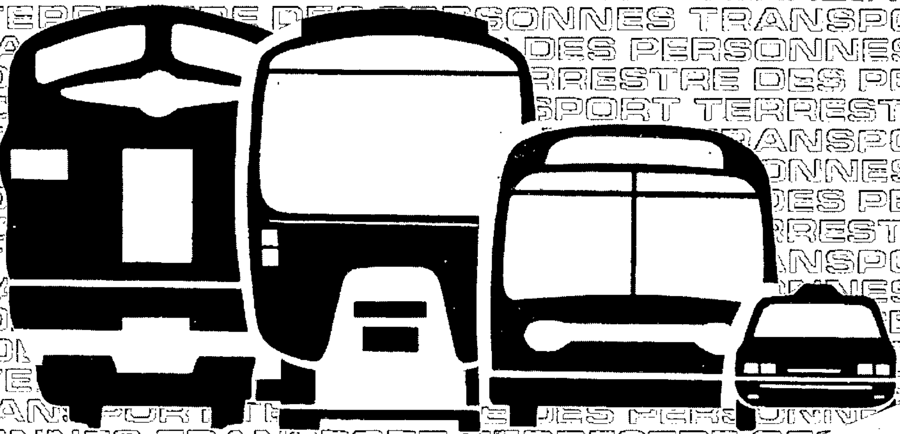
COMPUTER GRAPHICS AND MICRO-COMPUTERS

powerful tools available to transportation managers and planners



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

COMPUTER GRAPHICS AND MICRO-COMPUTERS

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

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SUMMARY

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The purpose of this presentation is to describe the computer environment of which the "Direction générale du transport terrestre des personnes" has availed itself, and, as a result, to show how its management and planning activities are defined and carried out in this context.

The environment is characterized on the one hand by the use of micro-computers which, in addition to their local intelligence, allow access to a central mainframe. On the other hand, computer graphics techniques play an important role, which allows for the efficient representation of the enormous amount of data involved in transport management and planning.

These tasks can be classified under two major headings: data analysis, where the principal tools are the SAS and SPSS packages run on the mainframe whereas dBASEII, LOTUS 1-2-3 and Stat-Pac are used with the micro-computers; and transport modelling, aided by the EMME/2, MADITUC and UTPS software.

Both in terms of hardware and software, graphics and micro-computers have been effectively incorporated into our environment, facilitating considerably the work of planners and managers and enabling that work to reach a level of quality which could not be achieved using conventional methods.

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INTRODUCTION

In the contemporary context of urban public transport, where citizen participation has become increasingly important, where requests from the public and from their elected officials have become more and more demanding and where the costs are inexorably on the increase, the decision-making process has become more and more difficult.

It is therefore necessary that accurate contemporaneous information be available as a basis for assessing the current situation. It is also essential to possess tools which enable the impact of administrative decisions to be evaluated.

Since the effectiveness and the productivity of a public agency are directly related to the speed and flexibility with which its employees function, requiring them to work with unwieldy tools traditionally reserved for use by highly specialized professionals would serve no purpose. Moreover, the staggering quantity of resultats which these tools can produce can never be fully exploited nor efficiently be transposed into graphical form by manual methods.

In order to maintain a high level of efficiency among its personnel and to provide the best possible service to the transport community, the "Direction générale du transport terrestre des personnes" has followed a course of acquiring flexible tools incorporating graphics techniques and to render them accessible to all of its personnel.

It has therefore established an Information Systems Service to carry out the following tasks:

1) Acquire, maintain and analyse all relevant data with respect to personal ground transport.

2) Develop or install models or procedures allowing for evaluation of road and public transport policy or projects

3) Design and maintain management information systems.

The presentation which follows will attempt to show the approach adopted by the D.G.G.T.P. in order to achieve these goals, with a particular emphasis on the role of micro-computing hardware and computer graphics techniques.

The first part of the presentation is a summary description of the computer environment which has evolved in our organization. This is followed by a demonstration, using numerous examples of graphics results, of how our activities are carried out in this environment. The reader will find, at the end of this text, a brief glossary of the acronyms used and reference index for the hardware and software products described.

2 COMPUTER ENVIRONMENT

COMPUTER ENVIRONMENT

Our computer environment, which we have attempted to illustrate schematically in Figure 1, consists of an array of hardware facilities supported and driven by a variety of software. The hardware has been divided into three (3) categories:

- mainframe,
- mini and micro-computers
- graphics equipment.

The software classification, considerably more complex, has the following general categories:

- operating systems
- communication systems
- high-level languages
- application software.

The illustration in Figure 1 is paradigmatic and while we recognize that the classification is debatable, our primary purpose is a descriptive one which will enable us to relate our actual transport activities to the computer tools used.

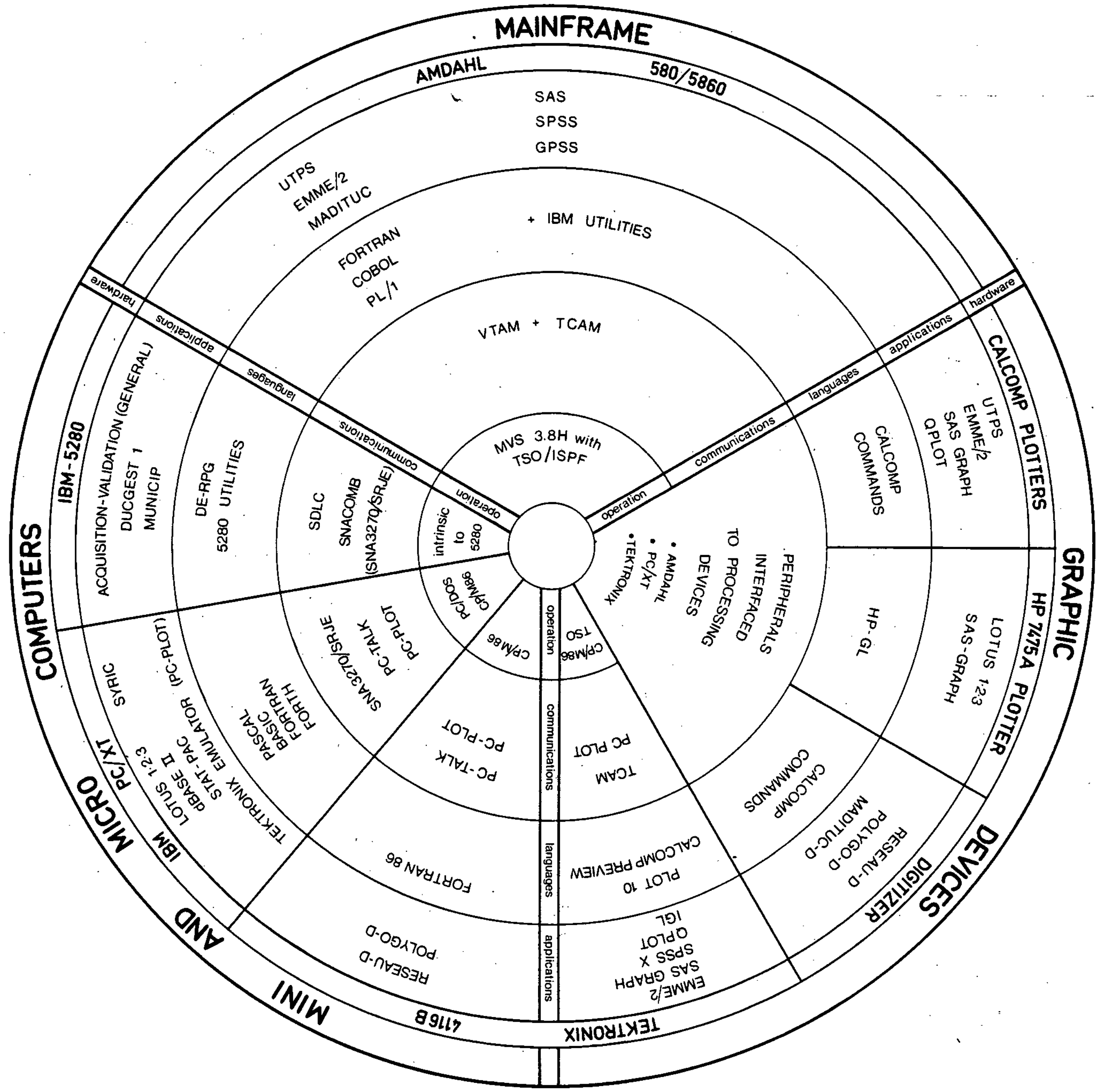
2.1 Hardware Configuration

Figure 2 is a schematic representation of the hardware configuration, where the pivotal point remains the mainframe operated by the Quebec Automobile Insurance Board (RAAQ) in Quebec City.

An initial telecommunications line links the mainframe to our IBM 5280 mini-computer under the VTAM protocol. The 5280, in addition to driving a line printer, allows for the emulation of IBM 3270 terminals. A number of PC-XT's can also carry out 3270 emulation under VTAM communications with the mainframe.

figure 1

computer environment



A second telecommunications line links the mainframe to an intelligent Tektronix 4116B terminal under the TCAM protocol. Numerous additional communications links can be established locally using modems, which also allow our micro-computers accessibility to other computers and external data banks under the ASCII communications protocol (ex.: Ecole Polytechnique, CRT, employee personal computers).

2.2 Mainframe

As we have seen, the mainframe is an AMDAHL 580/5860 operating under MVS. We access this machine essentially using TSO and ISPF, although other methods are available. Similarly, although this installation supports several high-level languages, we use FORTRAN almost exclusively.

Of the principal application packages available on the AMDAHL, the most relevant to our purposes are:

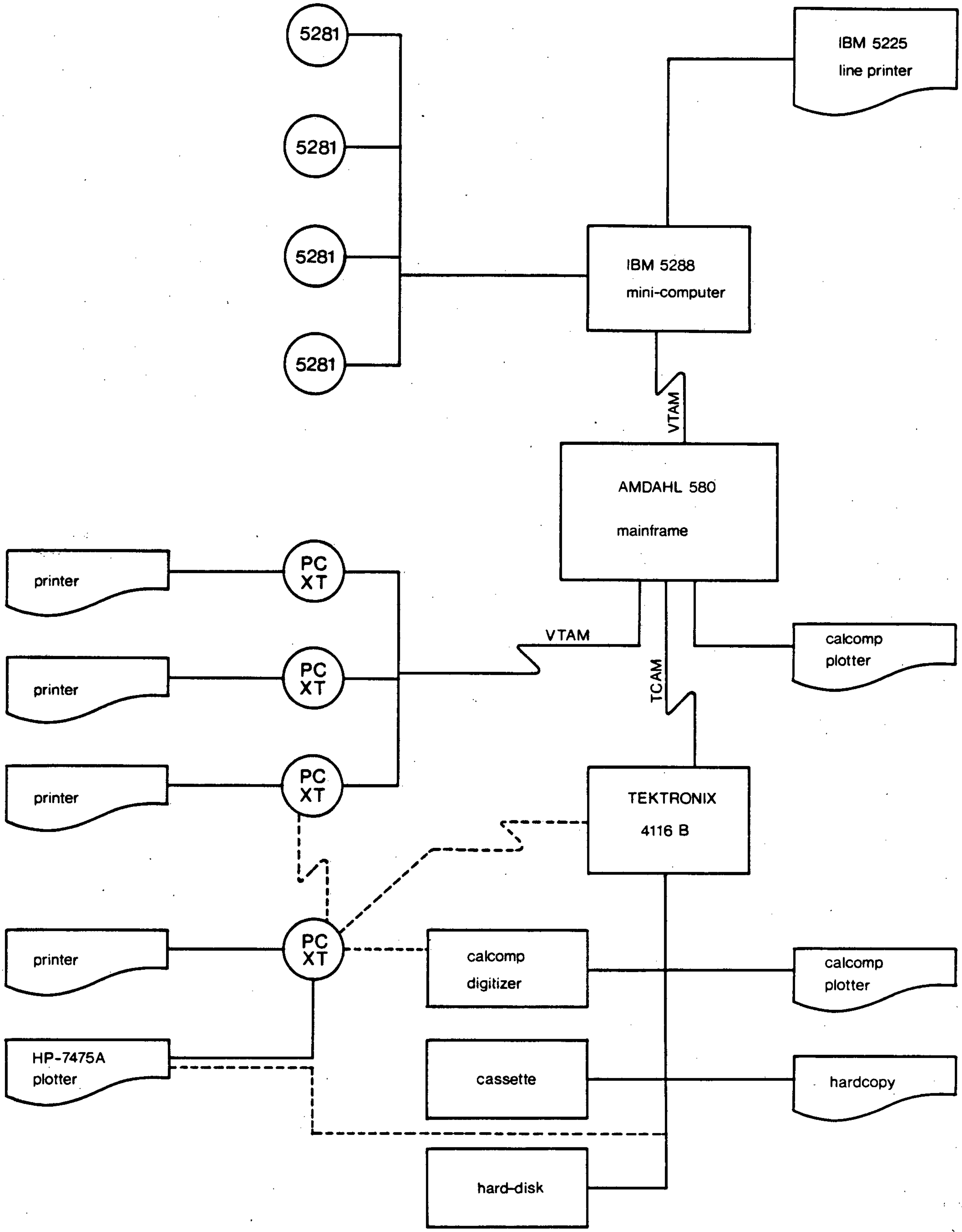
UTPS - ("Urban Transportation Planning System"), developped by UMTA of the U.S. Department of Transportation. This is one of the most widely used transport planning packages in North America.

EMME/2 - (Equilibre Multimodal - Multimodal Equilibrium) is a relatively recent package, developped by the Centre de Recherches sur les Transports of the Université de Montréal and installed this year on our mainframe. It is an interactive menu-driven package designed to support all network analysis and transport modelling functions.

MADITUC - (Modèle d'Analyse Désagrégée des Itinéraires en Transport Urbain Collectif). This package was developped at the Ecole Polytechnique de Montréal to support functions related specifically to operational planning for transit systems. It is characterized primarily by its disagregated approach and by its data structures which provide for more effective use of information available from O-D surveys.

figure 2

hardware configuration



SAS (Statistical Analysis System) and SPSS (Statistical Package for the Social Services) - are widely used statistical analysis and modelling packages.

GPSS - (General Purpose Simulation System) is used primarily for modelling stochastic phenomena, particularly traffic queues approaching highway interchanges and toll booths.

2.3 Local Computers

2.3.1 "5280" system

At our Montreal location, we operate an IBM 5280 "distributed data system", a mini-computer which, in addition to its computing function, allows the terminals to be emulated as IBM 3270's in communication with the mainframe and also drives a local line printer. This system includes an RPG compiler, enabling us to develop, for example, interactive programmes for survey data acquisition and validation. A complete budgetary and cost control system for the D.G.T.T.P. has been established in this way, as well as a data bank on Quebec Municipalities incorporating pertinent informations for the D.G.T.T.P. (ex.: city hall address, demographic patterns, licensed public transport operators, etc.).

2.3.2 PC-XT micro-computers

For some time, the D.G.T.T.P. has recognized the potential of micro-computers in transport planning and has moved towards making this technology available to its professional staff along with the proper software facilities.

Since their introduction, micro-computers have quickly become an integral part of the working environment and an indispensable tool in increasingly greater demand by our personnel. Our choice of machines were the IBM PC-XT's, each with 10 Mb of hard disk storage, and capable of emulating IBM 3270 terminals in communication with the mainframe.

Using modems at 1200 baud, local communications can be effected with software such as PC-Talk or PC-PLOT. The latter package includes the very advantageous facility of allowing an IBM PC to emulate a TEKTRONIX terminal driven by the PLOT-10 language. The PC-XT's can therefore function as development tools for graphics applications which alleviates the heavy demand placed on the TEKTRONIX terminal for production purposes. As for languages, application programming is carried out principally in PASCAL, supplemented by the ubiquitous BASIC for the non-computer personnel.

Of the numerous application packages for the PC-XT available on the market, the following three (3) are primarily used:

- dBASEII: data base management language;

- LOTUS 1-2-3: speadsheet with graphics;

- Stat-Pac: statistical modelling and analysis package.

It is noteworthy that some of the D.G.T.T.P. employees own micro-computers (es: Epson, Apple) and that these machines have been effectively integrated into our environment.

2.3.3 TEKTRONIX 4116-B

This graphics device incorporates the Intel 8086 (+8087) micro-processor, with 576 Kb of dynamic RAM. In this sense, and particularly since it has been equipped with a 10 Mb hard disk drive, it functions as a powerful micro-computer, under the CP/M-86 operating system executing programs developped locally. The only high-level language used for this development, apart from the IGL graphics subroutine library, is FORTRAN-86. The principal applications in local mode are the digitizing programs to which we will refer later.

2.4 **Graphics Devices**

2.4.1 TEKTRONIX 4116-B

This machine constitutes the pivotal point of our graphics applications. The screen is 630 mm (25 in.) with a visible pixel array of 4096 X 3120. Three (3) I/O ports provide RS232C interfaces to peripheral devices.

This apparatus can operate using TSO under TCAM communications with the mainfame or under CP/M-86 in local mode. Regardless of their origin, the graphics commands must conform to the PLOT-10 language in order to be interpreted by the graphic processor. The primary graphics applications are EMME/2 for transport modelling and SAS-Graph and SPSS-X for data analysis. There are two (2) graphics subroutine libraries invoked by our in-house applications. IGL, from TEKTRONIX, is a general package which supports a wide range of computerized draughting requirements whereas QPLOT was developped at the Centre de Recherches sur les Transports of the Université de Montréal specifically for graphic processing of transport networks.

2.4.2 Digitizer

Another part of our equipment is an electromagnetic CALCOMP digitizing table with dimensions of 1100 X 1500 mm (44 X 60 in). This device is normally linked to the TEKTRONIX 4116-B to carry out the digitization of networks and geographic zone boundaries, but numerous other applications are possible particularly since it can be driven by the IBM PC-XT's.

2.4.3 HP-7475 plotter

This small plotter, with maximum dimensions of 280 X 430 mm and six (6) addressable pens, provides for high resolution colour drawings. The graphics commands driving this device must conform to the "HP-GL" protocol. In addition to in-house applications, in PASCAL or BASIC, the plotter can also produce drawings generated by LOTUS 1-2-3 from the PC-XT or by the TEKTRONIX functioning as the host.

2.4.4 Calcomp plotters

We also have access to CALCOMP plotters capable of producing drawings with four (4) colors on a 760 mm continous roll of paper. These devices recognize commands in the CALCOMP protocol only.

Interfaces have therefore been developped which allow the plotters to be driven by applications such as UTPS, EMME/2 and SAS-Graph or in-house programmes using QPLOT. The "Calcomp-Preview" package is also available, which emulates a Calcomp plotter for prior display and verification of the image on a TEKTRONIX terminal.

3 PLANNING ACTIVITIES

PLANNING ACTIVITIES

In figure 3, we have tried to schematically show the general organization of activities related to our transport data bank, according to eight (8) principal categories, within each of which various subjects are identified. We will summarily describe these subjects with particular reference to the specific computer aids, which we have outlined previously, applied in each case. The list is not exhaustive, and indeed the headings used are not immutable since in reality the differentiation between subjects is far more fluid than it appears.

Of equal signifance in characterizing the organization are the two streams into which the activities fall. The first is data analysis, in the broadest sense. Software packages such as SAS, SPSS, LOTUS 1-2-3, Stat-Pac or dBASEII are used in this context to produce statistical or descriptive analyses of the data.

The other stream covers "transport modelling", where the objective is to model the supply of transport (the networks) and the demand for trips, and then to simulate volumes in the networks.

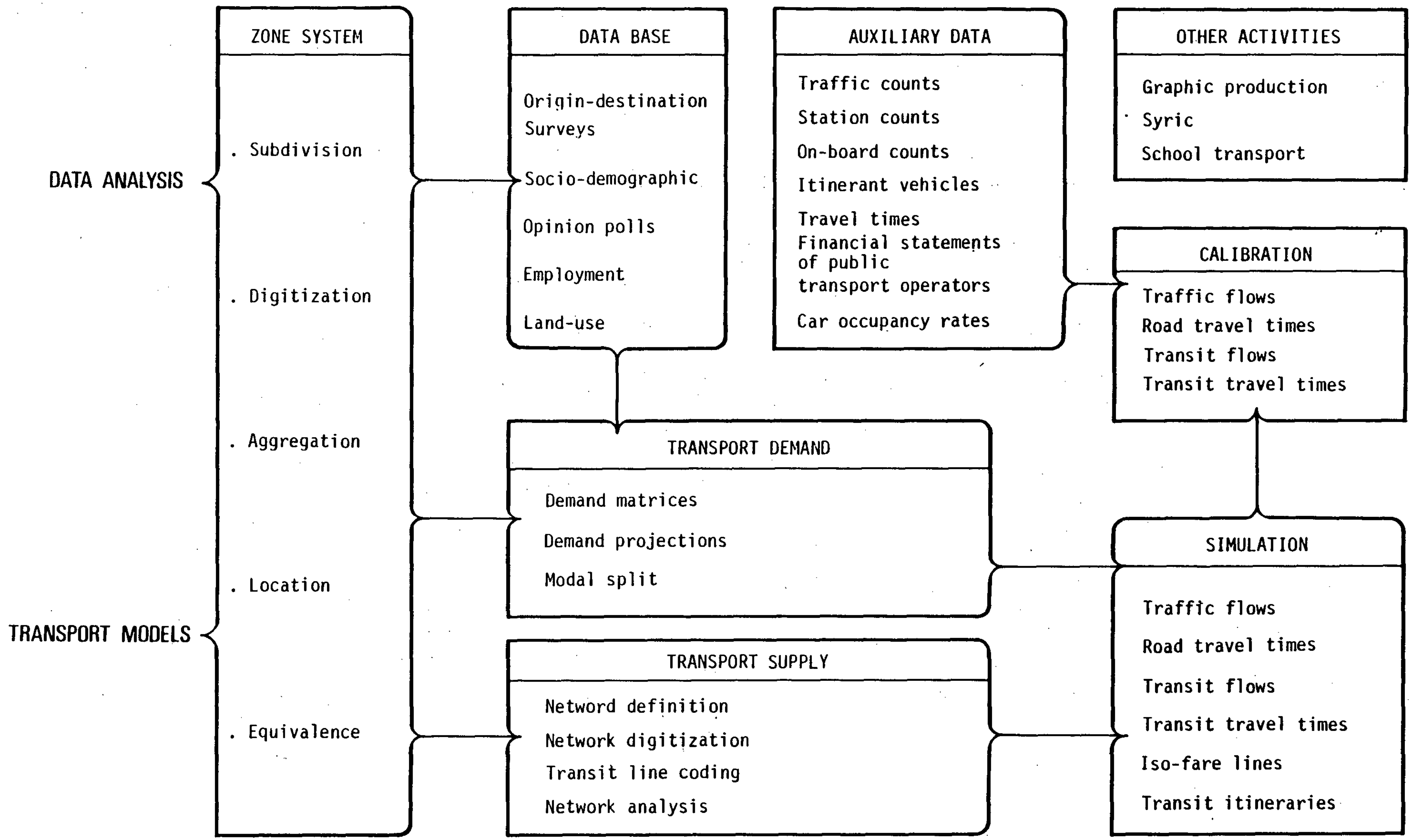
3.1 Zone system

3.1.1 Subdivision

Many of the activities related to urban transport planning require a cartographic subdivision of the region into analysis zones. However it is often the case that the subdivisions in different data banks are mutually incompatible thereby prohibiting the comparative analysis of data from different sources. Moreover the zone systems are frequently too detailed to allow for rapid analysis of macroscopic phenomena.

figure 3

general outline of activities



3.1.2 Digitization

Digitizing the subdivisions offers a way of overcoming these constraints since the resulting data can then be manipulated by computer. In the first instance, the zone boundaries can be used as a back-drop to spatially distributed results produced by software such as EMME/2 or SAS (figure 4) as well as by in-house applications as will be demonstrated.

3.1.3 Aggregation procedures

The main advantage to the digitization lies in the use of aggregation tables to create images of new zone systems simultaneously with a corresponding aggregation of the data. In this way, for the Montreal region, a rapid transition can be made from a 1500 zone system to a 700 zone system, 149 municipalites or 66 districts (figure 5). The graphics aggregation procedure is tied to the data representation structure which is based on three (3) lists: the vertices of the polygons, the edges of the polygons and finally the assignment of the edges to specific zones.

3.1.4 Node location

Another capability arising from digitization is the automatic identification of a zone associated with a network node or link pinpointed by a graphics input technique. Graphics input on the screen also allows for interactive creation of zonal aggregation tables or extraction of survey data for pinpointed zones.

3.1.5 Zone equivalence

This same procedure has enabled us to "recode" Statistics Canada data available at the enumeration area level according to the MUCTC's base system of 1 500 survey zones. By

figure 4

digitization of zone polygons

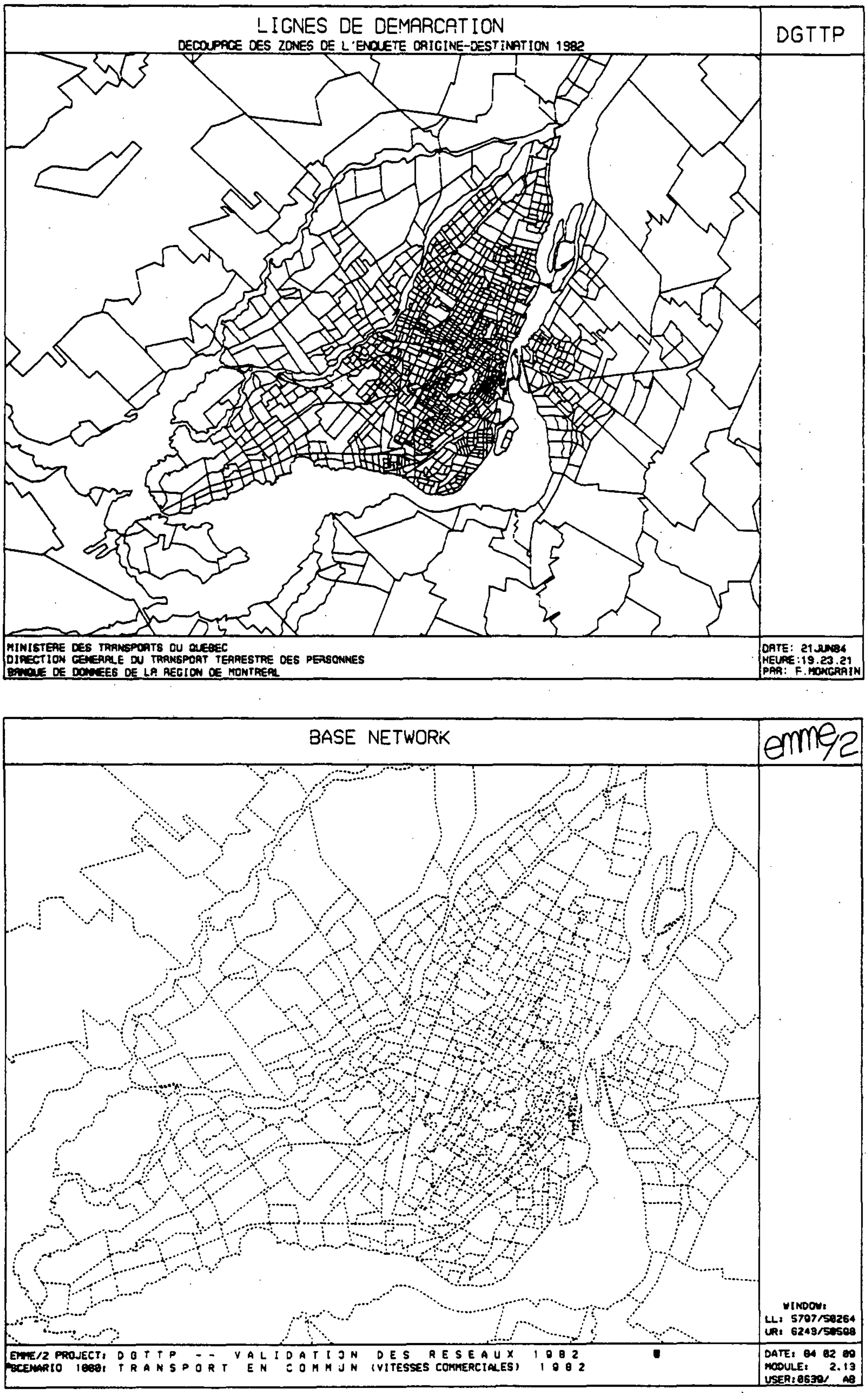
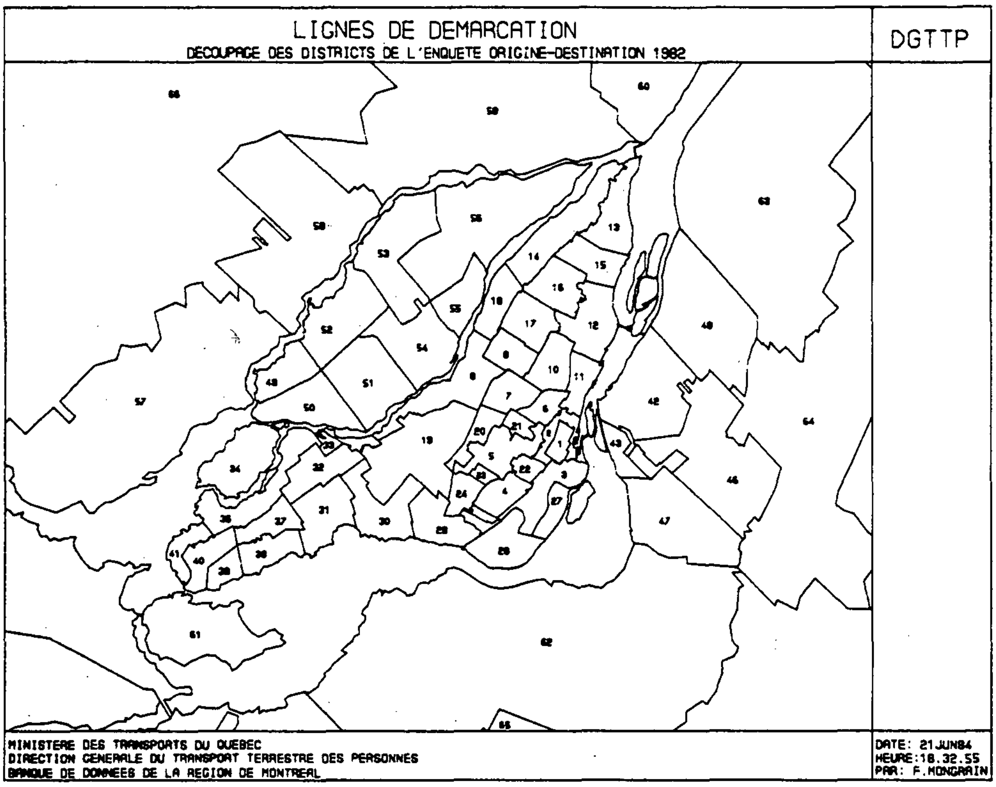
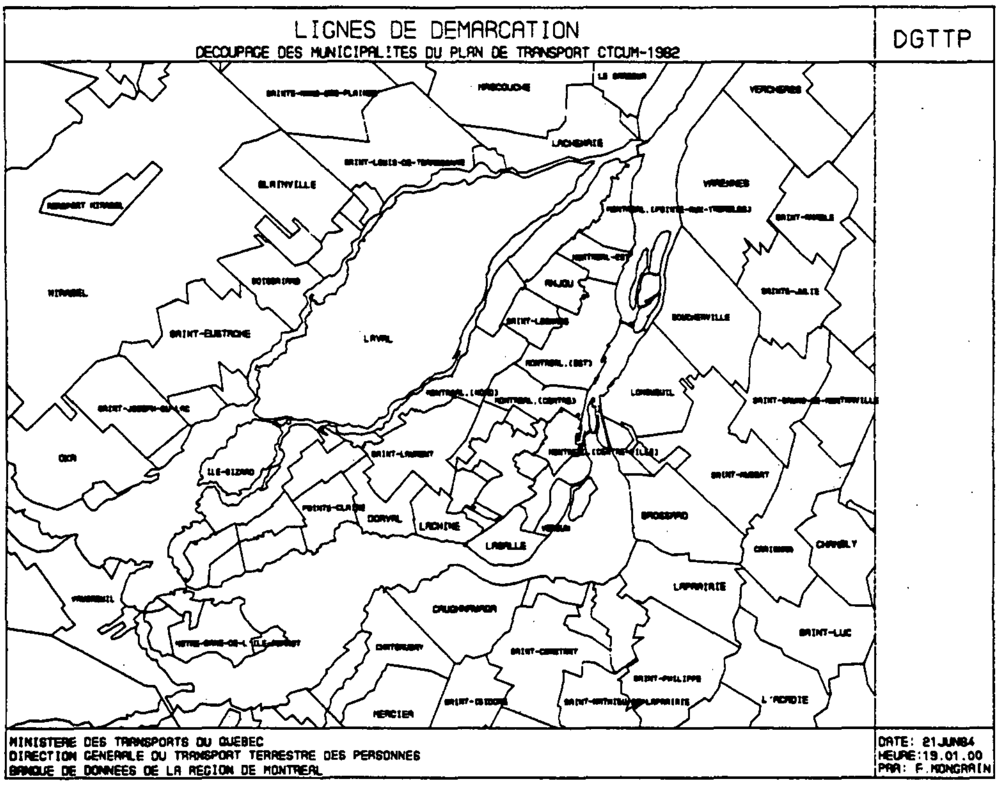


figure 5

zone aggregations





identifying the zone in which the centroid of each enumeration area is located, a satisfactory recoding of the initially two incompatible systems is achieved, albeit with some inevitable overlaps. In the same fashion, it is possible to associate zone numbers with postal codes, which produces an aggregation table useful, for example, in processing automobile registration files without having to geocode each record.

3.2 The data base

Urban tranport planning is dependant on two major sources of information:

- origin-destination surveys
- socio-demographic data

3.2.1 Origin-destination surveys

Origin-destination surveys provide the means to not only qualify the demand for trips between various analysis zones but also to categorize and qualify that demand. We use primarily the O-D surveys carried out by the MUCTC in 1970, 1974, 1978 and 1982, which cover the Montreal region with a sample varying between 5% and 10% of all households. Figure 6 shows a graphic example of data extracted from a survey.

We have carried out additional O-D surveys in order to study specific phenomena. Data acquisition and validation programmes have been developped for surveys on board suburban trains or express lane buses, to compile ticket counts for zoned fares and to process small O-D survey data collected in outlying suburban areas.

3.2.2 Socio-demographic data

The other major source of information is socio-demographic data provided by Statistics Canada or by the Bureau de la Statistique du Québec. Recoding programmes have occasionnally been used for compatibility between the zone subdivisions. The data includes, for example, population stratified by age and sex, and may serve to forecast future demand within the context of trip generation models. This category also includes employment and land use data provided by the Ministère des Affaires Municipales as well as information of an economic nature.

Demographic data can often be represented by density, as in shown in figure 7 which illustrates the population density by urbanized hectare for the city of Laval.

3.2.3 Polls

These data are supplemented by various public opinion polls or surveys concerning, for example, the fare structure for public transport.

3.2.4 Analytical tools

Whether it is for transport modelling or simply to respond to requests emanating from various parties concerned with transport in the region, the analysis of these data represents a significant part of our activities. The SPSS and SAS packages are used on the mainframe, while tools such as LOTUS 1-2-3, dBASEII and Stat-Pac are available for the micro-computer. The actual data acquisition is normally carried out on the "5280" system, using the RPG language, or on a micro-computer with dBASEII. Data from external sources are usually provided on magnetic tape. Complete familiarity with the data and software at our disposal allows us to quickly and easily extract any information requested, according to the specific requirements of the user.

figure 6

survey data retrieval

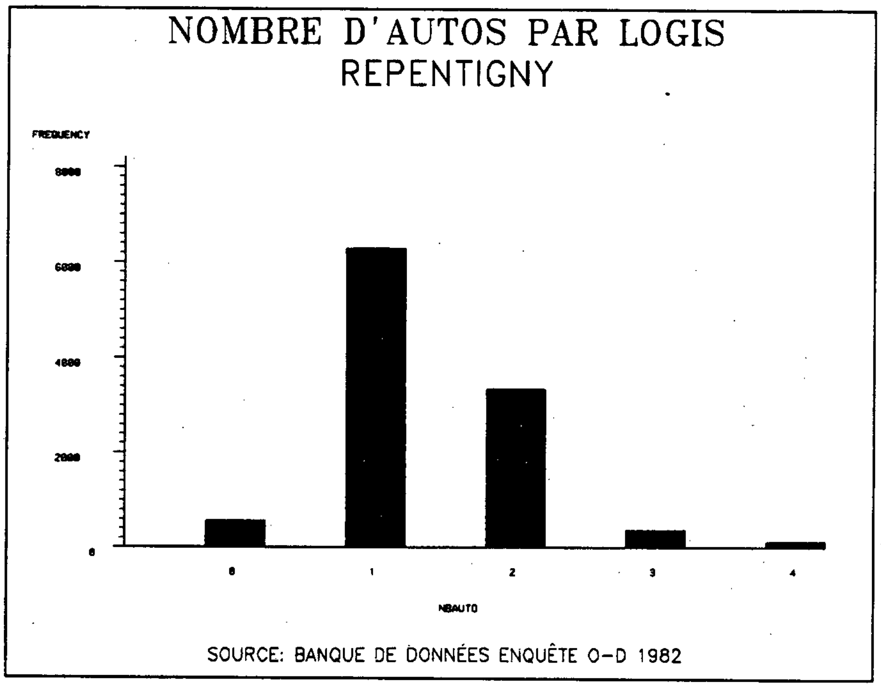
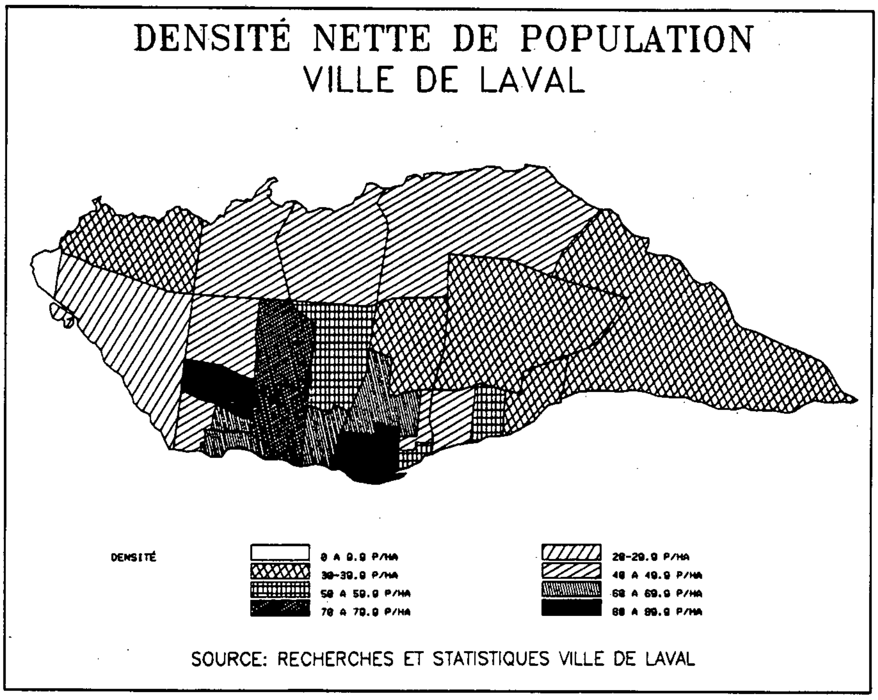


figure 7

representation of demographic data



3.3 Auxiliary data

A wide range of other data used for specific purposes are incorporated in our system.

3.3.1 Road traffic counts

By virtue of our access to information from the Quebec Ministry of Transport and the Traffic Service of the City of Montreal, as well as of other municipalities, have created a traffic count data bank for calibration of our models. The survey stations are located in a grid pattern which allows the margin of error of simulations to be evaluated and provides a means of comparing production/attraction measures from the O-D survey with entrances and exits at the cordon points.

3.3.2 Transit station counts

For public transport, entrance and exit counts at metro and train stations are available, as well as specific additional surveys such as movement counts at bus termini and at park-and-ride lots. These counts lend themselves to comparative analyses with the results of simulations based on O-D surveys (figure 8).

3.3.3 On-board counts

Counts on-board vehicules (trains or buses) allow the ridership along lines to be assessed. Using the LOTUS 1-2-3 package with programmes written in PASCAL, a micro-computer procedure based on ([1]) has been written for on-board ridership data acquisition and analysis (figure 9).

([1]) Chapleau, R. et Baass, K-G.; Use of Supercalc to compile and report statistics in public transportation, Ecole Polytechnique, Montréal, January 1984 (Presented at the 1984 Congress of the Transport Research Board, in Washington).

figure 8

station transit counts

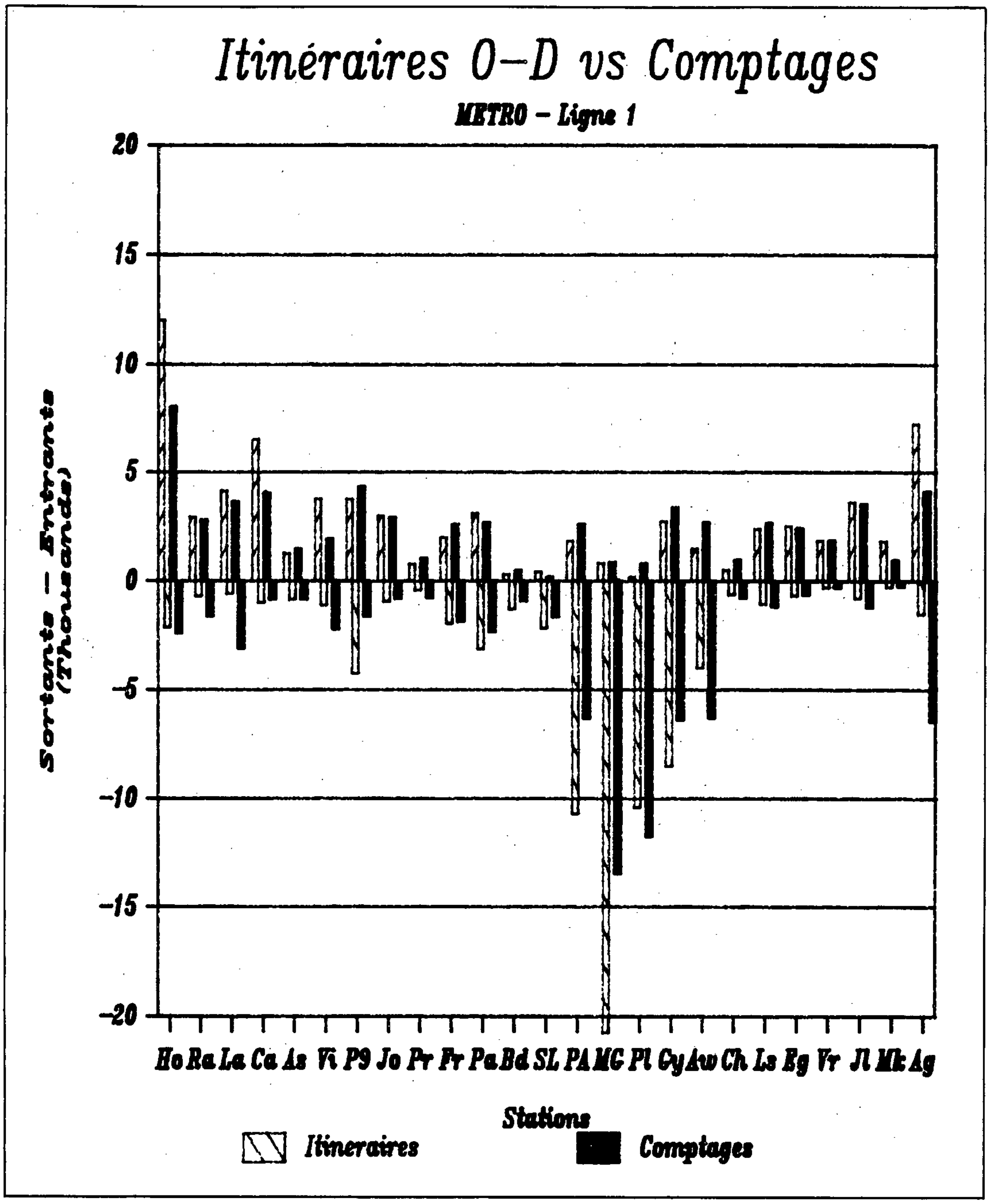


figure 9

on-board counts

C> CTL - PLAN DE TRANSPORT 1984 - COSIGNA 44288 - COMPTES-A-BORD

Ligne No. CTL: 60 Code DGTTP: 460 Nom ligne:
Direction: de HB Cap:
(versHB/deHB/Est/Ouest) Dates:
Jour: Sem Nom abrege: C-60dHB
(Sem/Sa/Di) Ligne CTL Dir Jour

ARRET				Dis-tance	Temps	Passagers a Bord PERIODE					
No. Seq.	Noeud DGTTP	No. CTL	Intersection ou Localisation	(km)	(mn.)	Pointe AM	Creuse jour	Pointe PM	Creuse soir	24 Heures	% Utilisateurs Pte / 24 h
1	4269	1	Term HB	0.00		125	367	480	141	1113	54.36
2	4166	2	Laur/Cartier	1.45		134	399	500	150	1183	53.59
3	3247	5	Laur/Tourangeau	2.15		178	459	482	157	1276	51.72
4	3239	8	Laur/Concorde	2.85		210	525	490	170	1395	50.18
5	3230	11	Laur/Gianchetti	3.63		204	584	473	177	1438	47.08
6	3228	14	St Martin/ Laur	4.66		256	740	515	209	1720	44.83
7	3222	16	St Martin/ Vallierres	5.08		274	777	512	212	1775	44.28
8	3220	17	St Martin/ Sun Valley	5.37		278	832	510	209	1829	43.08
9	3219	20	St Martin/ Industriel	6.22		252	817	506	206	1781	42.56
10	3215	21	St Martin/ McNamara	6.40		251	793	472	188	1704	42.43
11	3216	22	St Martin/ Tessier	6.85		247	772	442	179	1640	42.01
12	3217	23	C D Laval	7.76		229	723	442	187	1581	42.44
13	3172	24	Corbusier/St Martin	8.23		232	744	439	206	1621	41.39
14	3174	28	Carrefour/Corbusier	9.24		217	708	404	184	1513	41.04
15	3161	32	Carrefour Laval	11.01		144	378	327	166	1015	46.40
16	3162	35	Dan Johnson/Face LCHS	11.98		98	458	331	167	1054	40.70
17	4133	36	C D 2000	12.58		84	442	304	163	993	39.07
18	4121	42	St Martin/Mayfield	14.01		35	404	252	141	832	34.50
19	4124	43	Labelle/Souvenir	14.63		23	406	225	118	772	32.12
20	4716	47	Notre Dame/Labelle	15.75		6	153	96	43	298	34.23
21	4718	50	Notre Dame/75e Ave	16.29		4	79	55	14	152	38.82
22	4719	51	Notre Dame/Chomedy	16.51		4	65	35	9	113	34.51
23	4132	54	Centre Hosp Juif Conv	17.15		0	0	0	0	0	0.00
			3883 /jour	Embarquants totaux:		428	1752	1176	527		
			64 /jour	Nombre de voyages:		11	25	14	14		
			60.67	Nombre de pass moy/voyage:		38.91	70.08	84.00	37.64		

Diagramme de charge: Periode CREUSE LE JOUR
09:01H à 15:30H

Nom d'arret	No	C.in
Term HB	4269	367
Laur/Cartier	4166	399
Laur/Tourangeau	3247	459
Laur/Concorde	3239	525
Laur/Gianchetti	3230	584
St Martin/ Laur	3228	740
St Martin/ Vallierr	3222	777
St Martin/ Sun Vall	3220	832
St Martin/ Industri	3219	817
St Martin/ McNamara	3215	793
St Martin/ Tessier	3216	772
C D Laval	3217	723
Corbusier/St Martin	3172	744
Carrefour/Corbusier	3174	708
Carrefour Laval	3161	378
Dan Johnson/Face LCH	3162	458
C D 2000	4133	442
St Martin/Mayfield	4121	404
Labelle/Souvenir	4124	406
Notre Dame/Labelle	4716	153
Notre Dame/75e Ave	4718	79
Notre Dame/Chomedy	4719	65
Centre Hosp Juif Con	4132	0

Note: FACTEUR = 10.0

Nombre de voyages par periode (V) : 25 VOY/PER
KM productifs (VEHKM=V*LONGUEURLIGNE) : 428.75 VEH.KM
Passagers embarques totaux par periode (E) : 1752 PASSAGERS
Utilisation (UT=SUM(PASSABORD*DELTADIST)) : 9058.26 PASS.KM
Distance moyenne par passager (DM=UT/E) : 5.17 KM
Indice de productivite kilometrique (IPK=(UT/(VEHKM*CAP))*100) : 42.25 %
Passagers / KM productif (PAVKM=E/VEHKM) : 4.09 PASS/KM

3.3.4 Itinerant vehicles

In order to develop volume/speed relationships, essential for estimating road traffic speeds at the peak period, a series of routes were travelled by itinerant vehicles operated by the M.T.Q. The resulting data, after processing, have led to a categorization of the major elements of the road network in the region and to the establishment of a family of volume/speed curves which will be used for simulation purposes.

3.3.5 Travel times

Itinerant vehicles provide measures only of travel times along particular segments of the road network. However, in order to obtain a more complete verification of simulated inter-zonal travel times, a survey was carried out among two large employers in the region (Lavalin and the Université de Montréal). The processed data from this source can be represented by maps of isochrone lines showing the spatial distribution of road and transit network travel times (figure 10).

3.3.6 Transit financial data

Data related to the public transport fare structure have been gathered in order to build zone-to-zone fare matrices. In conjunction with this, data has been collected according to a format that will facilitate analysis, using LOTUS 1-2-3, of ridership, revenue and operating costs of public transport operators (figure 11).

3.3.7 Car occupancy rates

Finally, surveys of private vehicle occupancy carried out at various observation points, are available for the morning peak period.

figure 10

observed travel times

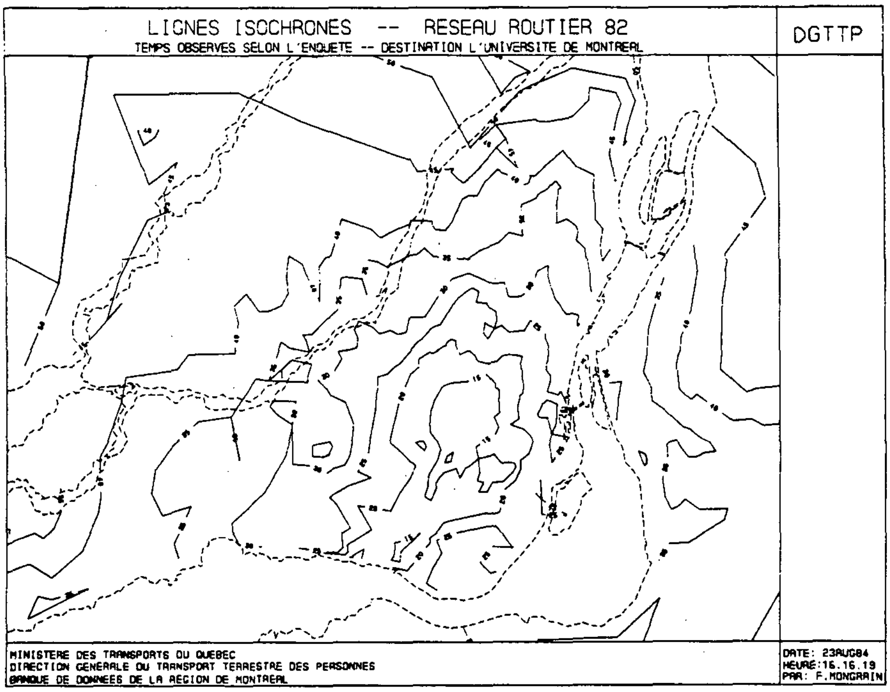
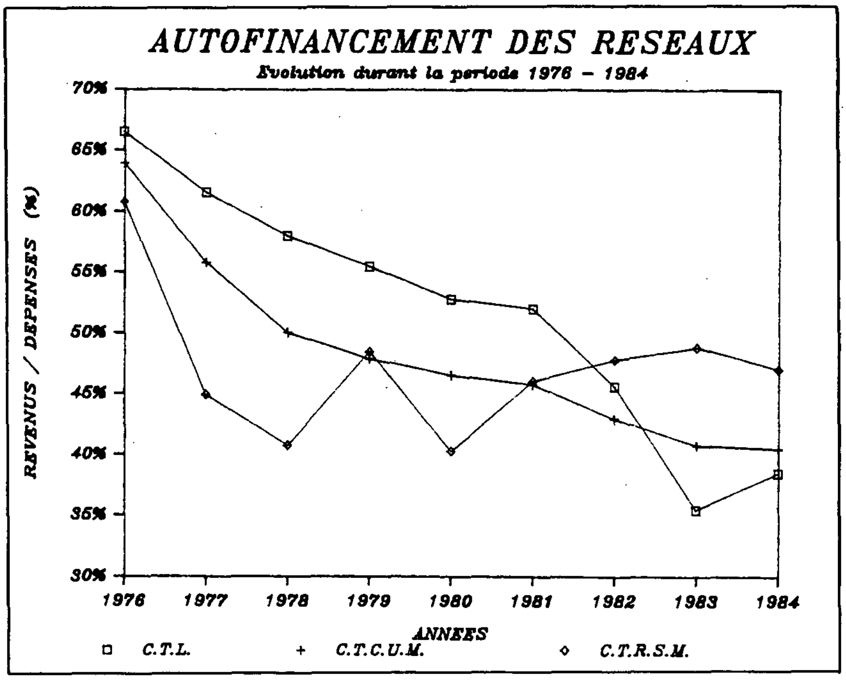


figure 11

transit financial data



3.4 Transport demand

Modelling on the basis of demand data assumes several forms.

3.4.1. Demand matrices

In the first instance, there are Origin-Destination trip matrices to be loaded onto the networks in order to produce assignments. These matrices can be constructed for any system of zones defined by the user.

Graphical representation of these data is essential considering the enormous quantity of information which they reflect, and numerous methods are available.

Histograms, for example, can be produced to demonstrate the distribution of the number of observations in each element of the matrix. This provides a visual indication of the number of elements which are empty or have negligible values and could therefore serve to redefine the subdivision of the zones. A more effective technique of quickly evaluating the homogeneity of the zone system is a frequency distribution of system production and attraction totals (figure 12).

The trips production and attraction totals can be spatially represented by bars which immediately indicate the relative importance of trip generation (figure 13). The illustration of trip demand corridors becomes a simple, instantaneous task, allowing the planner to effect numerous analyses with a minimum cost in terms of time and without constraints on the quantity of data which he can examine (figure 14).

A matrix can also correspond to the difference between two other matrices. Hence the comparison of two demand matrices corresponding to different points in time will immediately reveal the zones of significant increase or decrease. Figure 15 shows the evolution of demand, in terms of trip production, for a part of the Montreal region between 1978 and 1982.

figure 12

frequency distribution of generations totals

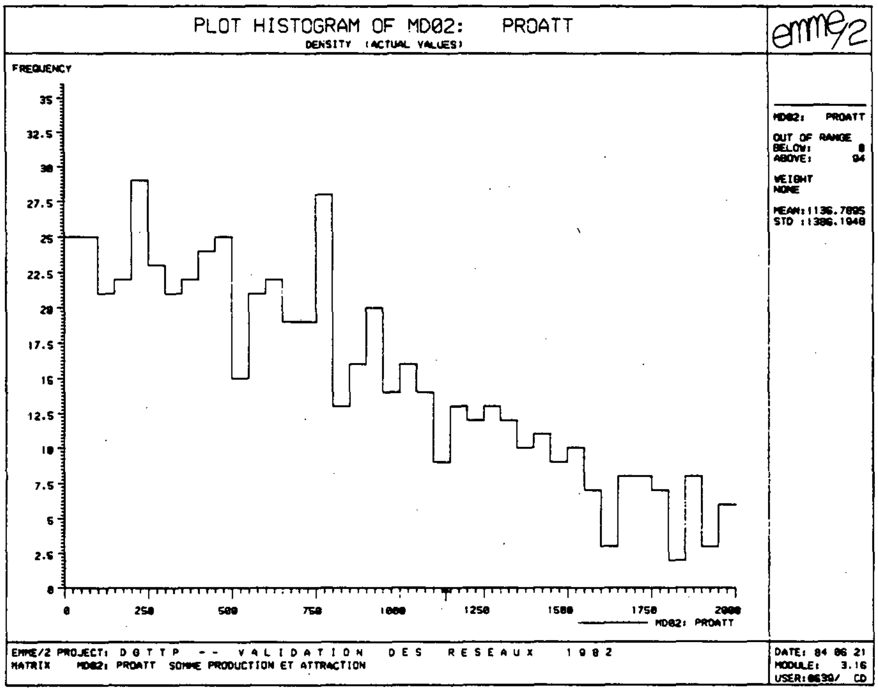


figure 13

trip productions and attractions

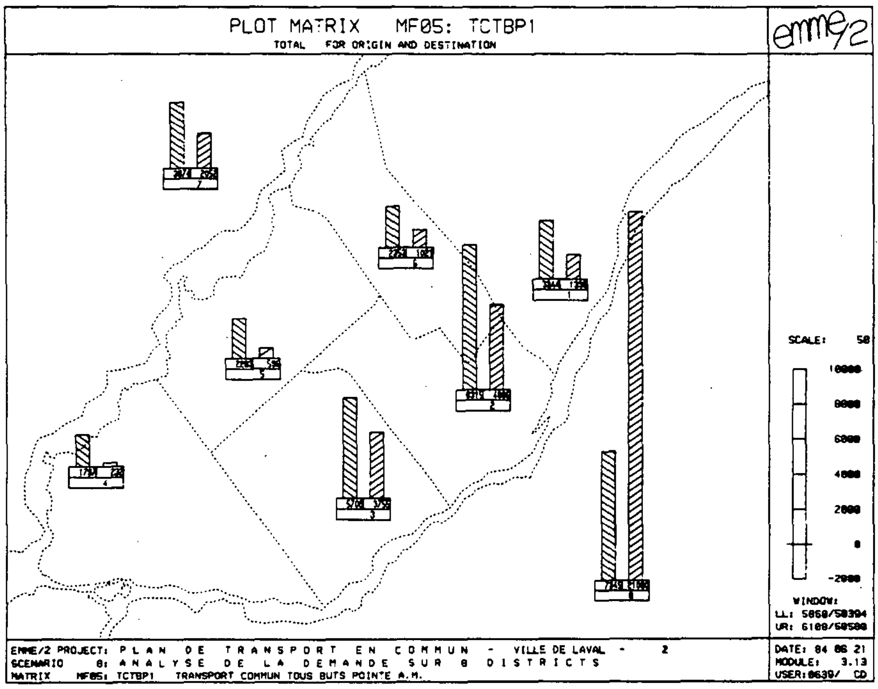


figure 14

trip demand corridors

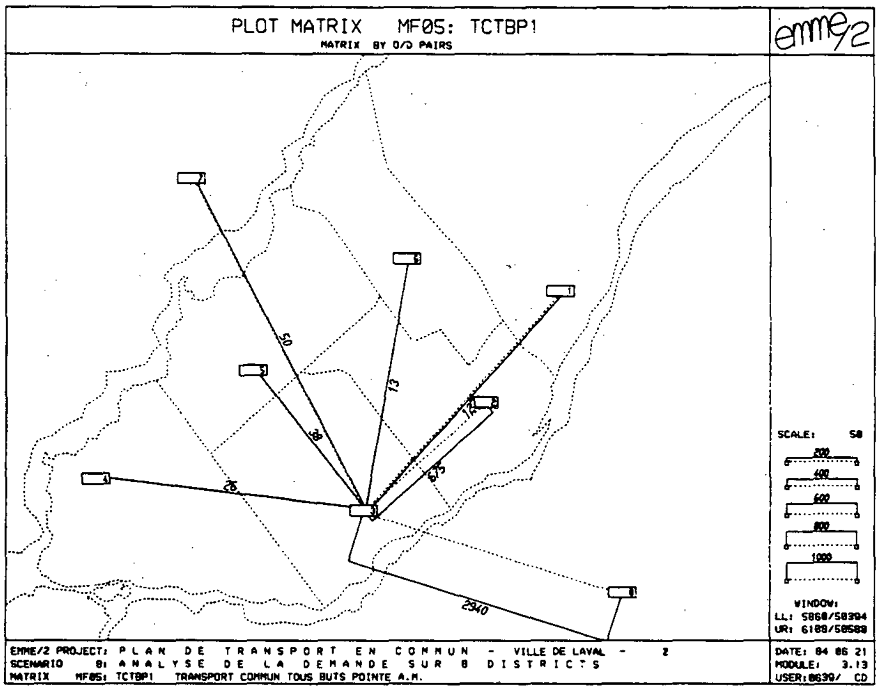
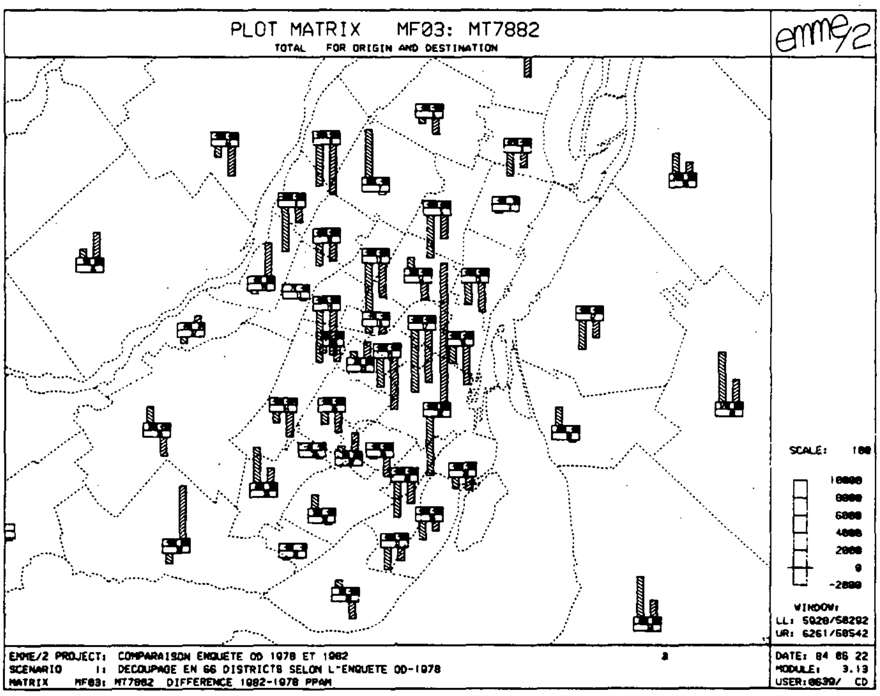


figure 15

evolution of transportation demand



3.4.2 Demand projections

Certain studies require the projection of demand for future time horizons. This procedure generally incorporates four (4) steps:

- population projections
- employment projections
- trips generation
- trip distribution

Failing alternative means of forecasting, the previously described data base is used to develop a cohort survival model in order to predict future population levels. For employment forecasts, data is provided by sources such as the OPDQ and MAM.

The traditional methods of aggregate trip generation have been rejected, since statistical analyses have shown that the socio-demographic variables available in the data are not sufficiently explanatory. As an interim alternative, linear projections of population cohorts and employment levels by category are used, and a disaggregate trip generation model is concurrently being tested.

A gravity model has been formulated for the purpose of re-distributing the trip matrix compiled directly from the O-D survey. Calibration of this model is currently in process.

We are also working with stochastic methods for temporal projections of demand matrices as a function of "observed" matrices which are available at four (4) previous points in time, corresponding to the O-D surveys in 1970, 1974, 1978 and 1982.

3.4.3 Modal split

We are not unaware of the currently extant problems inherent in the standard aggregate bi-modal split model, as our experience has shown that its explanatory power is limited. We are now developping procedures for estimating mode choice using, among others, the MADITUC package, in a disaggregate context.

3.5 Transport Supply

3.5.1 Network definition

Computer graphics software, particularly when it is interactive, has become an indispensable tool for coding transport networks. A computerized representation of the road network has been created incorporating highways, arterials and major collectors for the entire region of Montreal. In the same context, all of the significant public transport lines have been coded for the morning peak period.

Although we use three (3) distinct software packages for transport modelling (EMME/2, MADITUC and UTPS), we have constructed a unique network which each package can transform into its required data representation. The public transport networks are constructed in terms of this base network. With this integrated approach, not only is data processing minimized but the sofware packages can be interfaced through I/O procedures. For example, the flow on a link simulated by MADITUC can become an attribute of the same link in the base network used by EMME/2. The management of this universal data base is carred out on the mainframe, by FORTRAN programmes or by TSO commands.

3.5.2 Network digitization

In order to code the networks in a systematic and efficient manner, we have developped an interactive data acquisition system using a digitizing table. Figure 16 illustrates the configuration of the system.

The digitizing tablet with the mouse is used to pinpoint network nodes (street intersections or transit stops) or to trace non-linear network links. The graphic coordinates, within the space of the tablet or the graphic display area of the video screen, are converted to the coordinates defined by the user according to the scale and origin of the superimposed map.

The command menu at the top of the video display provides a set of commands corresponding to the different keys on the mouse. Each key is programmed to activate a initial node location and numbering or link distance calculation.

The dialogue area at the bottom of the video display is used to send instructions and simple prompts to the user. The required answers are Y(es)/N(o) responses or alphanumeric information corresponding to node and link attributes (e.g. node numbers, street names, volume/speed categories, etc.).

As the network information is obtained from the digitizer, it is simultaneously displayed in the graphics area of the video unit as a visual aid to the user. In this way, node and link files, as diplayed in figure 17 by EMME/2, can be quickly generated.

3.5.3 Transit line coding

As we have mentioned, the public transport lines are coded on the universal road network (figure 18). Since each of the three (3) simulation packages has its own particular features with respect to transit line representation, a unique, integrated coding would not have been warranted. However, the integrated nature of the node and link data facilitates the task on analysis because familiarity with only a single network is required. Moreover it allows, as we have indicated, a transfer of assignment results, when required, from one package to another.

figure 16

digitizing environment

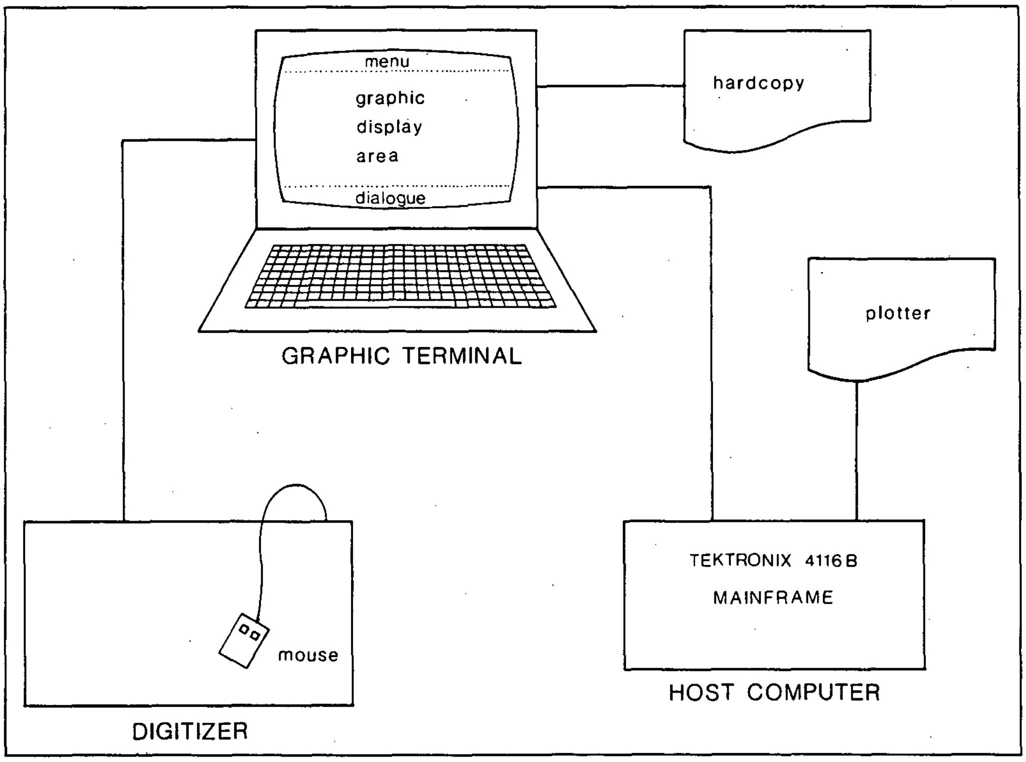
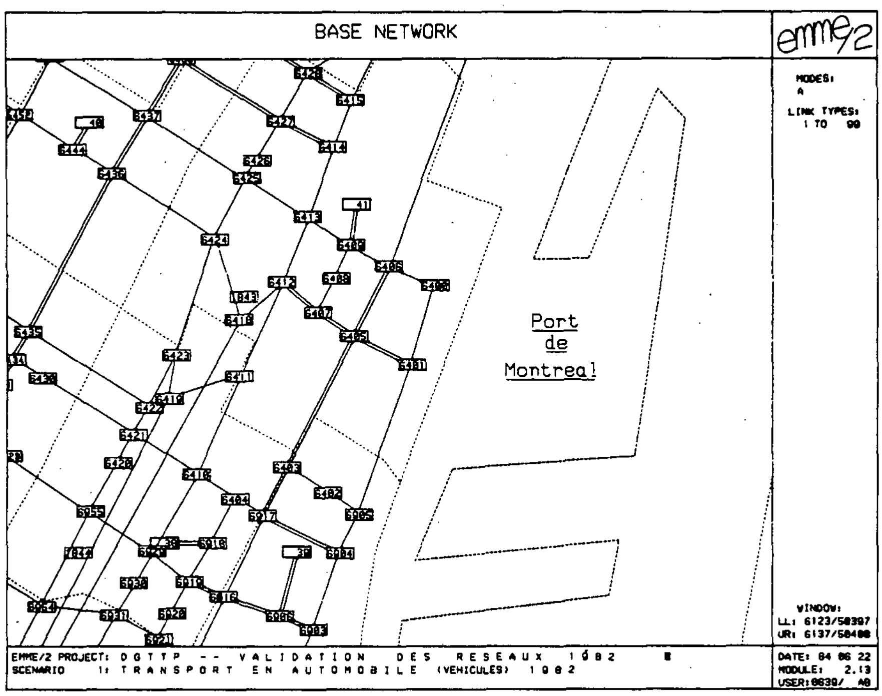


figure 17

network coding



3.5.4 Network analysis

Certain analyses specific to the networks can be carried out graphically. In terms of the road network, certain types of roads, for example, can be extracted from the data bank and their transport capacities displayed cartographically.

From a transit perspective, service levels in terms of seating capacity on the lines can be shown (figure 19). A further possible application is the extraction of bus lines according to criteria such as municipalities, the number of zones serviced or theresholds on the numbers of passagers transported.

figure 18

transit lines

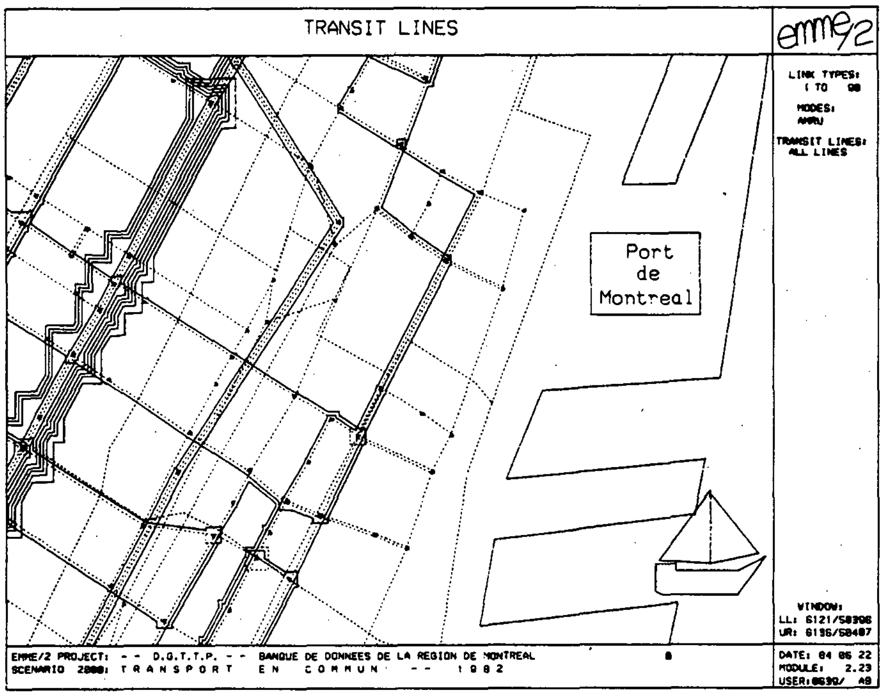
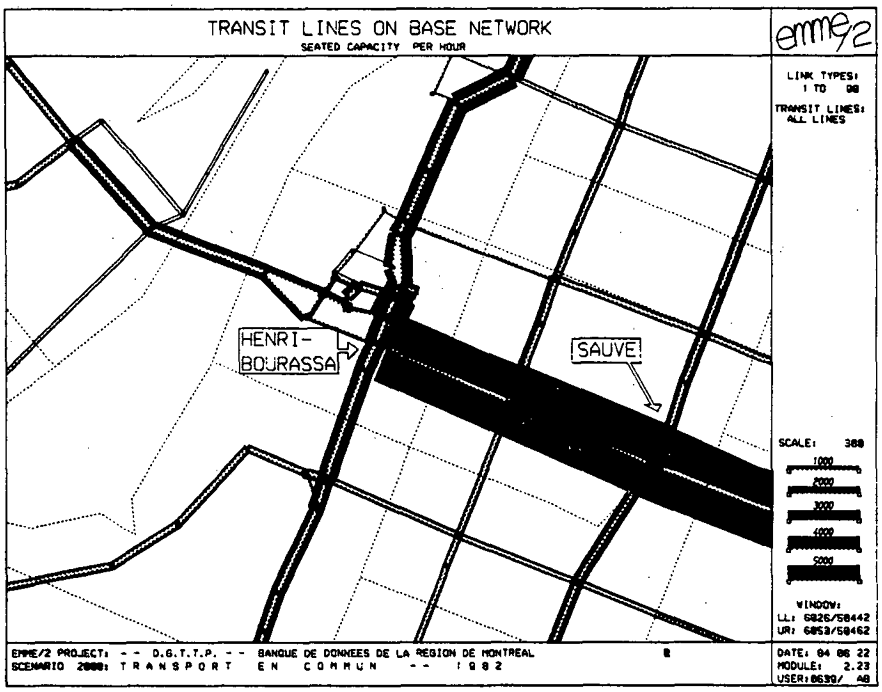


figure 19

transit capacity



3.6 Simulations

Transport simulation consists of the prediction of network flows resulting from the convergence of demand with supply.

3.6.1 Road traffic flows

Traffic simulations estimate equilibrium flows on the principal components of the road network. The flows can be graphically represented by bands of widths proportional to the volumes on the links chosen (figure 20).

3.6.2 Road travel times

Since travel times and volumes are related in term of the volume/speed functions, the analysis of each is inextricably linked with the other. The travel time frequency distribution can be studied either in the form of a histogram or as a cumulative curve. Figure 21 represents weighted frequencies for car trip demand.

For the analysis of travel times, one of the most effective graphics techniques has been the plotting of isochrone lines. Depending on whether a row or column is extracted from the inter-zonal time matrix, contours of equal time, respectively from any production zone or any attraction zone to all other zones, can be created (figure 22). These images can also be represented in three-dimensional from, by defining the time values as "altitudes".

3.6.3 Transit flows

In the same manner, the flows on transit corridor can be mapped with a clear illustration of the ridership levels (figure 23). This illustration can also be restricted to specific ridership on particular lines.

figure 20

traffic flows

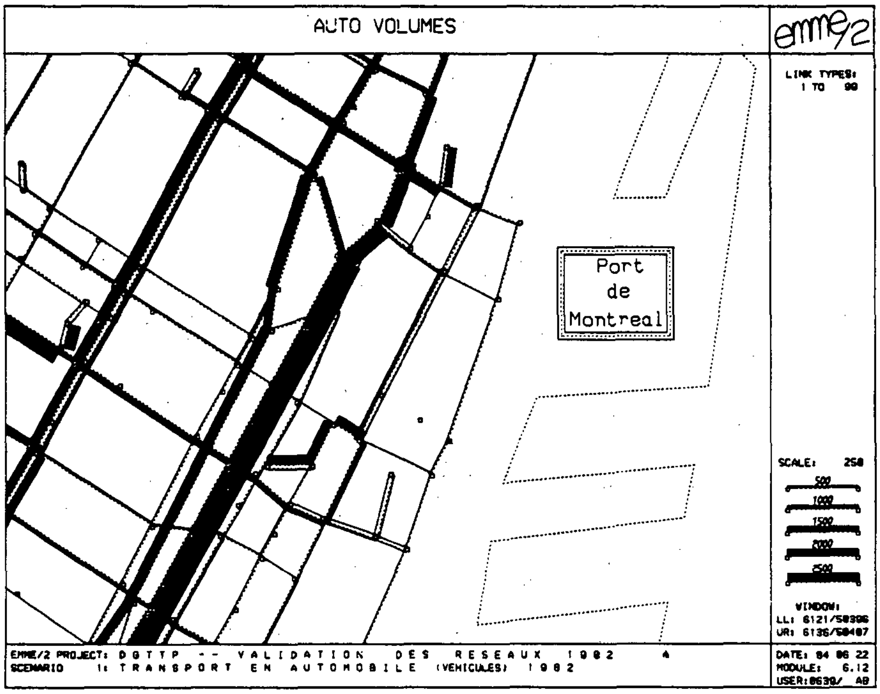


figure 21

frequency distribution of road travel times

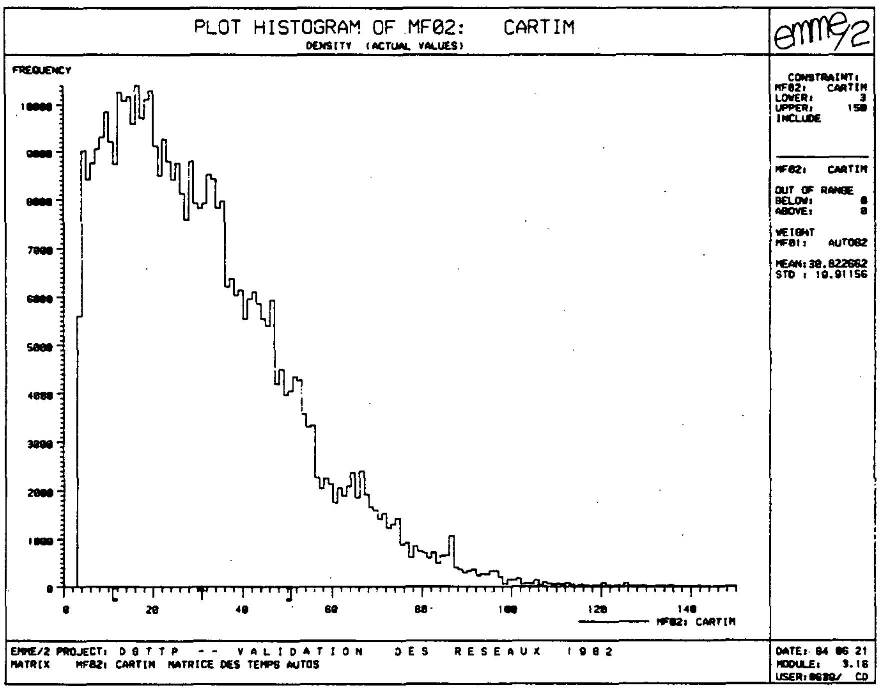


figure 22

road network isochrone lines

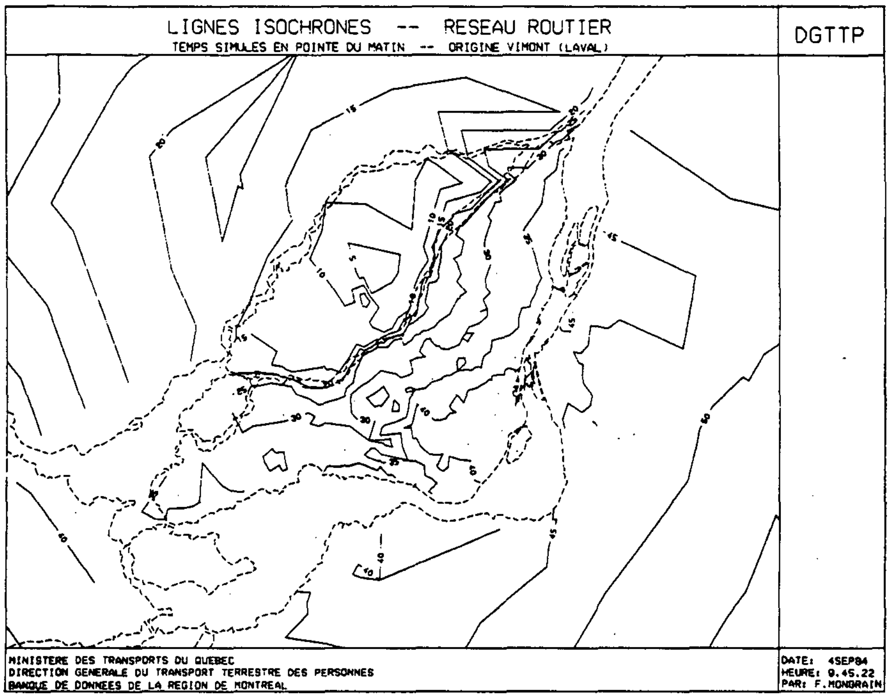


figure 23

transit flows

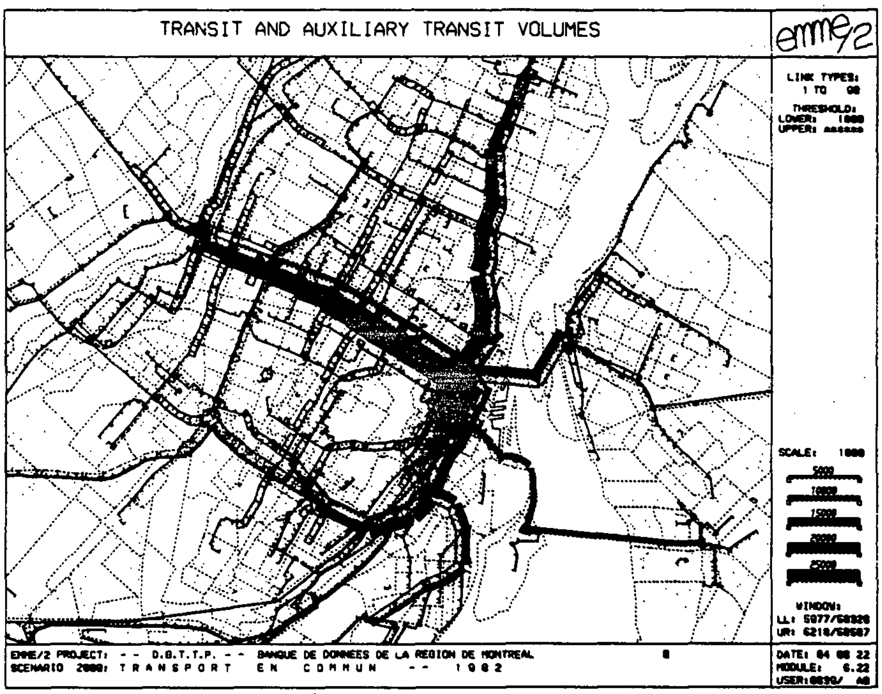


Figure 24 shows the ridership profiles for the morning peak period on three metro lines of the MUCTC. These volumes correspond to itineraries described in the 1982 O-D survey, as validated by MADITUC. The figure was produced by SAS-Graph using MADITUC files.

Another interesting illustration demonstrates passenger movements at network nodes. Examples are initial boarding volumes, transfers, total boarding volumes, alighting volumes, etc. These schematic images immediately reveal not only the zones where ridership is most important but also the major demand corridors, where proposals for infrastructures of medium or high capacity would be appropriate (figure 25).

3.6.4 Transit travel times

In contrast to the road network, travel times public transport are not dependant on flows in the infrastructure so that the simulation results are really a replay of the initial "Transport Supply". Nevertheless, the same analyses as for the road network apply here, ie:

- travel time distribution
- isochrone lines (figure 26)
- 3-D time surfaces

3.6.5 Iso-fare lines

Our programme for plotting iso-fare lines incorporates a procedure to analyse the costs and levels of service of public transport. The procedure calculates and maps break-even fares, in terms of demand and the allocation of operating and capital costs to transit users according to various formulae. Figure 27 illustrates, for the CBD, the equilibrium fares for a scenario where the user would defray 75% of operating costs and 25% of capital costs with the deficit supported by government subsidy.

figure 24

metro ridership profiles

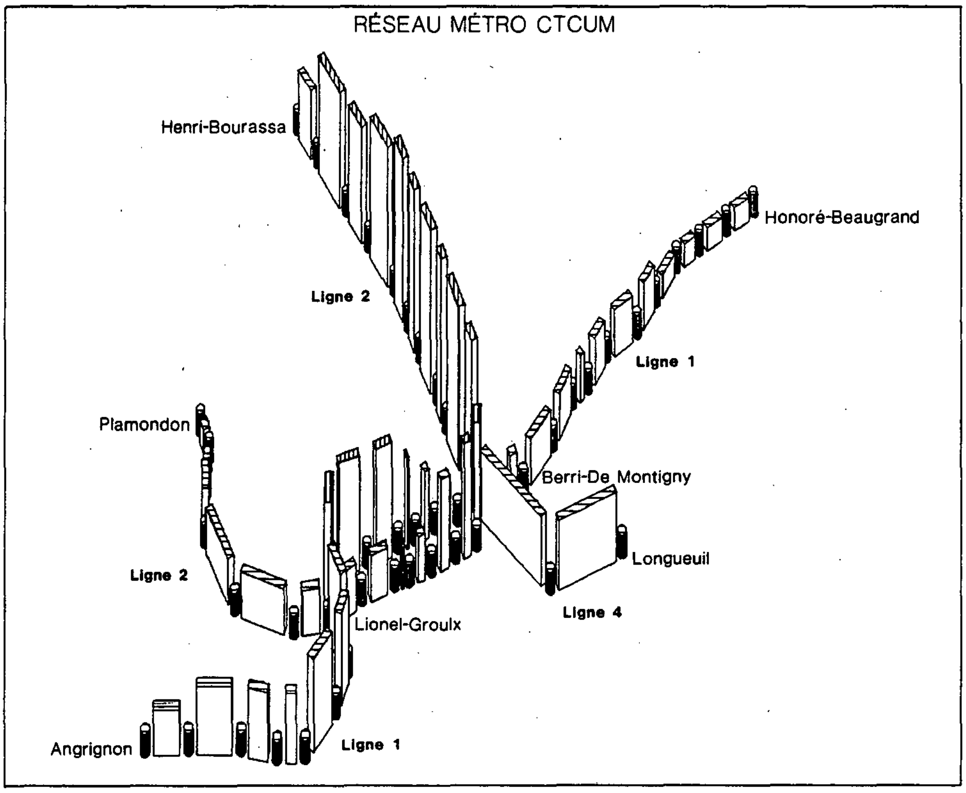


figure 25

transit boardings
a.m. peak period

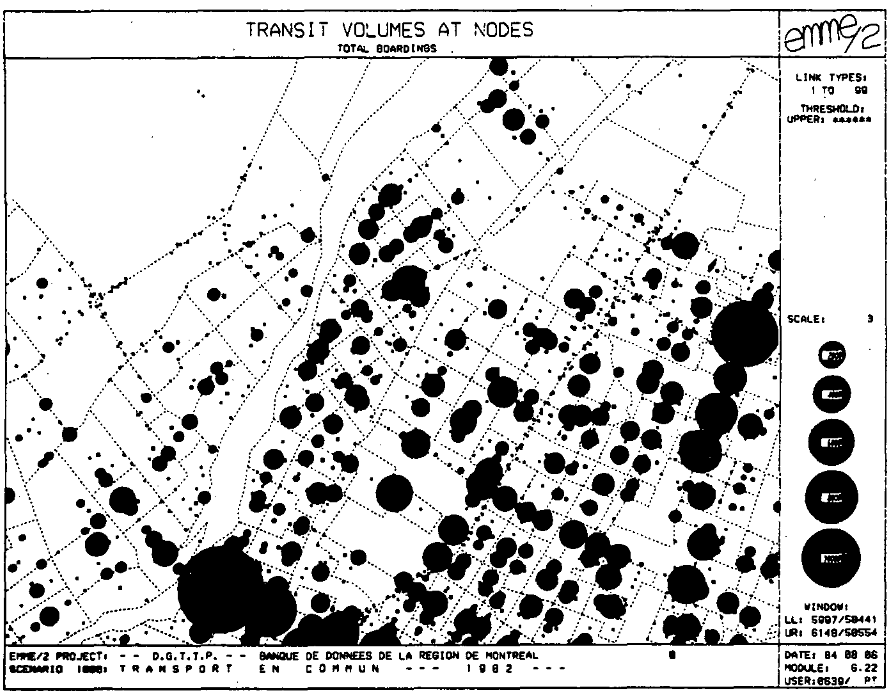


figure 26

transit isochrone lines

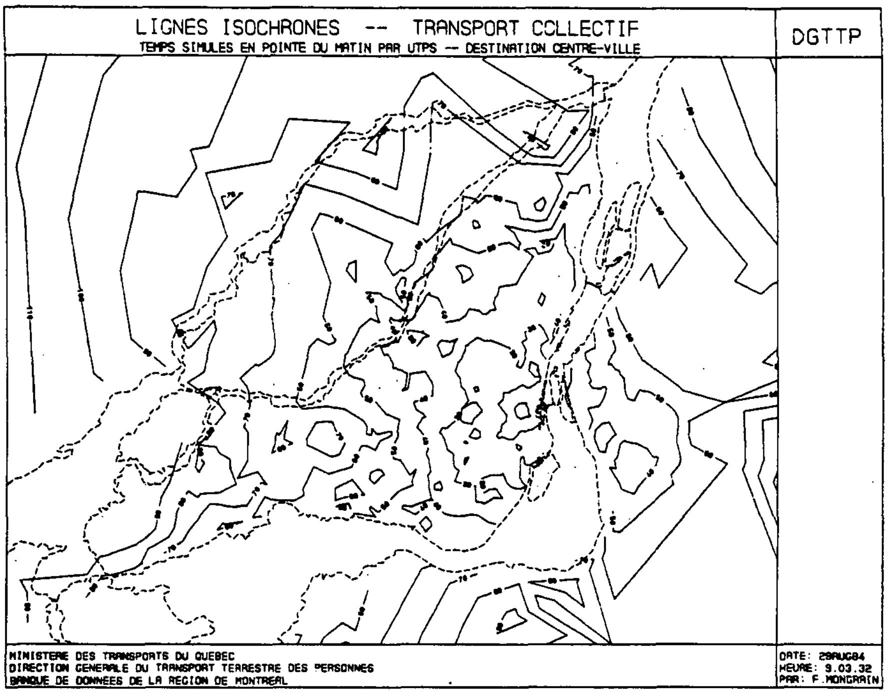
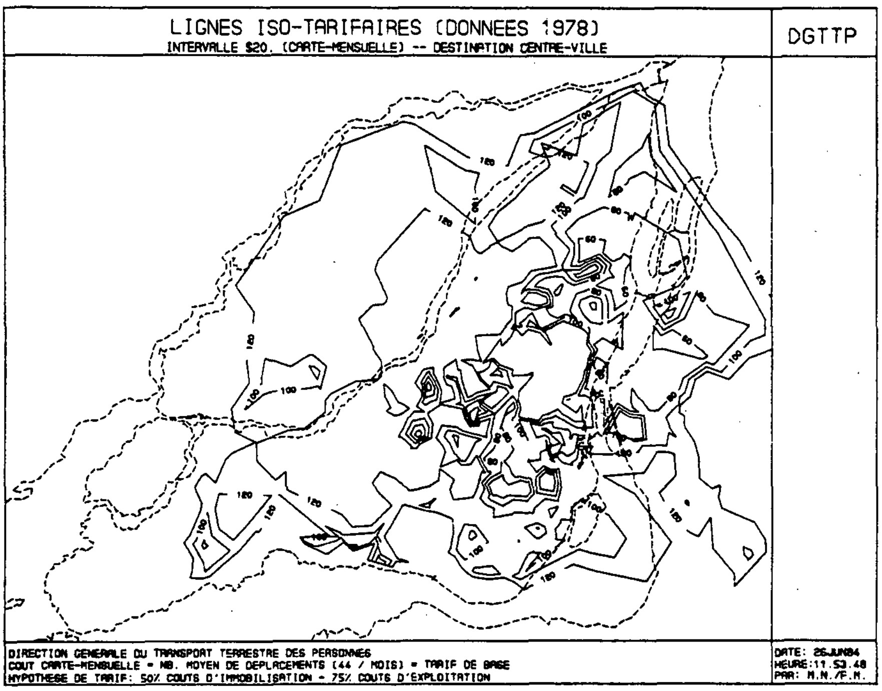


figure 27

analysis of fare structures



3.6.6 Disaggregated itinerary analysis

Although not by definition a simulation package, the MADITUC software, which has been recently installed, serves as a basis for disaggregate analysis of trip itineraries arising from the MUCTC O-D survey. Among other purposes, this facility will be applied to studies of choices between modes of access to metro and suburban train stations as well as to the conventional modal split between car and transit.

3.7 Calibration

The calibration of transport models is a distinct stage of the modelling process in which simulation parameters, including the volume/speed functions, are adjusted by comparison of simulated results with those observed in the networks during the period to which to the data base corresponds.

3.7.1 Road traffic flows

The differences between simulated and observed flows can be graphically mapped in order to rapidly assess the extent and spatial distribution of errors in estimation (figure 28). This is supplemented by report generation procedures which produce the results of successive calibrations with indices measuring the performance of each step.

3.7.2 Road travel times

Another means of identifying weaknesses in the model is by comparison of the simulated and observed times in the network, of which one representation may be histograms of the differences between both time matrices.

The comparison of isochrone plots for observed and simulated times can serve to identify those corridors where adjustments should be made. Finally, the spatial representation by zone of the discrepancies in travel time will clearly high-light those sectors where there are significant errors of estimation.

3.7.3 Transit flows

The availability of entry and exit counts at stations allows for the creation of histograms which are useful in evaluating the performance of the assignment models (figure 29).

Similarly, by superimposing simulated riderships profiles on the corresponding observed profiles, the difficulties in the modelling process are isolated. However, it should be noted that the temporal heterogeneity of the observed counts, the surveyed O-D data and the simulation results is a mitigating factor which complicates the calibration of the models.

3.7.4 Transit travel times

As in the case of the road network, the estimated transit travel times can be compared to observations in the following formats:

- distribution of differences
- comparison of isochrone maps
- spatial representation of differences

figure 28

differences between simulated and observed traffic flows a.m. peak period

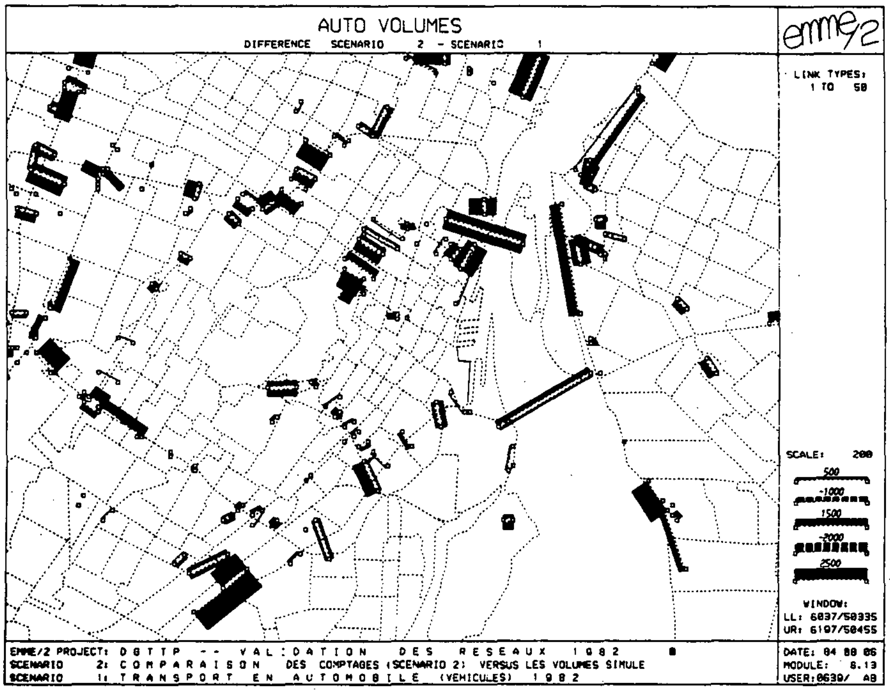
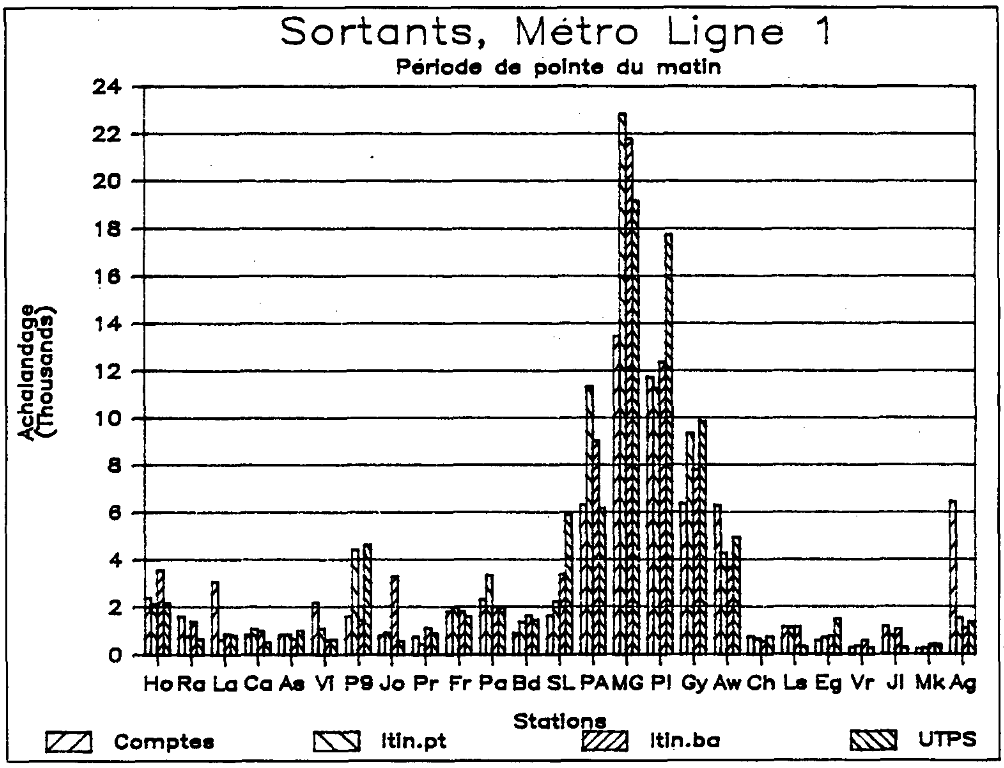


figure 29

ridership comparison at metro stations



4 CONCLUSION

3.8 Other activities

There are several other activities which we carry out generally in response to specific requests, and which do not fall into any of the above-mentioned categories. The following three examples suffice to illustrate their variety:

3.8.1 Graphic production

We are occasionally required to generate specific illustrations to be included in various reports or presentations produced by the D.G.T.T.P. Sofware such as LOTUS 1-2-3 provides flexible tools for responding efficiently to these requirements.

3.8.2 SYRIC: Computerized carpooling system

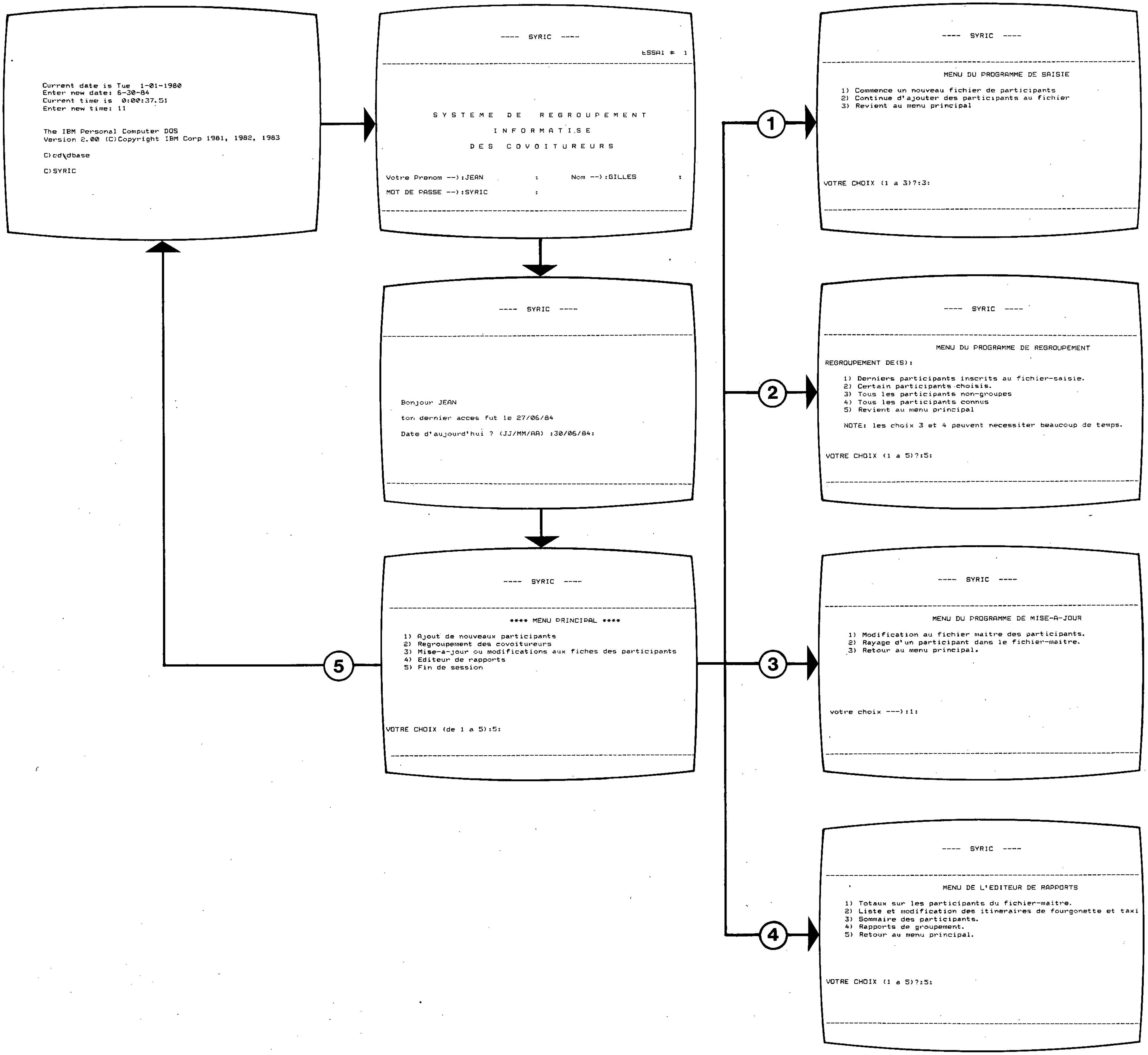
SYRIC is an in-house application for carpooling developped for "Covoiturage-Québec" and with their assistance. The package written entirely in dBASEII, is menu-driven on a micro-computer, with simple dialogue between the user and the screen (figure 30). The package is currently installed and available at "Covoiturage-Québec".

3.8.3 School transport study

School transport constitutes an additionnal concern of the D.G.T.T.P. and a working group is currently examining the state of the school bus fleet in the province, for which a data base was built by merging information from the R.A.A.Q registration files with data obtained from financial statements of fleet operators with membership in A.T.E.Q. This first step was done using S.A.S. on the main frame, but all subsequent analyses can be carried out locally on a micro-computer using the Stat-Pac or LOTUS 1-2-3 packages.

figure 30

carpool matching program



CONCLUSION

Three years ago, there were no more than five professionnals working on a regular basis within a computerized environment in our organization. But as the environment itself has evolved, particularly with micro-computer technology, it has absorbed a growing number of our personnel, both professionals and technicians, more than thirty of who, not including about ten secretaries capable of data entry tasks at the terminals, are now making extensive use of the tools available.

Many tasks are now effected interactively. Validation of data is done simultaneously with its acquisition and in many cases the analyses are carried out with interactive graphics.

We foresee extending this process of computerization to incorporate our library and our draughting facilites.

Computer graphics and micro-computers have become a part of our daily working environment.

GLOSSARY

GLOSSARY OF ACRONYMS USED IN THE TEXT

A.T.E.Q.	Association des Transporteurs d'Écoliers du Québec
CALCOMP	California Computer Products Inc., Anaheim, CA 92801
CBD	Central Business District
CP/M-86	Digital Research, Pacific Grove, CA 93950
C.R.T.	Centre de Recherche sur les Transports, Université de Montréal
C.T.C.U.M.	Commission de Transport de la Communauté Urbaine de Montréal
dBASE II	Ashton-Tate, Culver City, CA 90230
D.G.T.T.P.	Direction générale du transport terrestre des personnes, M.T.Q.
EMME/2	Équilibre Multimodal-Multimodal Equilibrium, from the C.R.T.
G.P.S.S.	General Purpose Simulation System, from IBM
HP	Hewlett-Packard Company, San Diego, CA 92127
HP-GL	Hewlett-Packard / Graphics Language
IBM PC-XT	IBM Personal Computer, model XT
IBM 5280	Distributed information system, IBM
I.G.L.	Interactive Graphics Library, Tektronix
INTEL	Intel Corporation, Santa Clara, California 95051
I.S.P.F.	Interactive System Productivity Facility, IBM
LOTUS 1-2-3	Lotus Development Corporation, Cambridge, MA 02142
MADITUC	Modèle d'Analyse Désagrégée des Itinéraires en Transport Urbain Collectif, École Polytechnique de Montréal
M.A.M.	Ministère des Affaires Municipales du Québec
M.T.Q.	Ministère des Transports du Québec
O-D	Origin-Destination
O.P.D.Q.	Office de Planification et de Développement du Québec
PC-DOS	Disk Operating System (IBM Personal Computer)
PC-PLOT	Tektronix 4010 Terminal Emulator, Microplot Systems Co., Columbus, Ohio 43229
PC-TALK	Pc-Talk III Communication Program, Freeware, Tiburon, CA 94920
PLOT-10	Plot-10 Terminal Control System, from Tektronix

QPLOT	Graphic subroutine library, from the CRT
R.A.A.Q.	Régie de l'Assurance Automobile du Québec
RAM	Randon Access Memory
R.J.E.	Remote Job Entry
RPG	Report Program Generator, IBM
RS-232	Standard RS-232 (Electronic Industries Association)
S.A.S.	Statistical Analysis System; SAS Institute Inc., Cary, North Carolina 27511
SNA	Systems Network Architecture
S.P.S.S.	Statistical Package for the Social Sciences, SPSS Inc., Chicago, Illinois 60611
STATPAC	Statistical Analysis Package, David S. Walonick, 1983
SYRIC	Système de Regroupement Informatisé des Covoitureurs, D.G.T.T.P.
TCAM	Telecommunications Access Method
TEKTRONIX	Tektronix Inc., Beaverton, Oregon 97077
T.S.O.	Time Sharing Option
U.M.T.A.	Urban Mass Transportation Administration, Washington
U.T.P.S.	Urban Transportation Planning System, from U.M.T.A.
VTAM	Virtual Telecommunication Access Method