Session Paper

Conducting Telephone Origin–Destination Household Surveys With an Integrated Informational Approach

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ABSTRACT

In the urban transportation planning scene, collecting information on mobility is a costly exercise. Most of the time, it is a multi-institutional, multi-objective and multidisciplinary project. A lot of discussions arise between partisans of a very detailed and extensive questionnaire and promoters of "short and sweet", unambiguous questions about trips made the previous day. Quality, quantity, significance, costs and nonresponse bias are legitimate issues that cannot be satisfactorily answered by a single survey method. Topics addressed in the presentation concern the demonstration of a survey method that integrates a set of technological innovations. Typically designed around the Montreal telephone household survey of 1993, the method illustrates the use of several techniques easily adapted to a standardized microcomputer environment:

- Cascaded questions focused on household, people living in it and trip characteristics of these people;
- Direct verification and validation of information fields and logical travel sequence (trip chaining);
- Interactive geocoding of origin and destination locations, with the help of spatially referenced databases, such as street addresses, street intersections, monuments (main trip attractors organized in suitable categories) and postal codes already structured within a specialized transportation geographic information system;
- Systematic interactive validation of trip modal components such as bridges, bus routes taken, subway stations, accessibility, multi-modal behavior, etc.

Some of the benefits of the method come from the fact that it uses the same integrated tools employed for transit network-planning modeling and user travel-information systems, these latter having been developed according to a totally disaggregate approach. Moreover, interactive graphics methods are used off-line to reconstruct badly obtained information. In conclusion, the paper demonstrates the current technological capability of conducting continuous telephone O-D surveys to monitor urban mobility in a cost-effective manner.

INTRODUCTION

Topics addressed in this paper are twofold: 1) the presentation of several transportation data collection cases where particular data conditions occur, for which limitations and insufficiencies are diagnosed, and 2) the suggestion of an integrated interactive informational approach for conducting telephone household origin-destination surveys.

Moreover, we will show how transportation data survey techniques have evolved in recent years and benefited from available technology, specifically with the introduction of microcomputers and related "transportation geographic information systems" (GIS-Ts), database management, local area networks, and feedback from transportation analysis and modeling.

Most of the learning is derived from collaborative efforts with the MADITUC group in several partnership activities. The Planning Department of the Montreal Urban Community Transit Corporation (MUCTC) conducted 5%-sampled telephone household O-D surveys in 1970 [2], 1974 [3], 1978 [4], 1982 [5] and 1987 [6] in the Greater Montreal area (3 million inhabitants). The Quebec Ministry of Transport conducted a joint effort with the MUCTC in 1993 [7] for a survey involving more than 60,000 households. There are also many other partners who provided survey opportunities: the Montreal South Shore Transit Corporation, the Quebec Urban Community Transit Corporation, the MUCTC Communication Service, the MUCTC Disabled Transport Service, etc.

SHORT HISTORY OF MONTREAL TELEPHONE ORIGIN-DESTINATION SURVEYS

In the 1970s, Montreal's O-D surveys had been strongly influenced by the methodology proposed by the Public Administration Services document titled "Procedure manual - Origin-Destination and Land Use", published in 1958 [1]. It started a long process of defining a "zoning system", and of developing mobility information on households, persons and trips, taking into account a limited number of very essential variables, such as trip purpose, travel mode and departure time.

THE 1982 ORIGIN-DESTINATION SURVEY: INTRODUCTION OF INDIVIDUAL TRIP PROCESSING

For the Montreal 1982 survey [5], the study territory was subdivided into 1,496 zones. The sampling was 5% for the central part of the area, and 10% for the suburbs. Telephone interviews were compiled on paper, and transcriptions of the origin or destination locations were coded by technicians with geographical maps and lists of important trip generators. When a trip was made by transit, information on subway and bus routes taken was gathered. A typical Montreal origin-destination survey has a limited number of questions. Information collected is on

- HOUSEHOLD: residential location (zone), number of persons, number of cars and household income (for a subsample of the survey);
- PERSONS: age, gender and car ownership;
- TRIPS: for every trip, the origin and destination zones, the departure time, the trip purpose (work, study, shopping, leisure, other, home return) and the travel modes taken (car driver, car passenger, school bus, pedestrian, others—taxi, cycle, transit rail, subway, bus, according to transit authorities and chosen routes).

The survey productivity is maintained at a high level, with 4 to 6 validated and complete households per hour per interviewer. Overall unit cost of collecting data for one household, including geocoding and trip validation tasks, is around $15 U.S. (1993 dollars).

With this survey, the totally disaggregate approach [15-17], as shown in Figure 1, was introduced to process every answer about the transit routes against an a priori

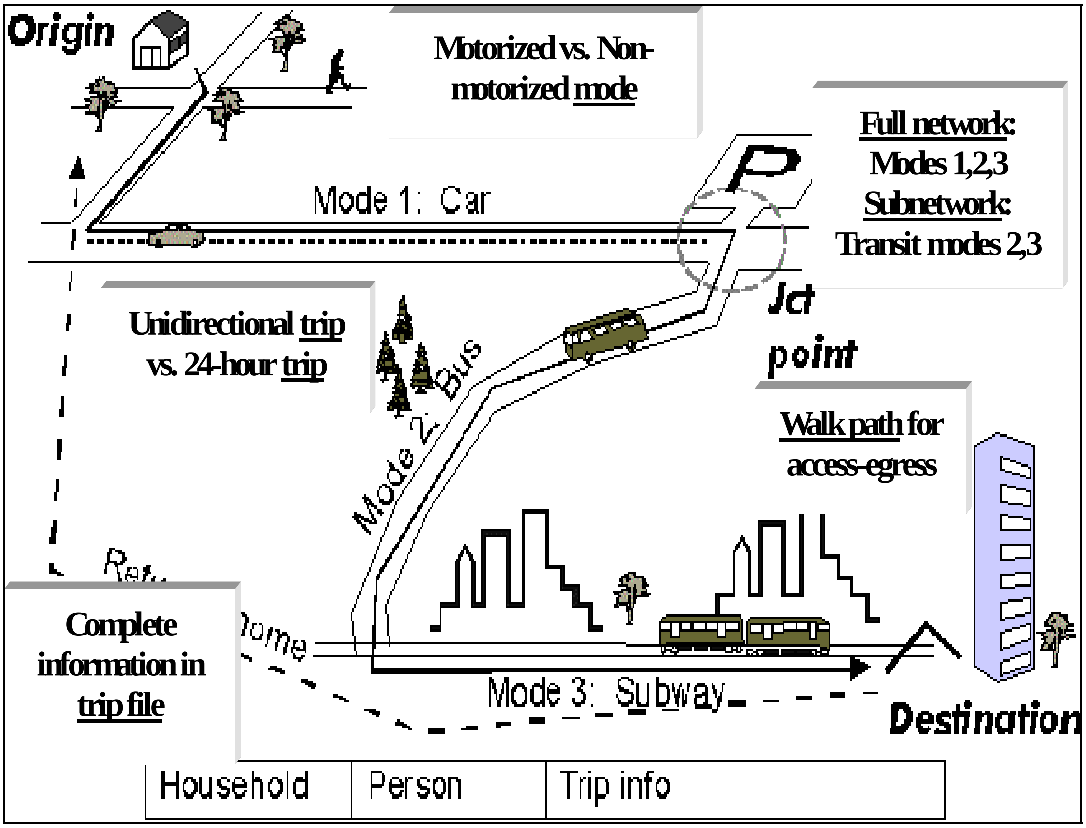


FIGURE 1 Totally disaggregate origin-destination trip modeling: 4 primary locations: residence, origin, destination, modal junction point (if necessary); secondary locations derived from the network processing: access and egress nodes (stops or stations), transfer nodes; and tertiary locations derived from the transit line specification (sequences of intermediate stops or stations).

analytical transit network developed for trip assignment. From partial transit information, the so-called "declared path," a validation procedure was developed to check errors about service hours, non-connecting routes, and impossible access distances. Then, with the aid of a special calculator, an "observed path" was derived containing declared transit routes and most probable access nodes and transfer points. From the fact that this new "observed path" is compatible with the transit network trip-assignment procedure (and of the same nature as any simulated path), a new methodology has emerged. Innovative capabilities are:

- Potential of network loading with "observed data"; derivation of route load profile; and calculation of network usage in terms of passenger-kilometers and passenger-hours. Incidentally, transit cost and revenue allocation studies have been developed over this type of data.
- Calibration of transit path algorithm taking into account walking, waiting and in-vehicle times, transfer, fare and mode penalties, by aiming at a perfect reproduction of itineraries (observed vs. simulated paths).

THE 1987 ORIGIN-DESTINATION SURVEY: GEOCODING AT THE BLOCKFACE LEVEL OF RESOLUTION

With urban sprawl and refinements in transportation analysis, the necessity of subdividing a 1500-zoning system was becoming cumbersome. With the emergence of new microcomputers (Intel 286 processors, available in 1987), it was then decided to directly process alphanumeric information, leaving to relational database concepts the burden of processing and verifying the data. In Canada, an interesting spatial reference was available, the postal code, having the property of being unique for any blockface in an urban area. As a result, the address matching was implicit, and the new level of resolution for geocoding origin, destination and residence was increased to 70,000 “centroids”, from 1500 (Figure 2). Post-survey semiautomatic and interactive geocoding, with the help of databases on postal codes, street intersections, street addresses and monument files, served as the main procedure to generate more extensive databases on trip generators [19]. By this process, the O-D survey itself generates its own spatially referenced databases. Moreover, during the survey, the destinations’ inventory is continuously updated and reintroduced as a reference for the automatic geocoding.

Numerous post-survey analyses address issues of trip generation modeling. Activity-based maps were derived from O-D trip data for the Montreal area [20], and specific trip generation categories have been thoroughly investigated, for instance, shopping centers, hospitals, colleges and universities, primary and secondary schools, factories, etc.

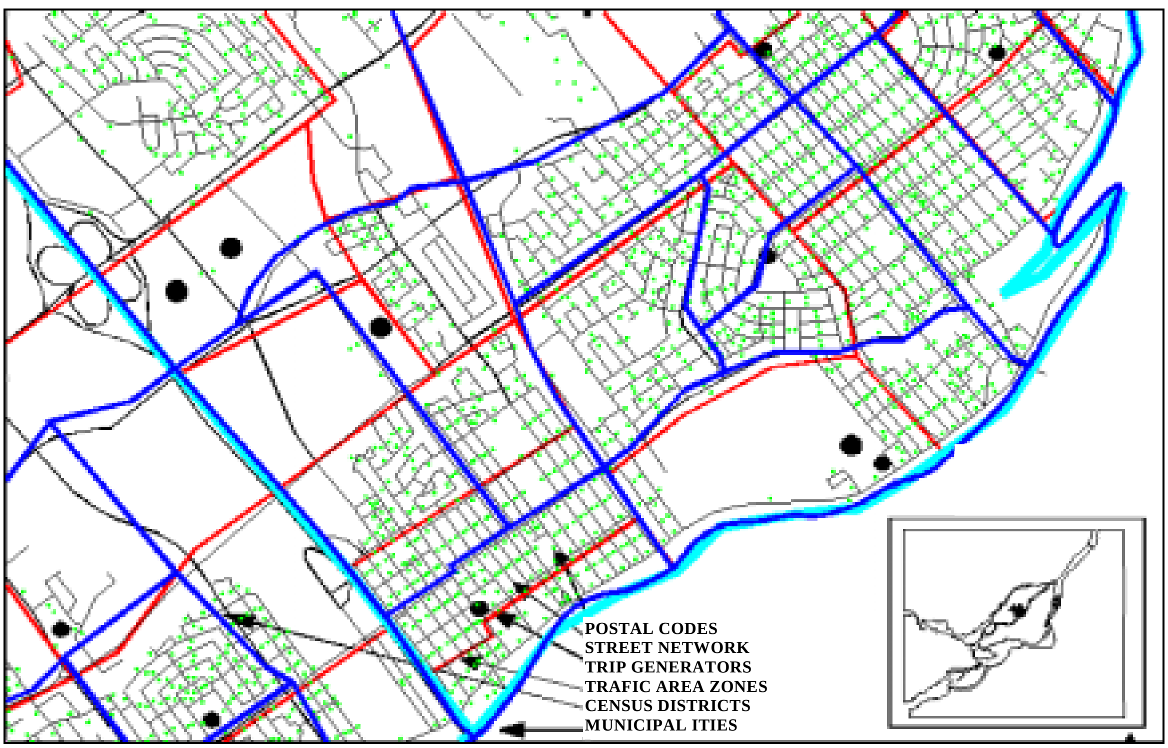


FIGURE 2 Spatial reference systems: Canadian postal codes, street addresses and intersections, landmarks and generators, and zoning systems (transit area, census tracts, and municipal boundaries).

THE 1993 ORIGIN-DESTINATION SURVEY: DIRECT DATA ENTRY AND SEMIAUTOMATIC GEOCODING

For the last Montreal telephone O-D survey, some questionnaire changes were made to benefit from direct data entry. A private specialized firm, Canadian Facts, has conducted telephone household interviews. To alleviate any bias from the interviewer, only a limited number of destinations were previously geocoded. Most of the time, the location of trip destinations was coded “as declared”, leaving to the post-survey processing stage the burden of semiautomatic and interactive geocoding. In addition, interactive graphical procedures were available to validate and recuperate any multimodal or transit route information. Moreover, for any car-driver trip made by commuters going to the island of Montreal, the bridge name (from a set of 22) was collected and is now serving to calibrate equilibrium trip- assignment models [22].

Typical post-survey analyses looked at trip attraction modeling, structure and coherence of trip chaining and chain patterns. In addition, several object-oriented modeling exercises have permitted conducting studies on transportation infrastructure usage within a fiscal framework (residence-employment-transport) [21]. These activities are research tasks undertaken as a normal data validation. Therefore, inconsistent trip data are investigated, and O-D survey validation procedures are updated accordingly.

THE 1995 TRANSIT TRAVEL INFORMATION SYSTEM: COHERENT INTEGRATION OF GEOMATICS, NETWORK SPECIFICATION, PLANNED SCHEDULES, AND INTERACTIVE PATH CALCULATION

The ideal interactive survey system is a telephone travel-information system. Since 1995, the Montreal Urban Community Transit Authority has driven its phone information system with an integrated system developed by the MADITUC group, and derived from the modeling and processing techniques applied in the O-D survey [23]. The system is operated by 20 phone agents working on a PC microcomputer platform and handling over 2,000,000 calls per year. The software generates a set of "smart" itineraries between any origin-destination pair in less than 2 seconds. The system integrates a complete geomatic description of any location in the Montreal urban community territory. Specification of origin and destination is determined by street address, street intersection, postal code, monument or generator, or any transportation identification (subway or rail stations, bus stops, terminals). It also includes:

- A complete transit network specification with a variable geometry network (about 500 transit routes over 7 types of day, peak, off-peak and night service).
- A complete schedule specification for the planned service at 16,000 bus stops.
- A complete pedestrian network specification of almost 80,000 links for the simulation of walk access path to the transit network.

The following figures (3 and 4) show some of the screens and databases available to the telephone agent when he/she is negotiating a trip specification with a customer. The system also integrates some interactive graphical aids.

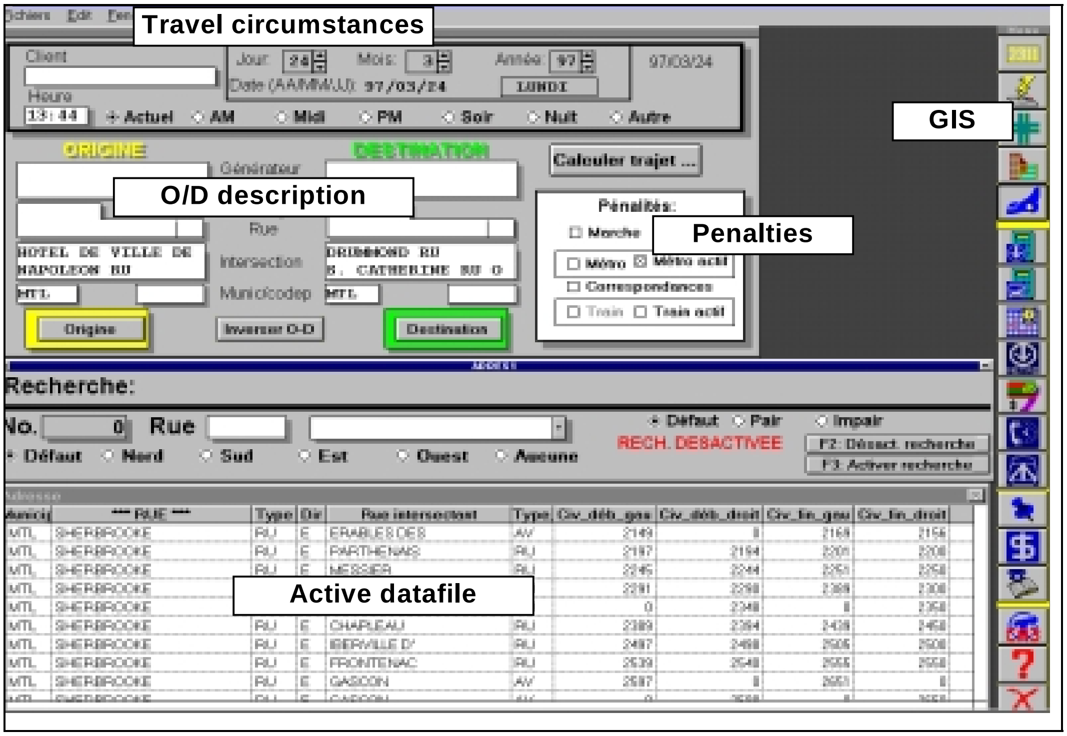


FIGURE 3 Interactive tool for transit trip specification and path calculation.

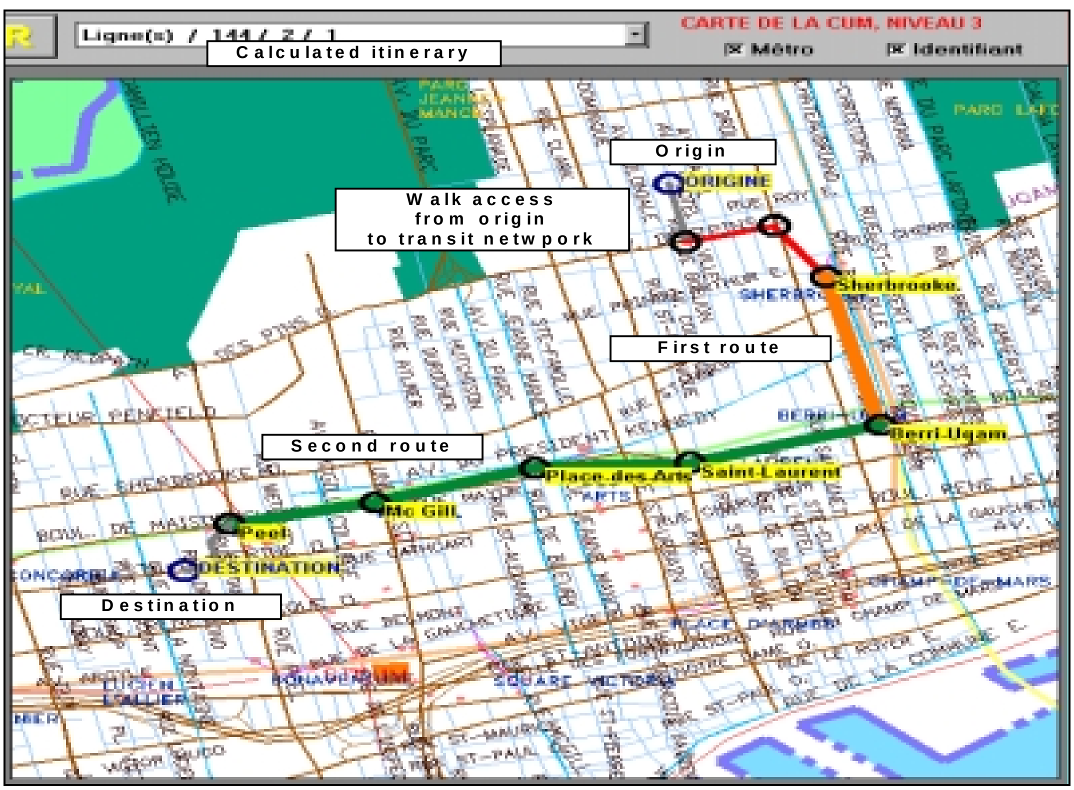


FIGURE 4 Graphically displayed calculated itinerary and related information.

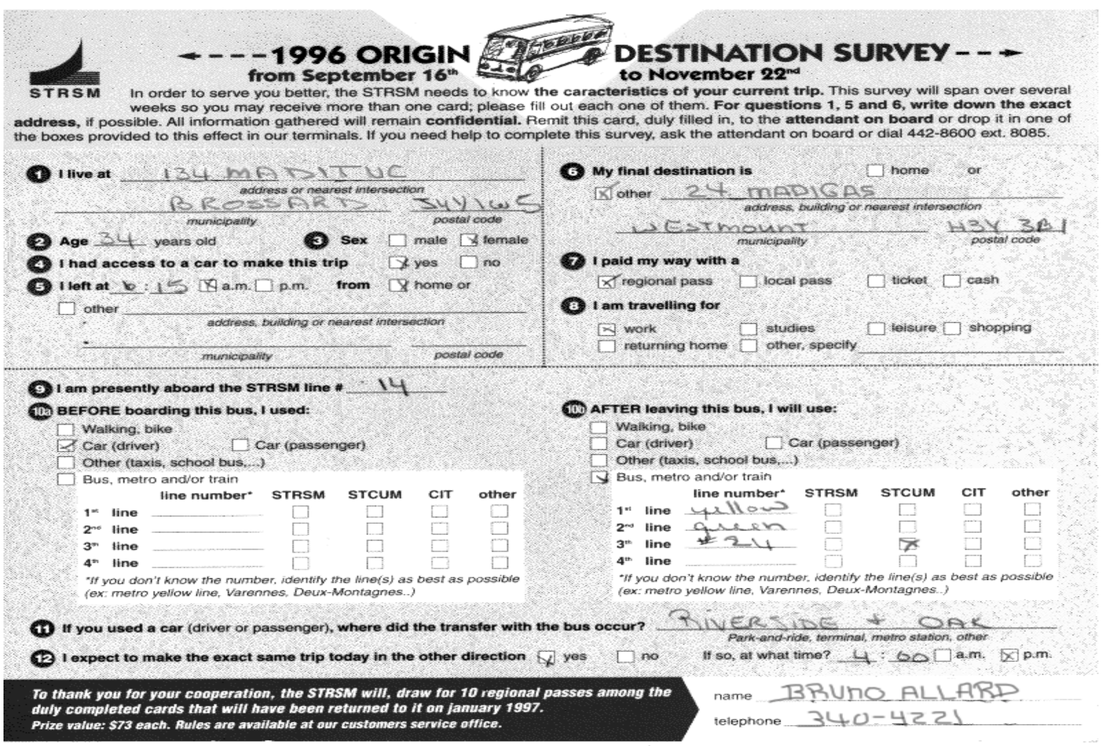
THE 1996 TRANSIT ONBOARD SURVEY: INTEGRATION OF DATA ENTRY, GEOCODING AND VALIDATION

The same techniques as above are used for the geocoding of precise information on transit usage. In a very specific geopolitical context, the Montreal South Shore Transit Authority had to carry out, in the fall of 1996, a survey needed to assess an equitable financing formula among seven municipalities [10]. The O-D survey was conducted onboard, using special forms, with a sampling of every vehicle run departing between 6:30 a.m. and 3:00 p.m. on an average weekday. The exercise was made for all 60 regular bus routes, 48 school bus routes and 6 collective taxi routes. The variables observed were the following:

- Rider residence to be geocoded at the blockface level or x-y coordinates.
- Boarding stop (controlled at the distribution level) and alighting stop (derived by the access model) on the bus route.
- Trip origin and destination, and bimodal junction point, to be geocoded at the *x-y* coordinate level.
- Sociodemographic characteristics, time and purpose of the trip.

It was planned to distribute 55,000 questionnaires (1,000 per day) with an anticipated response rate of 60%. In fact, the response rate was much higher, at the 86% level. Finally, 49,635 cards were distributed to riders, resulting in 44,990 processed questionnaires (78%), representing 57,585 customer boardings, for which:

- 30,571 directly passed the usual classic data verification on variables and variable domains at the first try (see Figure 5);


STRSM

←---1996 ORIGIN DESTINATION SURVEY--→
from September 16th to November 22nd

In order to serve you better, the STRSM needs to know **the caracteristics of your current trip.** This survey will span over several weeks so you may receive more than one card; please fill out each one of them. **For questions 1, 5 and 6, write down the exact address,** if possible. All information gathered will remain **confidential.** Remit this card, duly filled in, to the **attendant on board** or drop it in one of the boxes provided to this effect in our terminals. If you need help to complete this survey, ask the attendant on board or dial 442-8600 ext. 8085.

1 **I live at** 134 MADITUC (address or nearest intersection) BROSSARD (municipality) J4Y 1W5 (postal code)
2 **Age** 34 years old 3 **Sex** ☐ male ☒ female
4 **I had access to a car to make this trip** ☒ yes ☐ no
5 **I left at** 6:15 ☒ a.m. ☐ p.m. **from** ☒ home or ☐ other (address, building or nearest intersection) (municipality) (postal code)
6 **My final destination is** ☐ home or ☒ other 24 MADIGAS (address, building or nearest intersection) WESTMOUNT (municipality) H3Y 3B1 (postal code)
7 **I paid my way with a** ☒ regional pass ☐ local pass ☐ ticket ☐ cash
8 **I am travelling for** ☒ work ☐ studies ☐ leisure ☐ shopping ☐ returning home ☐ other, specify
9 **I am presently aboard the STRSM line #** 14
10a **BEFORE boarding this bus, I used:** ☐ Walking, bike ☒ Car (driver) ☐ Car (passenger) ☐ Other (taxis, school bus,...) ☐ Bus, metro and/or train

	line number*	STRSM	STCUM	CIT	other
1st line		☐	☐	☐	☐
2nd line		☐	☐	☐	☐
3rd line		☐	☐	☐	☐
4th line		☐	☐	☐	☐

*If you don't know the number, identify the line(s) as best as possible (ex: metro yellow line, Varennes, Deux-Montagnes..)

10b **AFTER leaving this bus, I will use:** ☐ Walking, bike ☐ Car (driver) ☐ Car (passenger) ☐ Other (taxis, school bus,...) ☒ Bus, metro and/or train

	line number*	STRSM	STCUM	CIT	other
1st line	yellow	☐	☐	☐	☐
2nd line	green	☐	☐	☐	☐
3rd line	#24	☐	☒	☐	☐
4th line		☐	☐	☐	☐

*If you don't know the number, identify the line(s) as best as possible (ex: metro yellow line, Varennes, Deux-Montagnes..)

11 **If you used a car** (driver or passenger), **where did the transfer with the bus occur?** RIVERSIDE + OAK (Park-and-ride, terminal, metro station, other)
12 **I expect to make the exact same trip today in the other direction** ☒ yes ☐ no If so, at what time? 4:00 ☐ a.m. ☒ p.m.

To thank you for your cooperation, the STRSM will, draw for 10 regional passes among the duly completed cards that will have been returned to it on january 1997. Prize value: $73 each. Rules are available at our customers service office.

name BRUNO ALLARD
telephone 340-4221

FIGURE 5 Example of a transit onboard origin-destination survey questionnaire.

- only 24,926 directly passed, at the first try, the complete transit path validation test performed by the MADITUC model (access distances, service hours, routes and transfers) to check all the spatially referenced data of the trip (see Figure 6) ;
- with interactive graphic validation procedures, more than 10,000 questionnaires were corrected and recuperated (see Figure 7); on summary: 14% nonresponse, 8% unrecoverable information, and 78% consistent trip data.

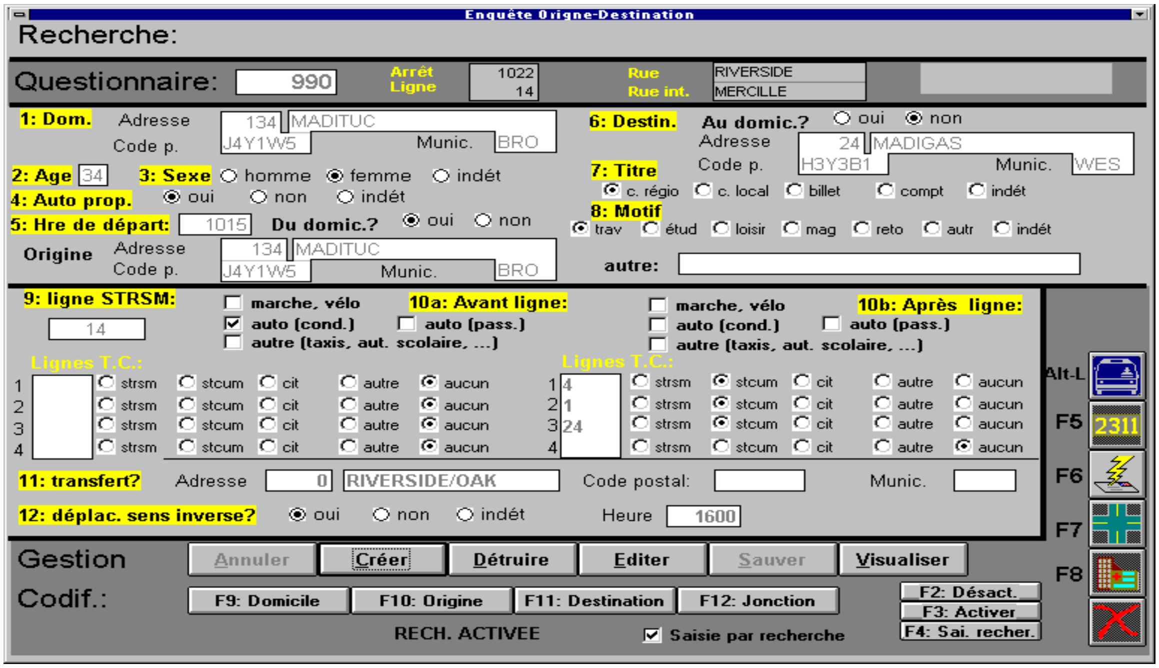


FIGURE 6 Data entry and coding screen of a transit onboard O-D survey program.

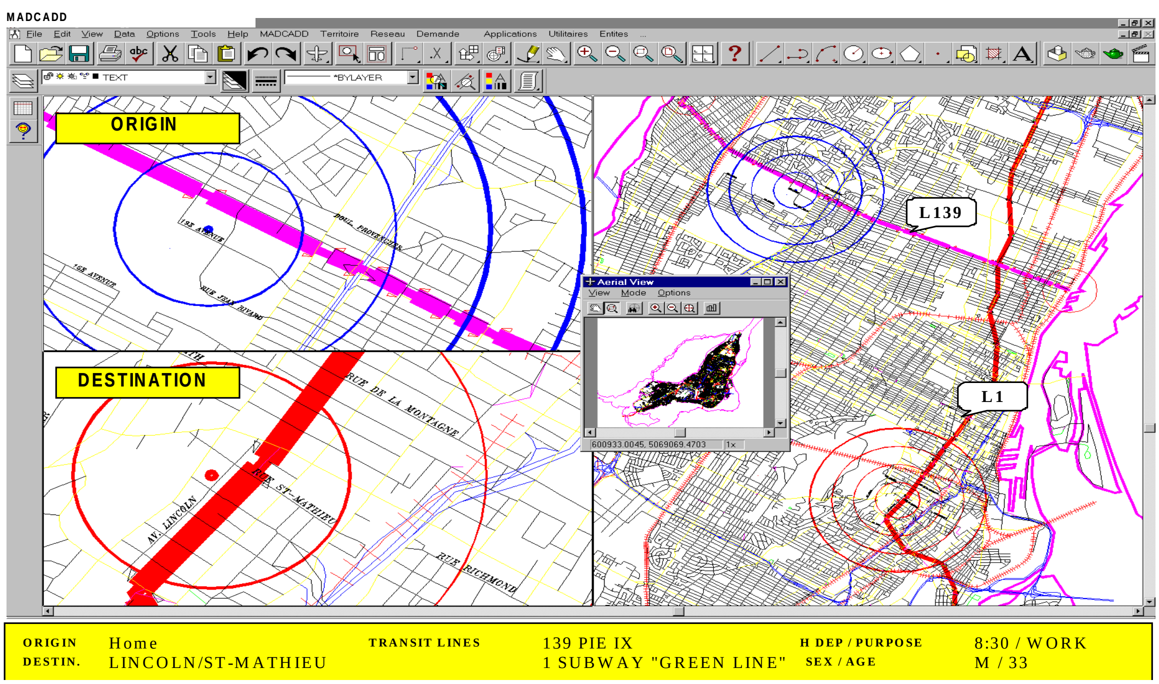


FIGURE 7 Itinerary interactive graphics validation procedure.

THE 1997 DISABLED TRANSPORT ANALYSIS: SYSTEMATIC GEOCODING OF TRANSPORT DATABASES

The last Montreal geocoding experiment was done recently with a 14-day sample of all the trips made by taxi and minibus ("Adapted Transport Service") [24]. Several databases have been mounted: customer (15,800 persons), taxi (12,143) and minibus (1,456) runs databases were available with spatial references (street addresses, for origin and destination stops of the riders). During that period, 47,030 O-D trips have been made by 4,330 active customers. The location information had to be geocoded before applying a disaggregate analysis (demand characterization and productivity evaluation). The exercise demonstrated a poor database quality due to many nonsystematic approaches. It was necessary to deal with a lot of badly coded data to locate some 5,700 different sites, enough to process more than 99.7% of the trips. Usual types of errors encountered are the following:

- spelling (mistyped data),
- same location addressed differently (alias),
- inconsistency in a typographic sequence,
- concatenated information (not enough characters),
- space suppression,
- insertion of special characters,
- affix presence,
- road type presence,
- numerous naming conventions: dashes, saint, numbered streets, etc…

TABLE 1 Some Examples of Typical Badly Coded Data to be Recovered

Orthographic (mistyped data)	
70 BEACONFIELD	Should be 70 BEACONSFIELD
Various location descriptions	
27 LAKESHORE, 27 LAKESHORE(HOP.BAYVIEW)	
Concatenated information (due to lack of space)	
AERODORVAL(ARRIVEE DOMEST	Should be AEROPORT DORVAL(ARRIVEE DOMESTIQUE)
Space suppression and word inversion	
860AVE90	Should be 860 90E AVENUE
Prefix presence	
10100 BOIS DE BOULOGNE, 10005 DU-BOIS-DE-BOULOGNE	
Street type presence (and language)	
8225 CHEMIN ROYDEN, 8225 ROYDEN, 8225 ROYDEN RD	
Mixed naming convention	
12057 STE-GERTRUDE, 12057 ST-GERTRUDE, 12057 ST.GERTRUDE 9084 7E AVENUE, 9084 7TH AVENUE	

In summary, because of the strong influence of the totally disaggregate approach for transportation data modeling in Montreal, geocoding has evolved from manually coded data in a detailed zoning system to a complete spatial disaggregation using any spatial reference available (*x*-*y* UTM coordinates, Canadian postal codes, street intersections, street addresses, landmarks, etc.). The surveys helped to develop the numerous databases, thanks to semiautomatic and interactive database management procedures. Interactive graphic validation programs had facilitated information recovering (see Figure 8). The resulting databases were refined, then submitted as a tool to make a comprehensive travel information system. Finally, geomatics (urban transportation geographic information system) has to be combined with chronomatics (transit route planned schedules) to achieve a more credible travel information system, frequently visited on the Web (http://www.stcum.qc.ca) [9].

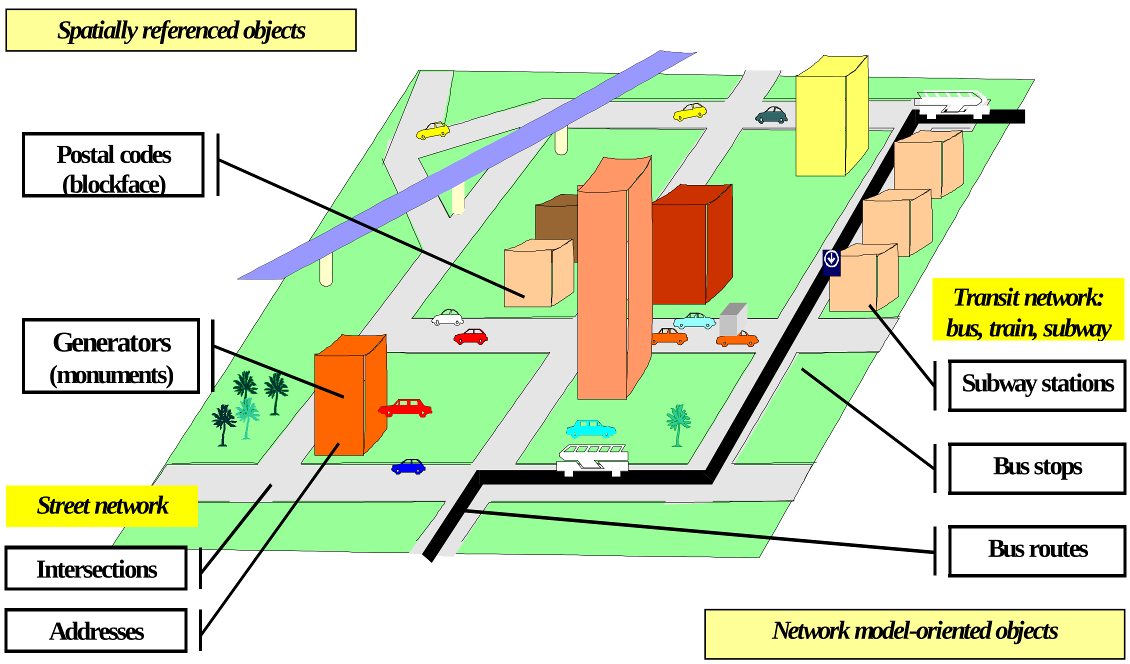


FIGURE 8 Information system objects taken into consideration in a travel survey.

AN INTEGRATED INFORMATIONAL APPROACH FOR TRANSPORT SURVEY

From the aforementioned experiments, it becomes clear that an efficient urban transportation survey must take into account numerous external considerations. The survey has to be

- Customer-oriented (or travel information-oriented). Questions about locations, or network components, have to be asked in terms of customers' knowledge of the spatial and network environment, in a manner similar to any other "travel information system". The trip specification by the interviewee could be partial, but should be confirmed by the interviewer, possibly by using some kind of redundancy (proximity location).
- Model-oriented. Models are based on relationships and logical events. Space and time processing have to be applied when checking trip chaining sequence, accessibility distances, bus route connections and type of destination (combination of travel time, age, gender and purpose). The trip assignment algorithms, sociodemographic trends, transportation cost and revenue analysis are models to be calibrated with reference information, and to be used for planning and decision making.

- Object-oriented. An integrated coherent information system distinguishes between household, persons, person trips, vehicles, modes, path components, bus stops, routes, residences, and trip generators. The GIS-T location data and operational data, combined with models (access and path calculators) and interconnected with relational databases, constitute some building blocks for subsequent analyses. The personal status, time and spatial trip attributes, and generator attributes such as employment or activity category could be left to expert models.

AN INTERACTIVE DIRECT-ENTRY TELEPHONE INTERVIEW

A household telephone interview has to process several objects: household, persons, trips, trip chains along time and space, vehicles, personal status (worker, student, other, nonmobile), employers, schools, etc. To achieve this task, a direct data-entry program is organized around a set of screens and reference databases. The following reproduces, on a microcomputer framework, the Montreal 1993 O-D survey questions.

Successive screens are:

- Telephone interview survey management: first menu (Figure 9).
- Household screen: first telephone contact with the sampled household. Automatic geocoding of the residence (Figure 10).
- Screen for obtaining the list of household members (Figure 11).
- Screen to assess trip sequence: destinations, starting time, purpose, travel mode and other information (fares, parking, junction point) (Figure 12).
- Structured summary screen of the household's trips (Figure 13).
- Interactive graphic validation of the trip chain (Figure 14).

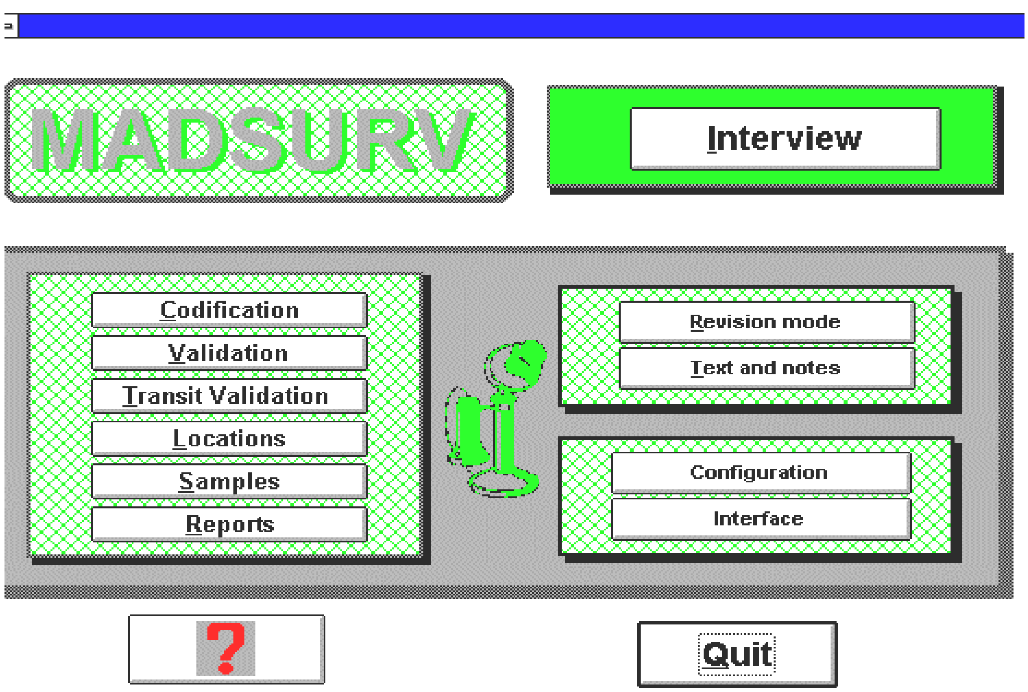


FIGURE 9 Navigation menu for the telephone interview survey.

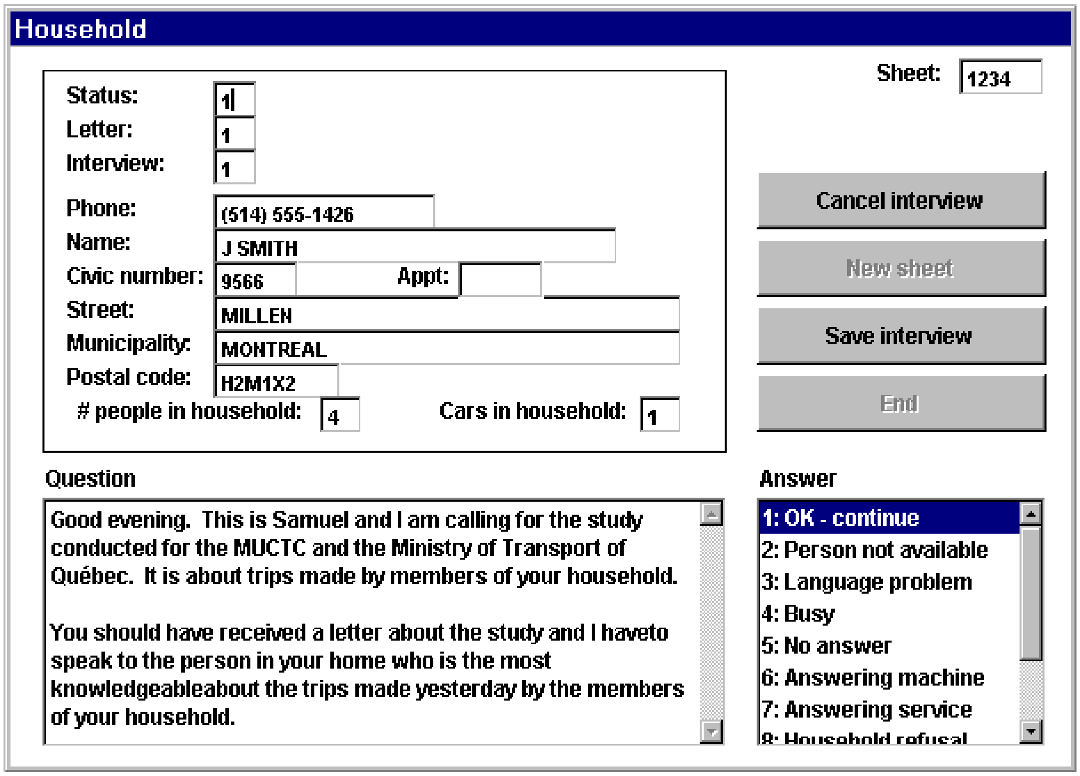


FIGURE 10 Telephone O-D survey: the household screen.

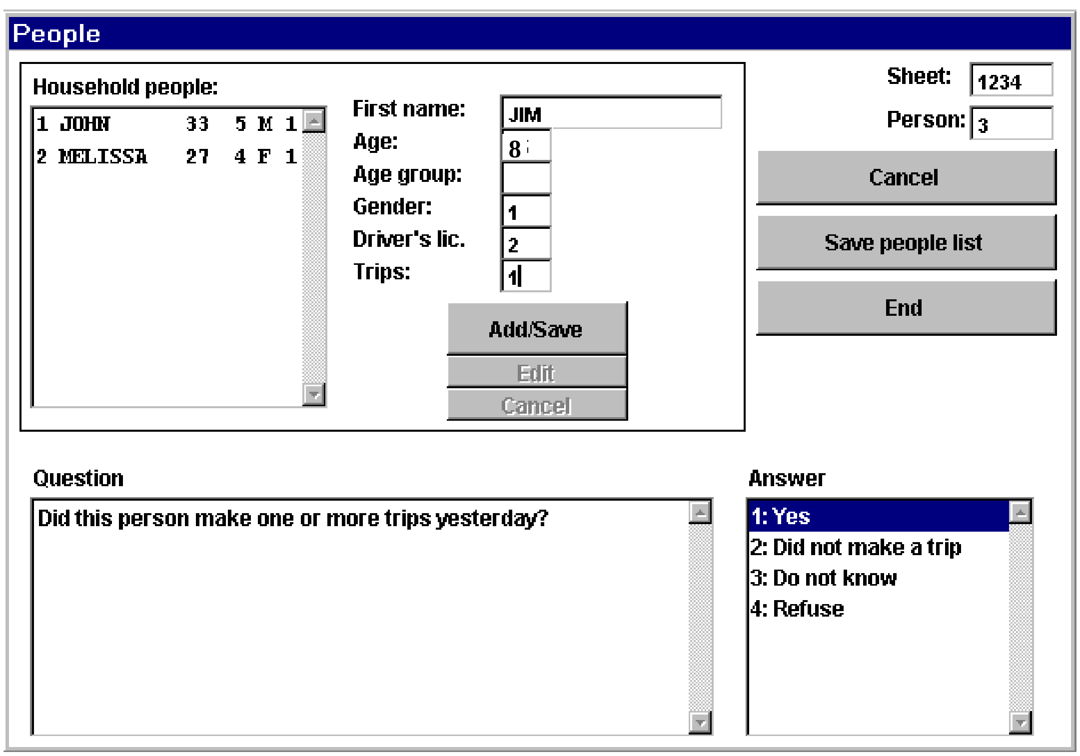


FIGURE 11 Telephone O-D survey: the household members screen.

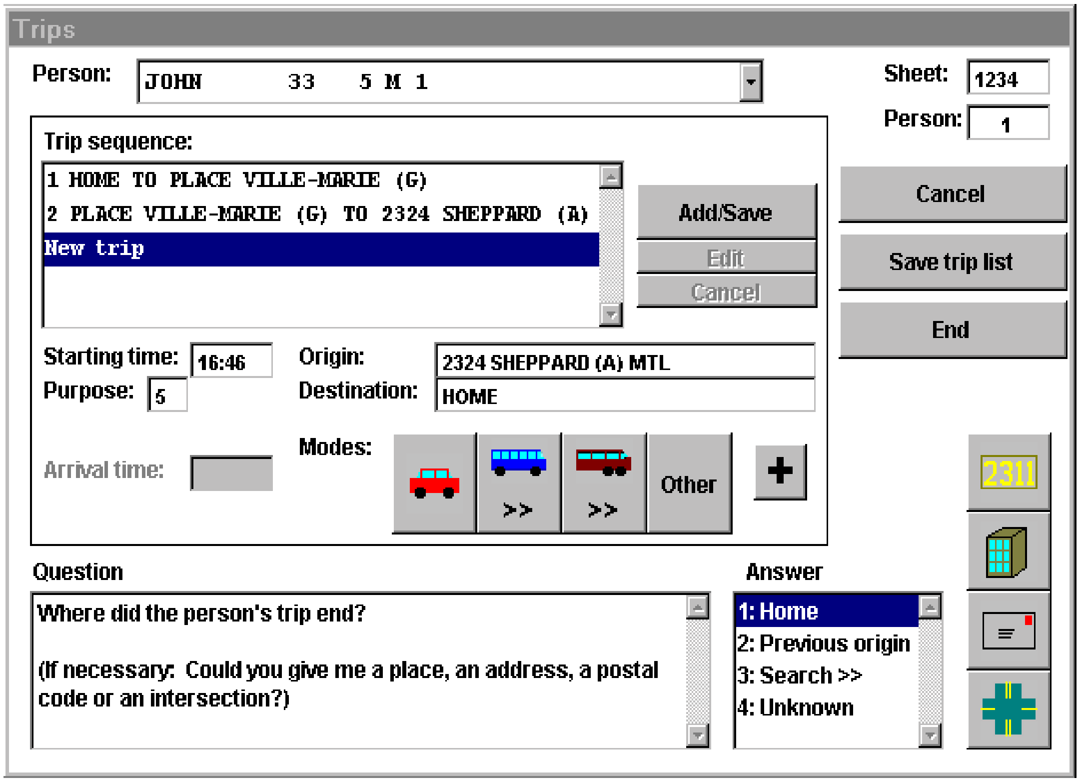


FIGURE 12 Telephone O-D survey: the trip sequence of an individual

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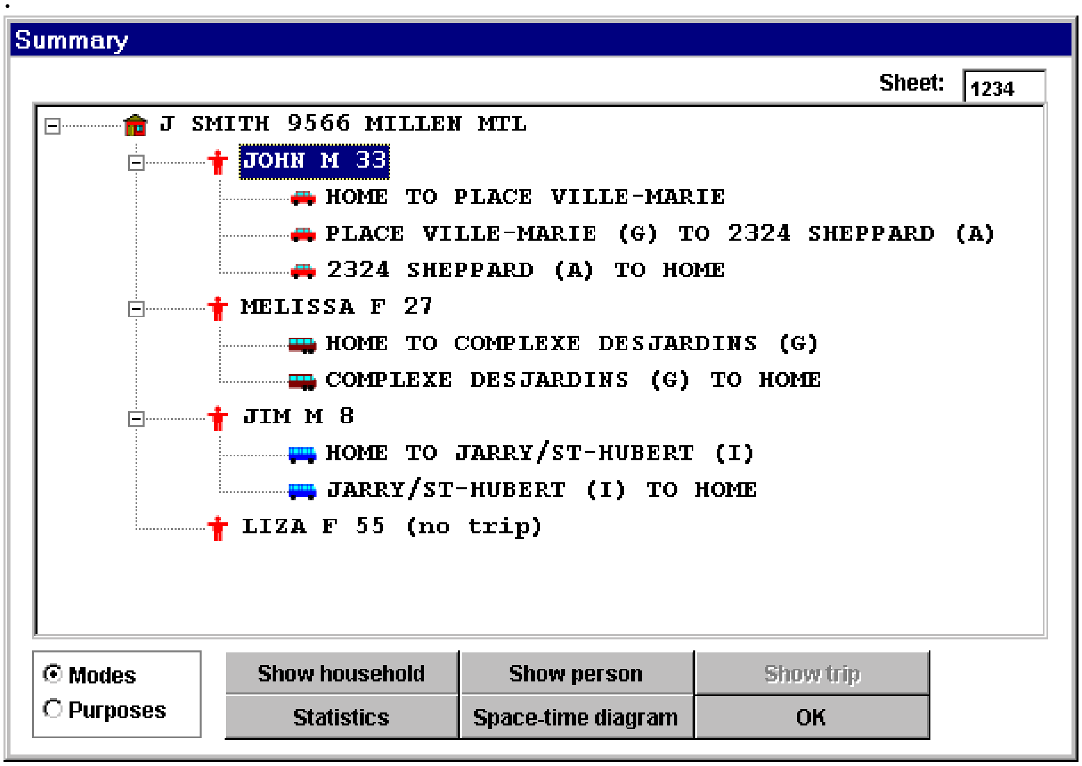

FIGURE 13 Telephone O-D survey: the household trips summary.

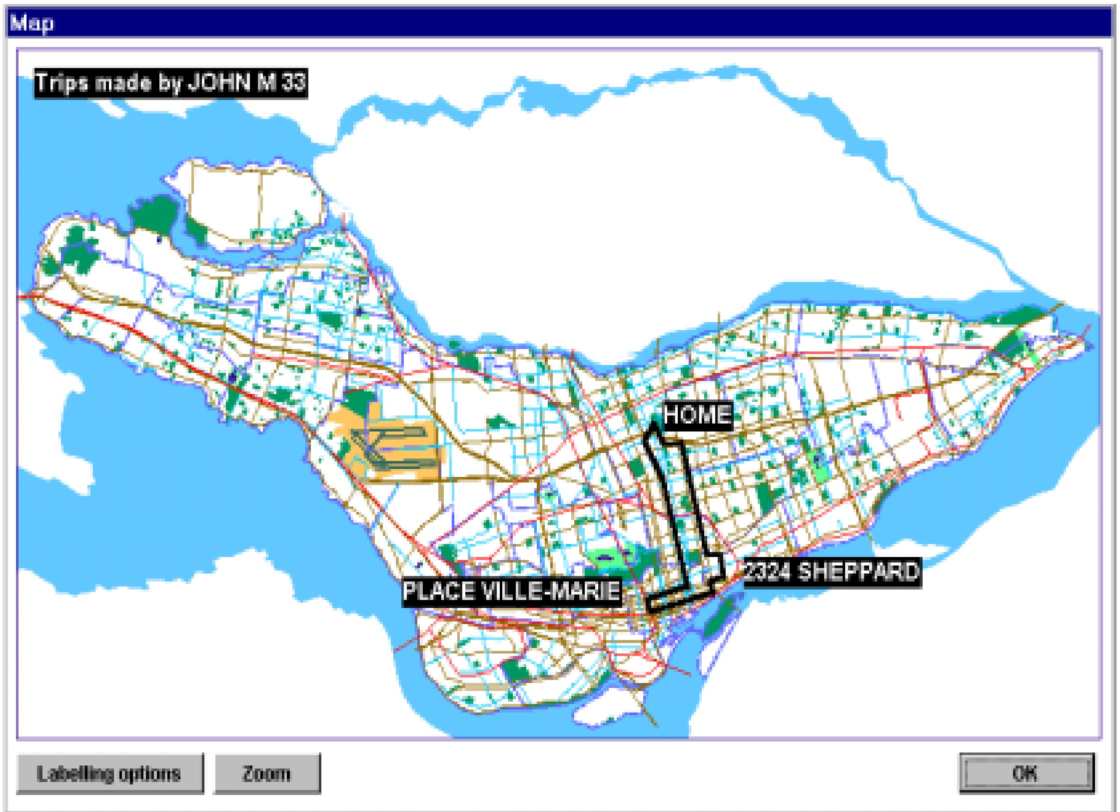

FIGURE 14 Telephone O-D survey: the map display of the trajectory of an individual.

CONCLUSION: INTERFACE IS INTERFACE IS INTERFACE

A transportation survey has always been an informational interface between the transportation users and the transportation planners. With telephone surveys, few things have changed over the last 30 years: not many changes in people's knowledge of the transport network; no drastic change in the telephone technology used for household surveys; and no change in the types of questions asked. Over the last 15 years, the real changes came from the models, a kind of anticipated synthetic knowledge, which served as the main framework to develop and structure information. Now, with the availability of microcomputing power, information about origin and destination locations can be geocoded during telephone interviews. The survey information system software can also conduct, during interviews, the following tasks: validation of transportation network usage (roads, routes and schedules), validation of space-time and purpose events (probable accessibility, trip chain sequence, mode speeds, trip generator functions), and simulation and graphical representation of all coherent integrated information.

For the Montreal case, the survey technique had developed gradually, over the years, and had been dependent on available information technology. However, some essential issues were determinant. In summary, it could be retained that the method is

- Conceptually based on the totally disaggregate approach, which is a method focused on individual trip processing.

- Conceptually focused on transportation network analysis, as derived from trip assignment procedures.
- Conceptually based on spatial disaggregation (geocoding at the x-y coordinate level), for a precise accessibility assessment. It is based on an essential GIS-T (geographic information system for transportation) composed of streets, monuments, and generators, and combined with related transportation.
- Fundamentally multiusage. Transportation planners (land-use and network management), transportation socioeconomists (demographic trends, urban taxation), marketing analysts, travel information system agents and operations managers benefit from sharing and maintaining quality referential databases.

Several authors should be worth mentioning for going into similar directions. Slavin [25] demonstrates the importance of object-oriented concepts for travel demand forecasting, while Lau and Kam [26] are using efficient geocoding on microcomputer for linking different databases together through their spatial attributes.
In the future, with the development of more refined concepts such as "transportation object-oriented modeling as an extension of the totally disaggregate approach", it will become easier to recommend continual telephone interview surveys as a means to address new simultaneous information challenges: interactive multimodal transportation planning, travel information system on the Web, integration of new data collection tools, integration of exceptional situations, etc.

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Object-Oriented Modeling and GIS-T

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