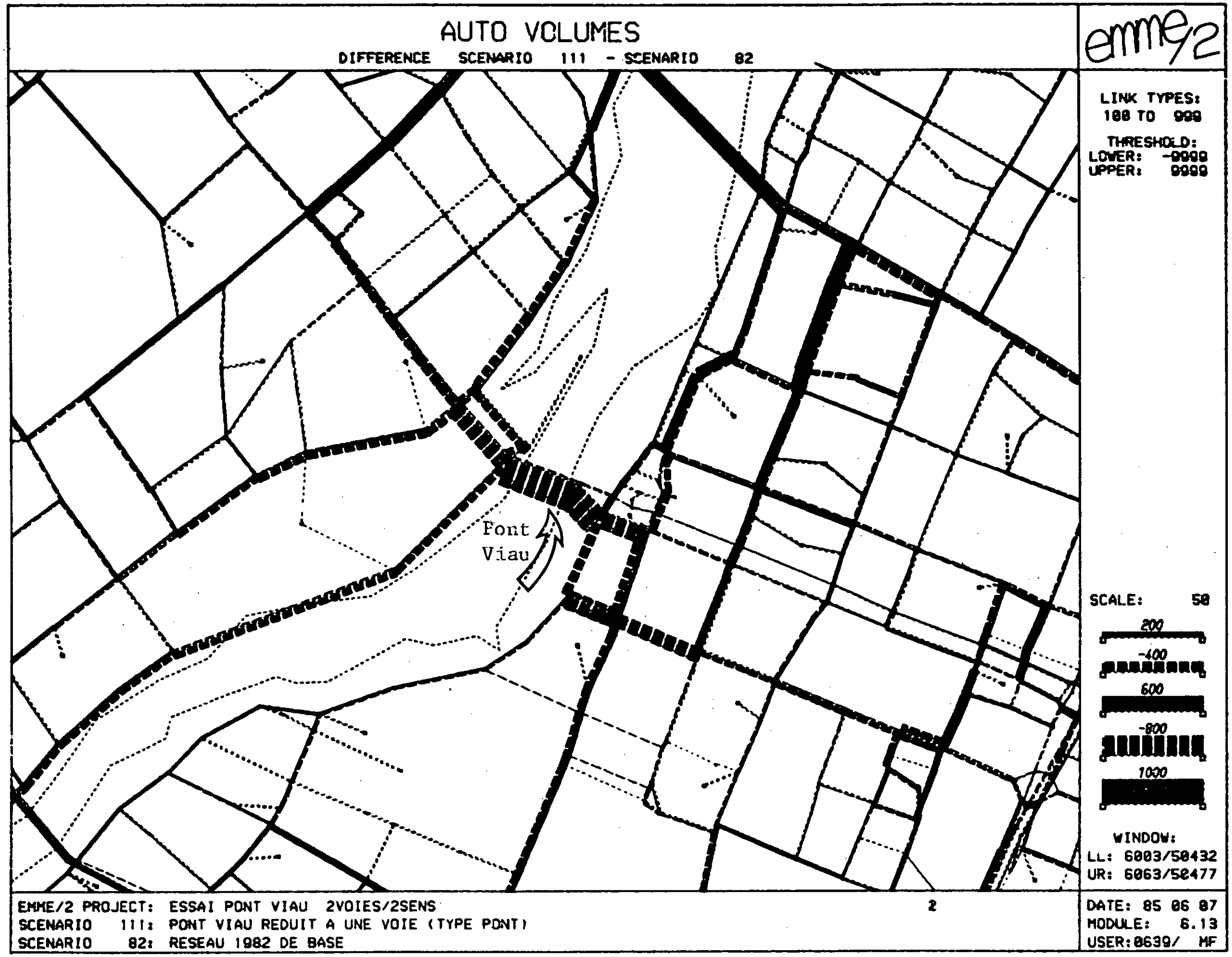

AUTO VOLUMES
DIFFERENCE SCENARIO 111 - SCENARIO 82
emme/2
LINK TYPES:
100 TO 999
THRESHOLD:
LOWER: -9999
UPPER: 9999
Pont
Viau
SCALE: 50
200
-400
600
-800
1000
WINDOW:
LL: 6003/50432
UR: 6063/50477
EMME/2 PROJECT: ESSAI PONT VIAU 2VOIES/2SENS
2
SCENARIO 111: PONT VIAU REDUIT A UNE VOIE (TYPE PONT)
SCENARIO 82: RESEAU 1982 DE BASE
DATE: 85 06 07
MODULE: 6.13
USER:0639/ MF

Figure 8

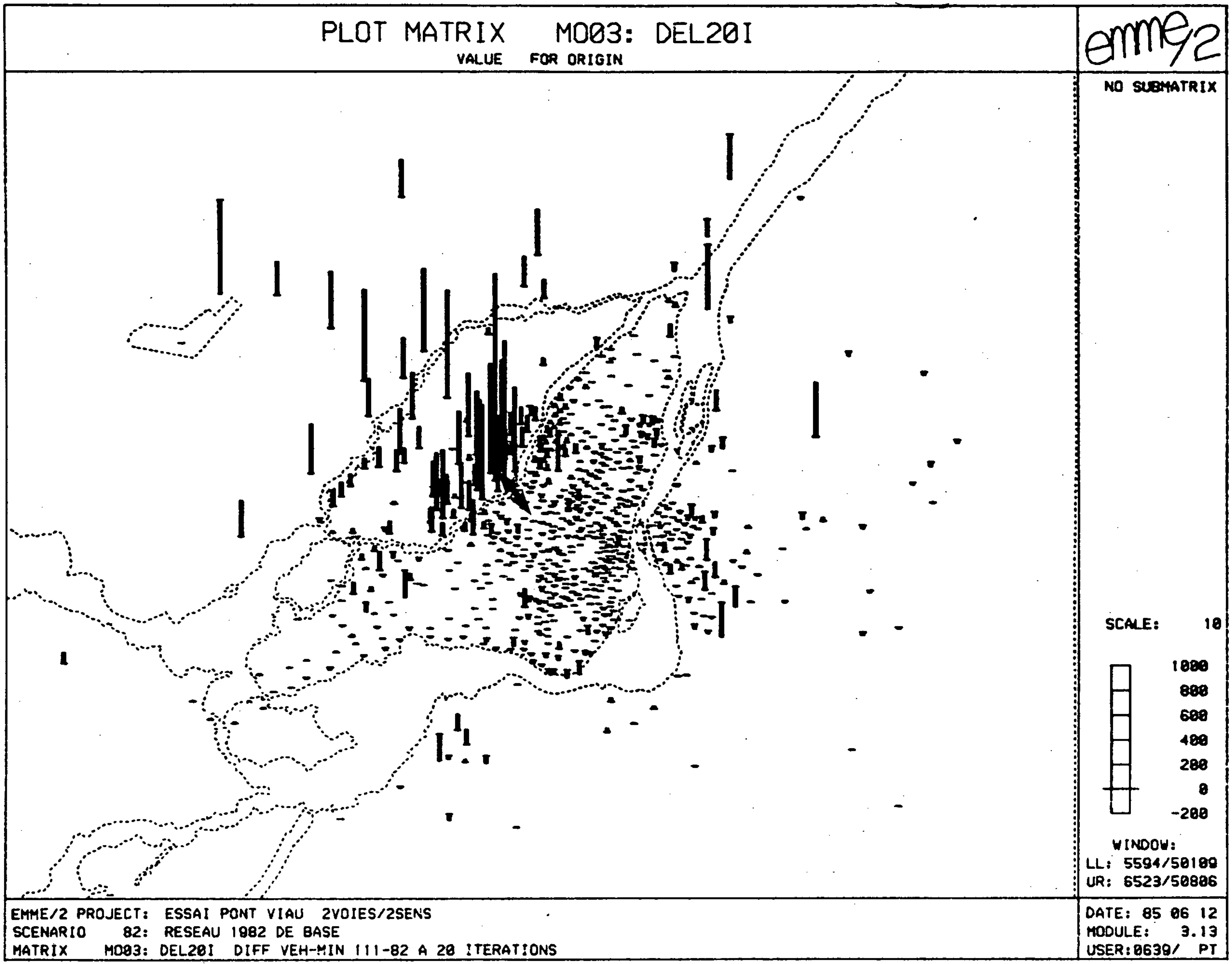

PLOT MATRIX M003: DEL20I
VALUE FOR ORIGIN
emme/2
NO SUBMATRIX
SCALE: 10
1000
800
600
400
200
0
-200
WINDOW:
LL: 5594/50100
UR: 6523/50806
EMME/2 PROJECT: ESSAI PONT VIAU 2VOIES/2SENS
SCENARIO 82: RESEAU 1982 DE BASE
MATRIX M003: DEL20I DIFF VEH-MIN 111-82 A 20 ITERATIONS
DATE: 85 06 12
MODULE: 3.13
USER:0639/ PT

Figure 9

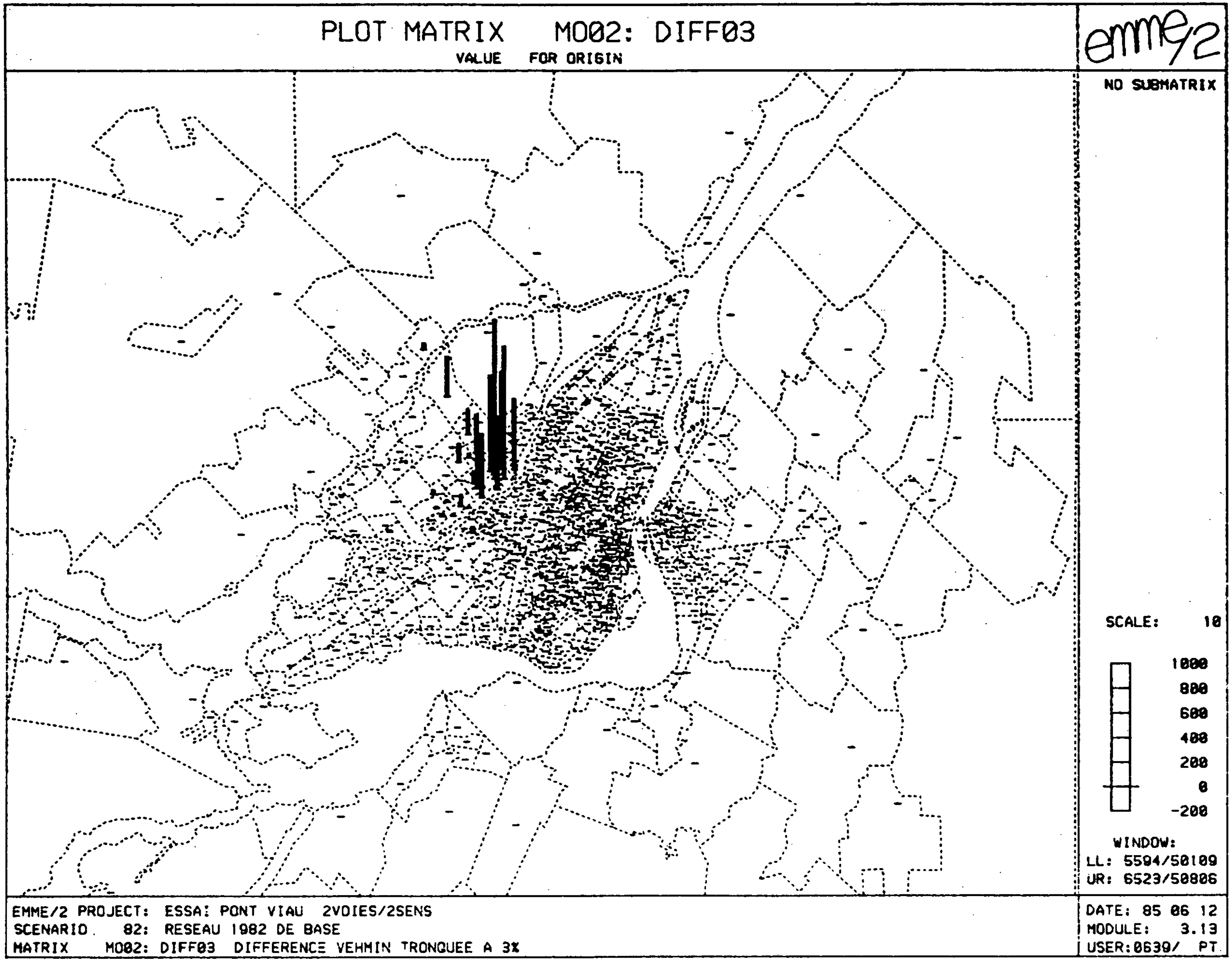

PLOT MATRIX M002: DIFF03
VALUE FOR ORIGIN
emme/2
NO SUBMATRIX
SCALE: 10
1000
800
600
400
200
0
-200
WINDOW:
LL: 5594/50109
UR: 6523/50806
EMME/2 PROJECT: ESSAI PONT VIAU 2VOIES/2SENS
SCENARIO 82: RESEAU 1982 DE BASE
MATRIX M002: DIFF03 DIFFERENCE VEHMIN TRONQUEE A 3%
DATE: 85 06 12
MODULE: 3.13
USER:0639/ PT

Figure 10

The "MRC Des-Moulins" sketch-plan

The second application involved a study which may be classified as a long range planning exercise, based on approximate estimates of population growth. The work was related to the project of a new autoroute bridge (A-25) in a corridor between the east part of the Montreal Island and the north shore suburbs of Laval and Terrebonne, which is quite far from the CBD (see Figure 2).

The future demand estimates were based on the simple hypothesis that population and employment would double for the regional municipality of MRC Des-Moulins, resulting in the doubling of trip production and attraction in the corresponding zones (e.g. total production of car trips increases from 11,400 to 22,800 during the AM peak period of 6 am to 9 am).

After a quick trip distribution revision, various scenarios were studied concerning two autoroute corridors (A-19 and A-25), with various conditions on the number of lanes and construction phasing. The results obtained were suitable for the purpose of a quick evaluation of the projects, and took approximately two days of work. This is a relatively easy application since great precision was not necessary and the corridors studied were clearly defined.

Figures 11 and 12 show the traffic flows before and after, when both autoroutes are fully completed and the predicted travel demand is applied. The graphic output of the EMME/2 system were used directly for presentations made to the politicians concerned with the issue.

The Edna/Rte-116 interchange

The third and last application which we report on as an example relates to a detailed impact study concerning the widening of an expressway and the construction of an interchange replacing an unsafe access point, which is not grade separated, on Road 116, on the South-Shore of Montreal. The project would also permit to link two municipalities which are currently separated by an impassable railway on nearly 5 km.

Population and employment projection were made to estimate the trip productions and attractions in the sector at year 2001. The traffic flows, for the AM peak, on the base horizon, are shown on Figure 13. The projected flows for the new configuration are shown on Figures 14 and 15, which is an enlargement of the future interchange area.

The results supported the recommandation of a diamond type interchange and also permitted a discussion of the impacts of the

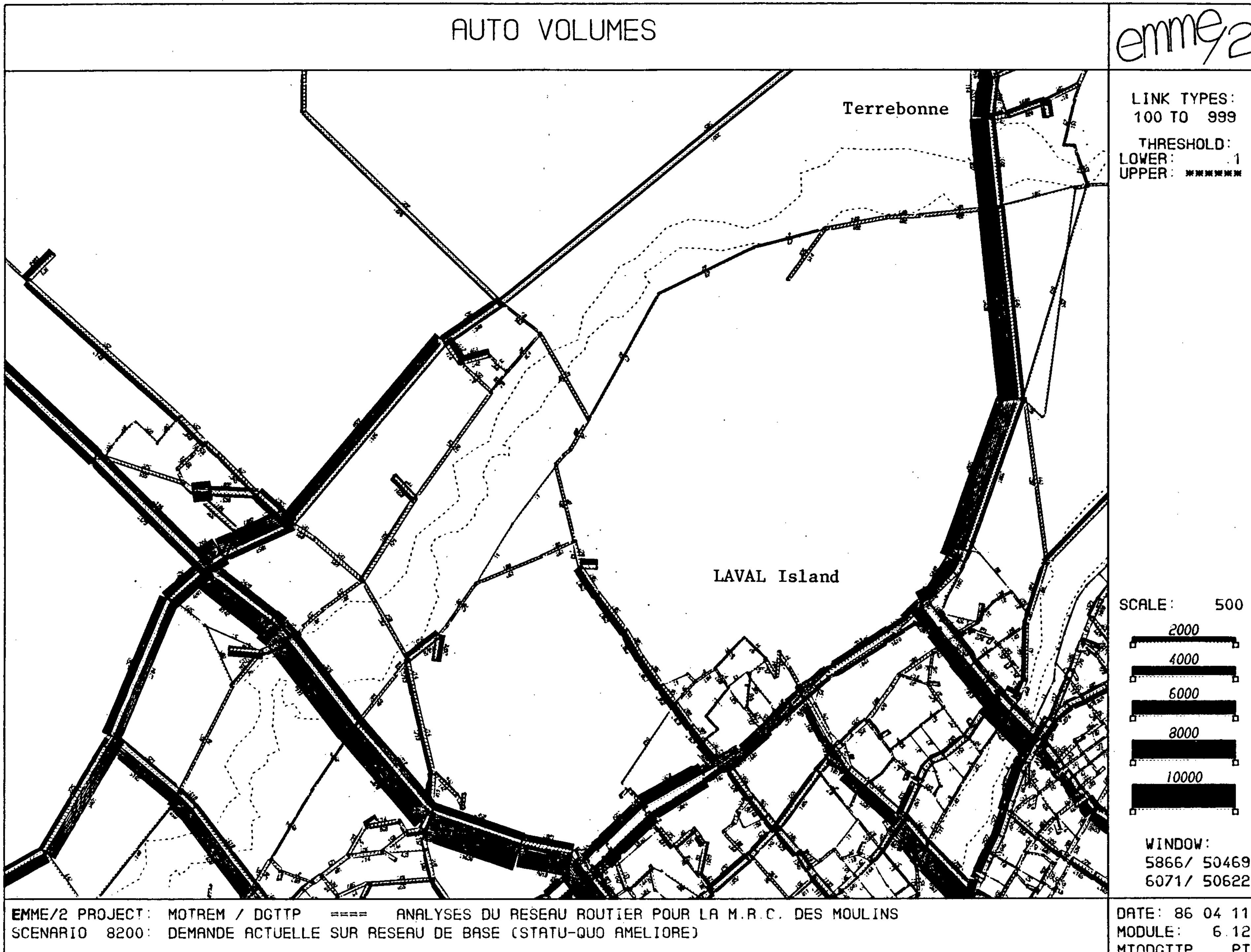

AUTO VOLUMES
emme/2
Terrebonne
LAVAL Island
LINK TYPES:
100 TO 999
THRESHOLD:
LOWER: .1
UPPER: ******
SCALE: 500
2000
4000
6000
8000
10000
WINDOW:
5866/ 50469
6071/ 50622
EMME/2 PROJECT: MOTREM / DGTTP ==== ANALYSES DU RESEAU ROUTIER POUR LA M.R.C. DES MOULINS
SCENARIO 8200: DEMANDE ACTUELLE SUR RESEAU DE BASE (STATU-QUO AMELIORE)
DATE: 86 04 11
MODULE: 6.12
MTQDGTTP....PT

Figure 11

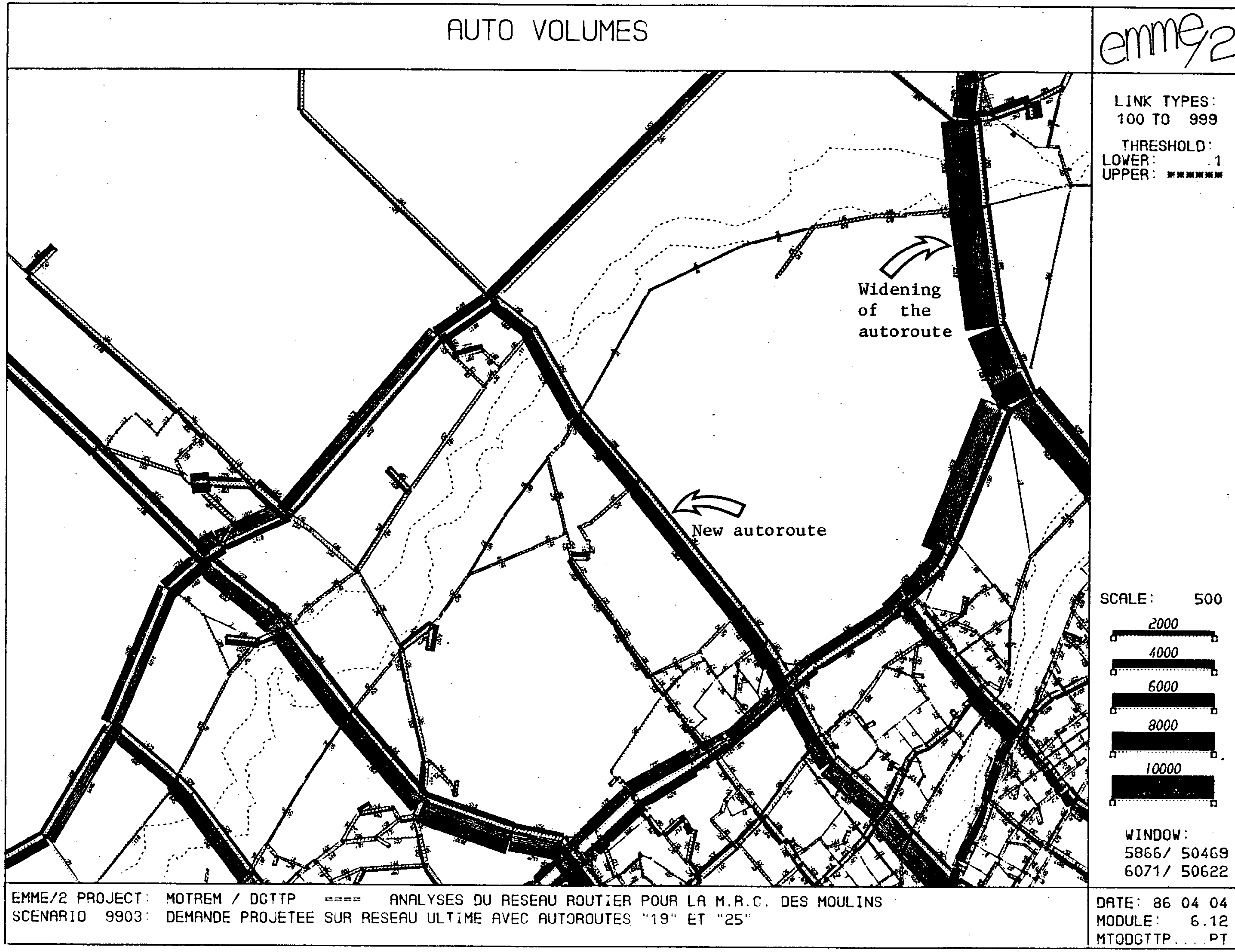
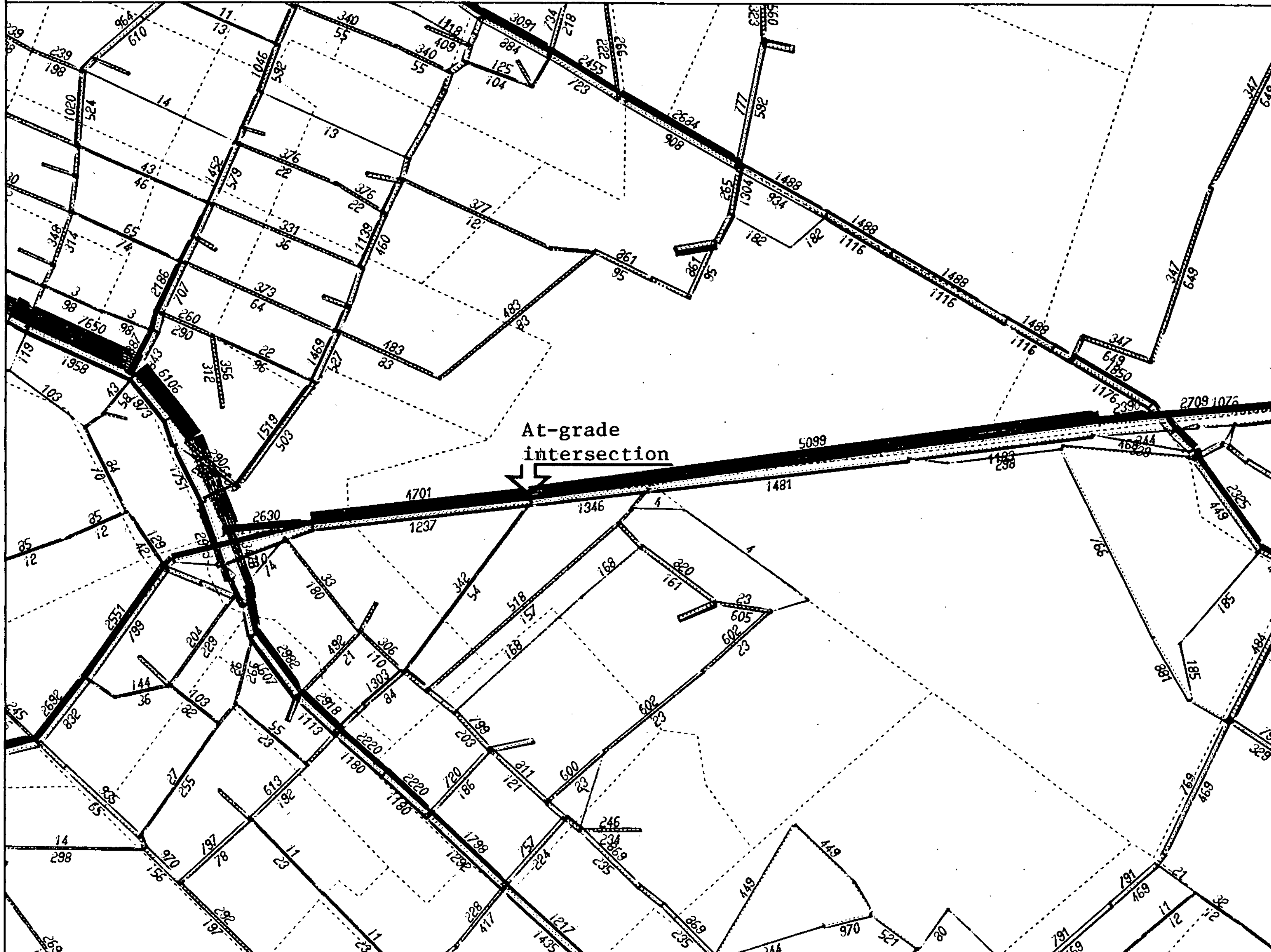

AUTO VOLUMES
emme/2
LINK TYPES:
100 TO 999
THRESHOLD:
LOWER: .1
UPPER: ******
Widening
of the
autoroute
New autoroute
SCALE: 500
2000
4000
6000
8000
10000
WINDOW:
5866/ 50469
6071/ 50622
EMME/2 PROJECT: MOTREM / DGTTP ==== ANALYSES DU RESEAU ROUTIER POUR LA M.R.C. DES MOULINS
SCENARIO 9903: DEMANDE PROJETEE SUR RESEAU ULTIME AVEC AUTOROUTES "19" ET "25"
DATE: 86 04 04
MODULE: 6.12
MTODGTTP....PT

Figure 12

AUTO VOLUMES

emme/2



LINK TYPES:
100 TO 999

THRESHOLD:
UPPER: ******

SCALE: 500

2000
4000
6000
8000
10000

WINDOW:
6170/ 50378
6230/ 50423

EMME/2 PROJECT: DGTTP - MOTREM : MODELE DE TRANSPORT DE LA REGION DE MONTREAL
SCENARIO 82: RESEAU 1982 DE BASE (V#38) *** DEMANDE 1982 P.P.A.M.

DATE: 86 10 08
MODULE: 6.12
MTQDGTTP....PT

Figure 13

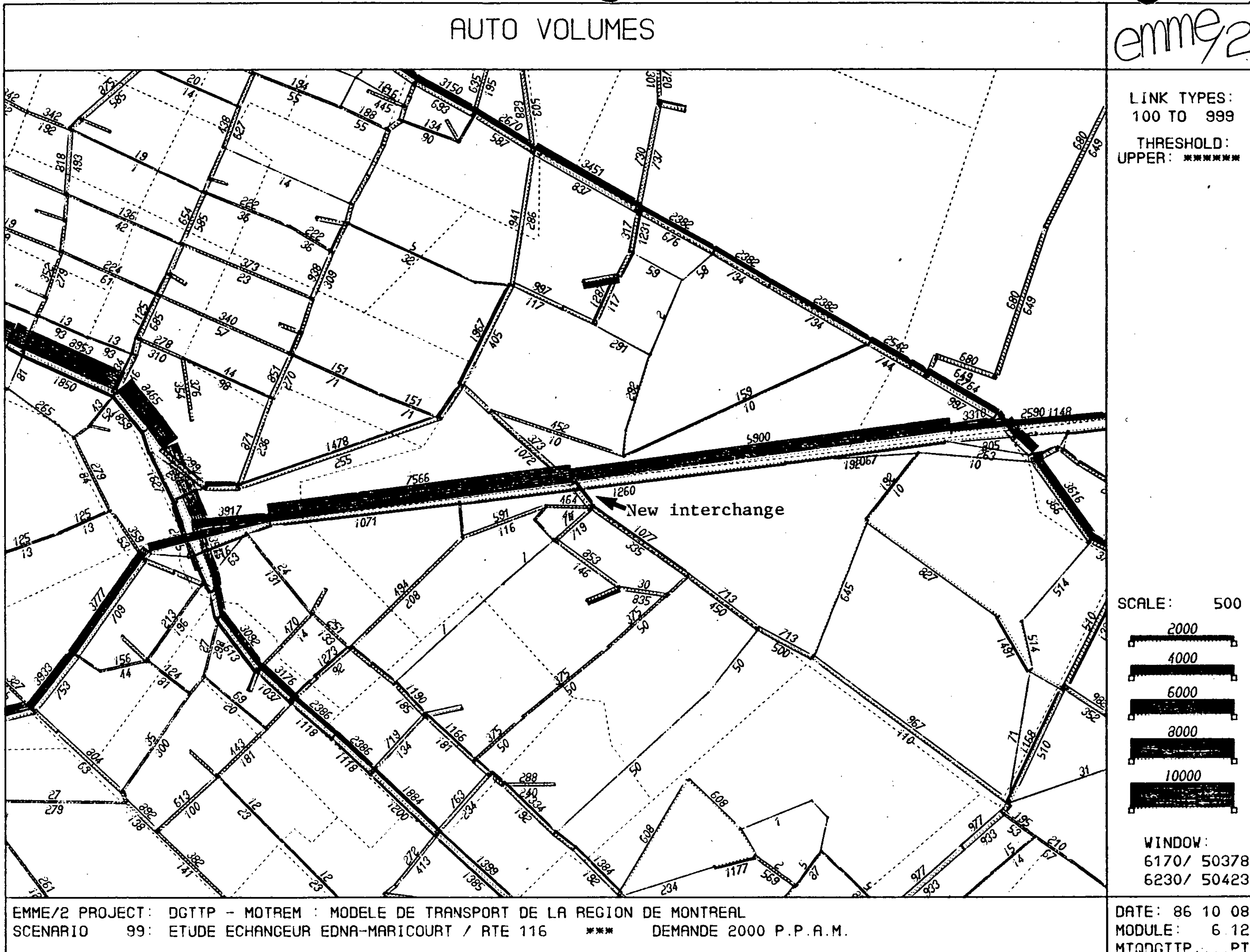

AUTO VOLUMES
emme/2
LINK TYPES:
100 TO 999
THRESHOLD:
UPPER: ******
New interchange
SCALE: 500
2000
4000
6000
8000
10000
WINDOW:
6170/ 50378
6230/ 50423
EMME/2 PROJECT: DGTTP - MOTREM : MODELE DE TRANSPORT DE LA REGION DE MONTREAL
SCENARIO 99: ETUDE ECHANGEUR EDNA-MARICOURT / RTE 116 *** DEMANDE 2000 P.P.A.M.
DATE: 86 10 08
MODULE: 6.12
MTQDGTTP.....PT

Figure 14

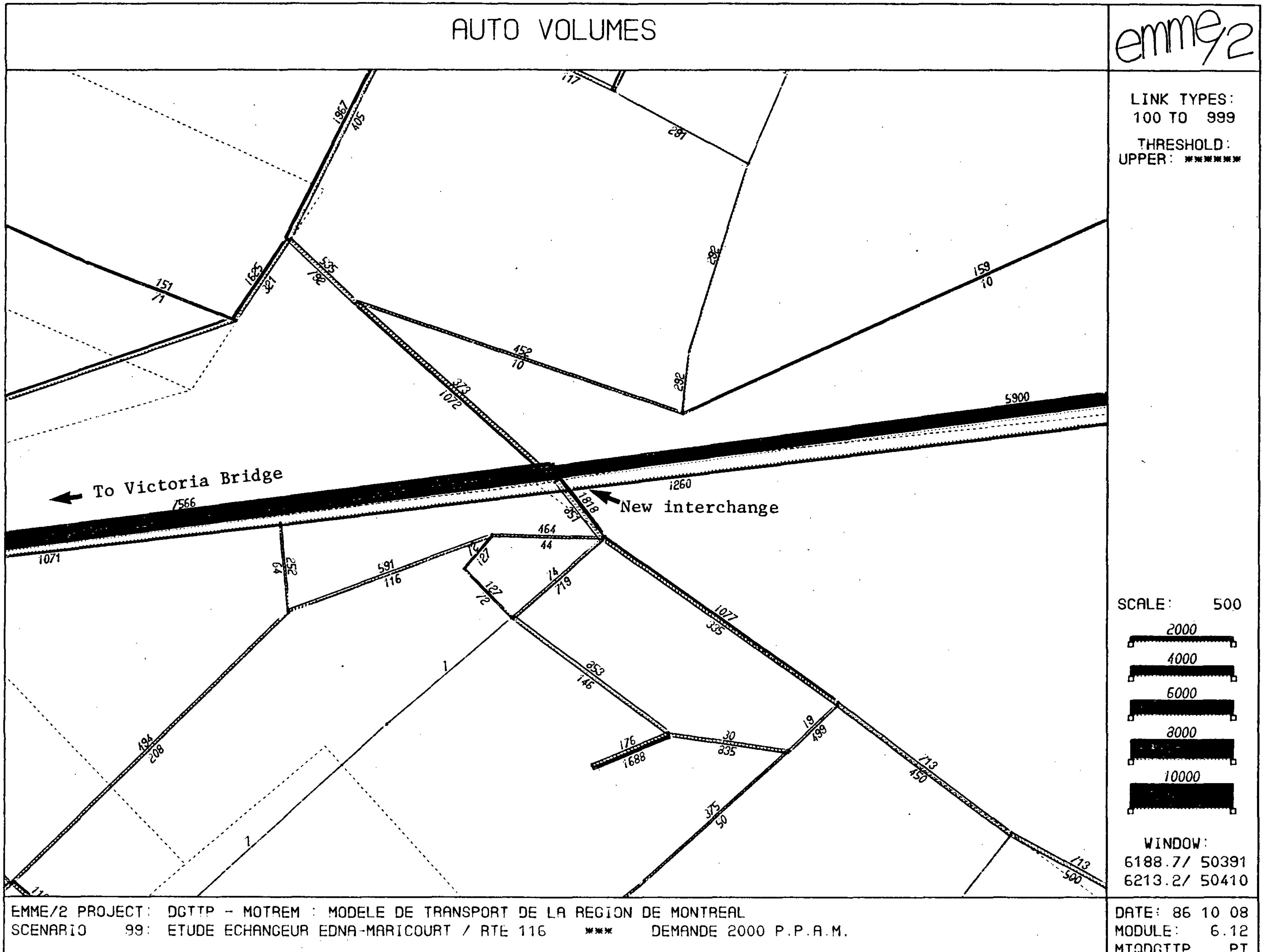

AUTO VOLUMES
emme/2
LINK TYPES:
100 TO 999
THRESHOLD:
UPPER: ******
SCALE: 500
2000
4000
6000
8000
10000
WINDOW:
6188.7/ 50391
6213.2/ 50410
To Victoria Bridge
New interchange
7566
5900
1260
1071
1818
857
EMME/2 PROJECT: DGTTP - MOTREM : MODELE DE TRANSPORT DE LA REGION DE MONTREAL
SCENARIO 99: ETUDE ECHANGEUR EDNA-MARICOURT / RTE 116 *** DEMANDE 2000 P.P.A.M.
DATE: 86 10 08
MODULE: 6.12
MTQDGTTP....PT

Figure 15

increased flows on the Victoria bridge, on the local traffic; in fact, major problems are to be anticipated within this region, since it is linked to the island of Montreal by five bridges that are already severely congested each morning.

9. CONCLUSION

The usefulness of large regional traffic assignment models is well established, in spite of the difficulty associated with their elaboration. The calibration and validation of such a model must thus be thought of as a continuous process; each time the model is used, it can be improved in the particular area under scrutiny.

In the Montreal region, a new origin/destination survey will be carried out in 1987. This new data on the demand for travel may be combined with more refined peak hour factors and a better analysis of commercial traffic flows to improve the quality of the predicted flows. Also, the volume/delay curves used may be refined by gathering new data on travel times by the "floating car" method. Similar models will also be developed in the near future for the Quebec and Outaouais regions.

A proper use of the model is conditioned on the analyst's awareness of its limitations. Model outputs must be analyzed with caution and the "client" must be made careful in its interpretations and conclusions, even if this may be disappointing at times.

The interactive-graphic approach leads to big gains in the productivity of the analyst in preparing scenarios and, above all, analyzing and communicating the results. This may lead to performing more assignments in a given time period and, in counterpart, incurring the associated increased computing costs. In our case, the assignments are done at night on the MTQ's computer, when the marginal cost is nearly zero. For less ambitious applications, the use of super-microcomputers should be an efficient way to get the same productivity, without the computing cost constraints.

Last, but not least, this paper is one of the few documented validation and application of a network equilibrium model, such as those reported by Nuzzolo [8], Florian and Nguyen [9], and Bovy and Jansen [10]. The application presented here is on a much larger scale than those reported previously.

REFERENCES

[1] UTPS - Urban Transportation Planning System; by Urban Mass Transportation Administration, U.S. Department of Transportation, Washington (frequent updates).

[2] EMME/2 - User's Manual (about 600 pages); by A. Babin, I. Constantin, M. Florian, L. James-Lefebvre and H. Spiess, Centre de Recherche sur les Transports, Universite de Montreal (frequent updates).

[3] "Mobilité des personnes dans la région de Montréal - Enquête origine-destination régionale 1982"; by Société de Transport de la Communauté Urbaine de Montréal, Service de l'Aménagement du réseau, Montréal (1983)

[4] CHAPLEAU, R., "Transit Network Analysis and Evaluation with a totally Disaggregated Approach"; paper presented at the World Conference on Transport Research, Vancouver (May 1986); published by Centre de Recherche sur les Transports, #462, Montreal (April 1986).

[5] FRANK, M. and WOLFE, P., "An algorithm for Quadratic Programming", Naval Research Logistics Quaterly, 3, pp. 95-110, (1956).

[6] SPIESS, H., "Contributions a la theorie et aux outils de planification des reseaux de transport urbain" -Doctoral thesis; Departement d'informatique et de recherche operationnelle, Universite de Montreal (1984).

[7] FLORIAN, M., GUELAT, J. and SPIESS, H., "An Efficient Implementation of the 'PARTAN' variant of the Linear Approximation Method for the Network Equilibrium Problem"; To appear in Networks.

[8] NUZZOLO, A., "An Empirical Analysis of Assignment Models for Urban Car Networks"; Dept. of Transportation Engineering, University of Naples, Italy; Paper presented at the International Symposium on the Management and Planning of Urban Transportation, Montreal, August 1986.

[9] FLORIAN, M. and NGUYEN, S., "An Application and Validation of Equilibrium Trip Assignment Methods"; Transportation Science, 4, pp. 374-390, (1976).

[10] BOVY, P.Y.L. and JANSEN, G.R.D., "Network Aggregation Effect upon Equilibrium Assignment Outcomes: an Empirical Investigation"; Transportation Science, 17, pp. 240-262, (1983).