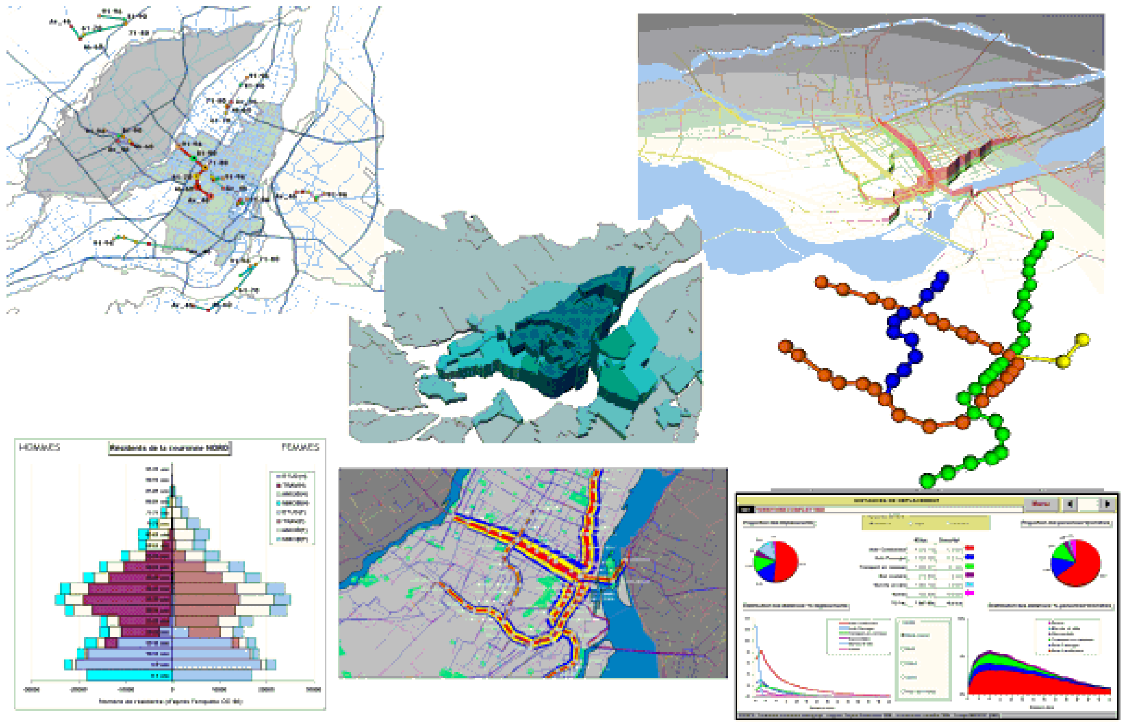

# Visualisation of the Urban Transportation Reality: Some Key Views

**Robert Chapleau, Ecole Polytechnique, Montreal**

Conference paper
Session: Visualising, mapping, charting and utilising travel behaviour data

**Moving through nets:**
**The physical and social dimensions of travel**
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## Abstract

"*An image is worth 1000 words*"… "*Not always… visualisation is necessarily a hybrid of images and words*", says J.C. Dürsteler (2000). Even at the cost of heavier files, it is also agreed that images are more effective to show structural relations, location information and for providing detail and appearance. As such, synthetic images should be preponderant and relevant in representing urban transportation reality.

Since many years, spatio-temporal demand/supply phenomena have been represented by several drawings and maps. The more traditional representations (desire lines, spider-web network, bus route load profile) were already recommended in the era 1958-1964 (Public Administration Service), and in Potts and Oliver (1972). Now, GIS (Longley and al., 2001; Chrisman, 2002) takes all the place.

Besides, as cited by Dueker and al., "*in integrating the three technologies – the GUI (graphical user interface), the DBMS (database management system), and the spatial modeling tools – GIS becomes a powerful spatial information system capable of digital mapping, managing, analyzing and presenting spatial information and associated attributes*". Correspondingly, the present report goes further, and focuses on a selected sample of images that are elaborated within the context of several transportation analyses conducted in the Greater Montreal Area in the recent years. Because of the information technology environment supporting the Totally Disaggregate Approach (Chapleau, 1992), extensive databases from large-scale Origin and Destination surveys have been processed to respond to numerous questions and audiences. Concurrently, census data, travel demand, GIS, road and transit networks databases have to be processed in a very consistent fashion. For that reason, graphic interfaces are commonly utilised to check and validate complex analytical environment.

Thus, the paper shows several concepts and examples from three classes of urban transportation analysis by visualisation: static spatial data to express variable level of a typical aggregate character, network analysis data when looking at equity and performance issues, and interactive rendering of huge data sets for sharing with specialized and selected audiences.

Keywords

Visualisation, urban transportation, travel survey, virtual reality, International Conference on Travel Behaviour Research, IATBR

Preferred citation

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# 1. Introduction, perspective, context

In the recent book « On Equilibrium » (by John Ralston SAUL, Éd. Penguin, 2001), the author introduces its own perspective by an evocative object-concept, the "door-handle", in this way:

« *Most mornings we turn a door-handle and walk out into a larger world. At first there is an interim stage of sidewalks or suburban highways, country roads or semi-abandoned stretches of urban tarmac. Sometimes we are walking, sometimes in cars, subways, buses, sometimes on bicycles, sometimes in boats.*

*We move across our world, at least across a tiny section of it. This is the society of which we are part.*

*…All of this is the minutiae of our lives. What does this reality imply? That we leave homes each day for an incalculable numbers of reasons…. Turning that door-handle can be a moment of adventure or joy. Of anticipation. Of purpose. Of a reminder of failure. Of emptiness. Of angry frustration. Of terrible anxiety. We may feel as if we are floating through a void, from home to a port of destination…….*»

For an urban transportation analyst, turning a door-handle is the same as working with interfaces to get a better understanding for both substantial and methodological challenges he is facing.

Multiples influences are to be taken in account when considering visualisation in the context of transportation systems analysis. There is no tradition, and no background theory around the way to make use of images in the context of issues clarification or project evaluation. We are all immersed in a computer-oriented era, and we may consider that most of the conviction for decision is developed in a symbolic way.

A little note of philosophy: amongst the several "paradigms" around the question of visualisation, one may enumerate these seemingly unparallel tracks: persistence of vision (phenomenon at the base of animation), anamorphism (drawing deformation according to the point of view), world of illusion (as demonstrated by Escher's famous drawings when 3D situations are rendered in 2D), the metaphoric power of holograms, impressionism (paints by Seurat), McLuhan's "The Medium is the Message" (respective power of hot and cold media), semiotics and memetics.

Just like Robert Moog was saying "*voltage is voltage is voltage*" about music synthesizer, our perspective about tools for transportation planning is based on the following aphorisms: "modelling is modelling is modelling"; "information is information is information"; "modelling is some kind of information and information of something"; "information is modelling".

Consequently, in our perspective, the role of visualisation will be to develop "information for modelling".

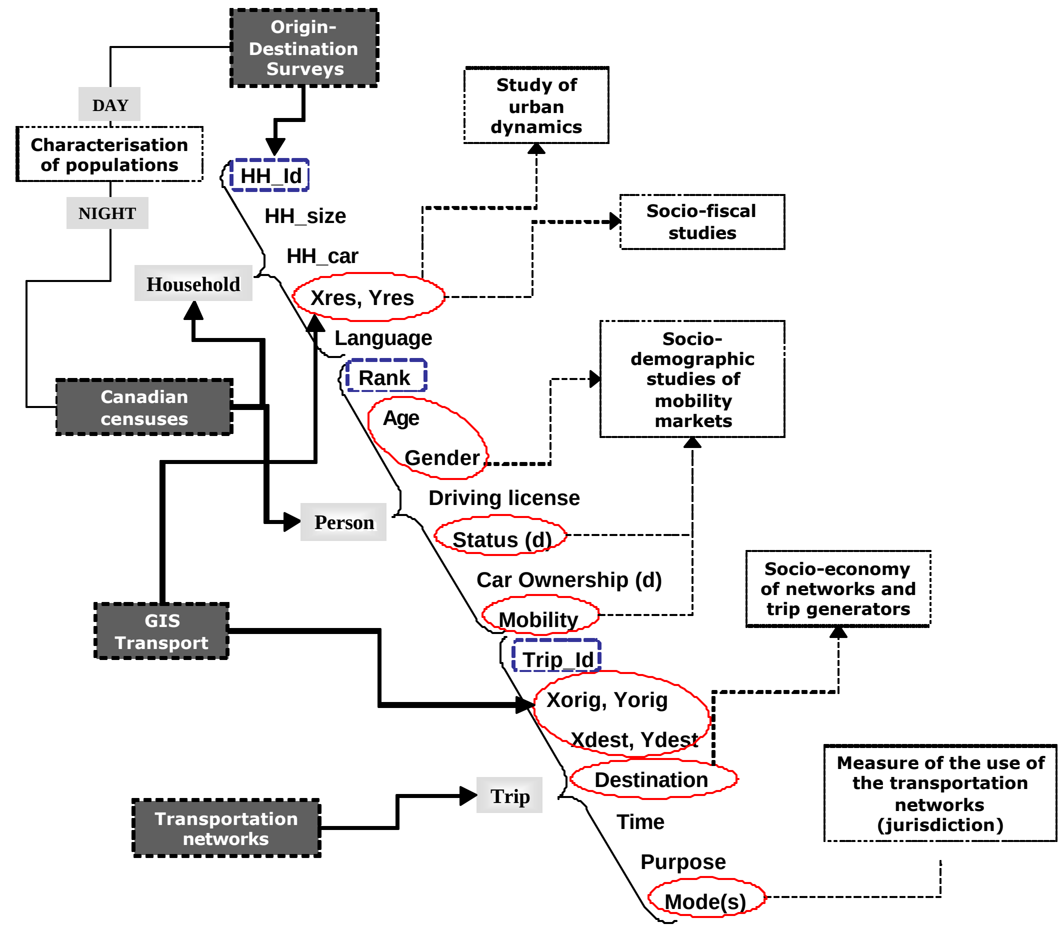
The paper is organized as follows. Firstly, it addresses the context of the so-called totally disaggregate approach when the analysis can be fundamentally based on INFORMATION. The second part illustrates typical representations associated with spatial data about measures of relative transit usage, car ownership, income, trip rates of a pre-defined (often geopolitically oriented) zoning system. The third part looks at the visualisation of several transportation network perspectives. The last section shows an example of an interactive tool for integration and dissemination of travel survey data within a specific technical environment. With some inspiration from the theme "Pictures at an exhibition" from Mussorgsky, focus is on images.

## 2. The intentions of the totally disaggregate approach

The totally disaggregate approach has been defined in previous studies by Chapleau (1992) and essentially constitutes a methodological effort to address transport analysis in a comprehensive (coherent, integrated, interactive) way. It is based on an object-oriented decomposition of the transport system, and every component has its own information system; so, the processing is always done at the higher level of resolution (disaggregate = micro-simulation), the geo-referenced data are GIS-based and can be aggregated at any level of analysis, the different sources of data are merged by the best available geo-references or by any suitable synthetic model, and moreover, any relevant analysis object can be looked at according to its own perspective (household, person, groups: age cohorts, gender, municipal sectors, transit route, bridges, subway stations, transport modes, geo-political jurisdictions, vehicles, by time periods, etc…).

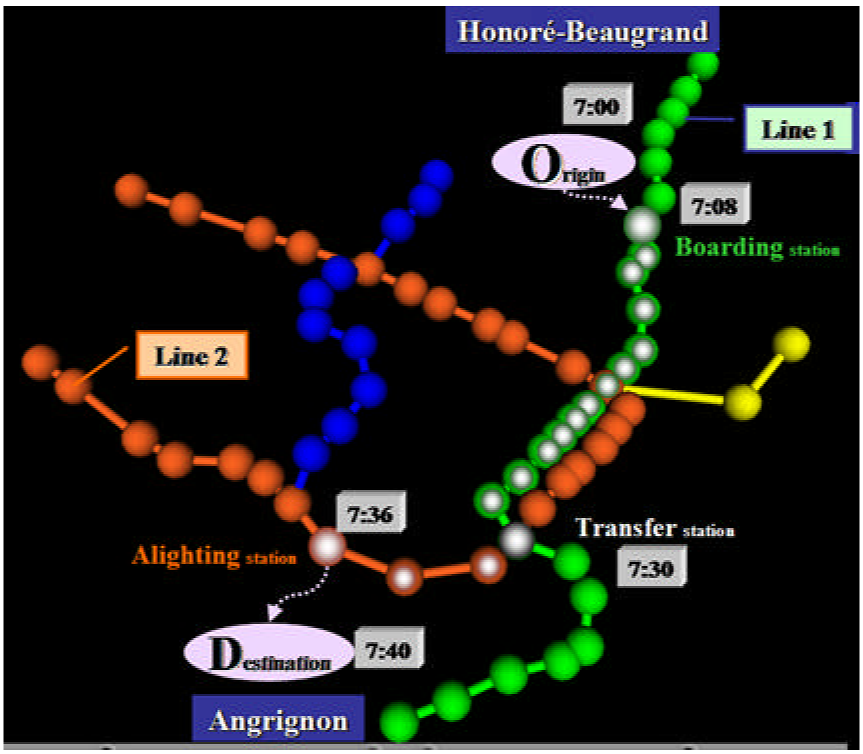
Typically, as it is practiced in the Greater Montreal Area context, we find an information environment of the urban transportation analysis system where the driving core is composed of the detailed data provided by the regularly-conducted travel Origin-Destination telephone-interviewed household survey, at a 5%-sampled rate. The Figure 1 explains how other data sources are merged and involved in the process to enrich the analysis capabilities. Population and socio-economic data are acting as weights, and are derived from Canadian censuses conducted at respectively 100% and 20%-sampling rates. Enumeration areas of 300 households are the most precise data. The GIS-T data assembly disposes of geo-referenced database on street addresses, intersections, postal codes (blockface centroids), landmarks, and trip generators. Transportation networks are described at the bus stops level, and comprehend all modes and services, and even bridges.

Figure 1 Articulation of the integration of several information system components for the Totally Disaggregate Approach analysis system: 3 additional databases supporting the geo-referenced travel database; day-and-night activity pattern description; household/person/trip linkages; several types of analyses developed accordingly within the framework.




For instance, within the TDA (totally disaggregate approach), Figure 2 shows how a typical O-D trip may be represented in VRML (Virtual Reality Modelling Language) when, for example, the Montreal subway network is involved. With that sort of processing, travel demand can be analysed according to, say, residential zone (coupled with Census data), origin or/and destination sectors in terms of trip movements (O-D matrix), specific trip attractors, movements at any subway station, load profile of subway lines or bus routes, for the time distribution of arrivals at nodes, cost and revenue allocation of transit services according to the passenger-kilometres consumed on any part of transport modes, and so on. The numbers involved in the large scale household surveys (400,000 records for an average weekday) are, most of the time, sufficient to obtain significant and relevant results on those questions. More information on the technical aspects of this type of survey is found in Chapleau and al. (1997, 2001, 2003).

Figure 2 Example of trip and network elements considered in the processing of travel data: case of a single itinerary over the Montreal subway, in VRML.



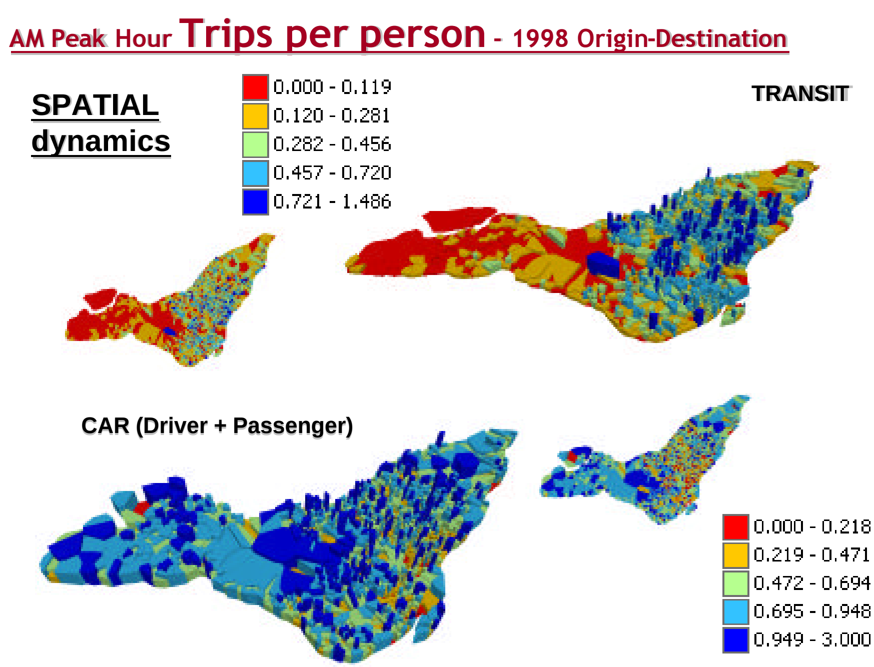

## 3. Static spatial data representation

Most of the time, in transportation systems analysis, data are gathered according to a predefined zoning system. It is utilised to demonstrate some general relationships. With a very disaggregated approach, any spatial segmentation may be used to express some measurement of the mobility. As shown in Figure 3, the number of motorized trips per person is calculated for very small areas, for instance, Thiessen polygons derived from census enumeration areas centroids. Evidently, it confirms the fact that mobility measures at a high level of resolution are not suitable for synthetic or aggregate modelling. In many contexts, aggregation by large zones is more adapted to phenomena where geo-political boundaries are relevant in context. The Figure 4, by the means of a choropleth 3D graphic, shows the relative usage of transit by 65 municipal sectors in the greater Montreal Area: values go from a basic 2% to a maximum of 47% of the origin trips. Color is associated to a data class (range of 2 to 9%) while the height of the variable is proportional to the specific value of the zone.

Same sort of dataset are presented in the Figure 5 where, over the same Montreal Area background, zone fields (average household size increasing with the distance from CBD, and transit share declining with the distance from CBD) are mapped on surfaces with contour lines. A mix of GIS techniques from scattered data is producing some kind of DEM (Digital Elevation Modelling) drawing – from scattered data to a grid to surface generation characterised by contour lines and colors-.

When more general multi-dimensional patterns are to be demonstrated, an interesting 2D-technique proposed by statistical analysis packages is to be applied. In Figure 6 and Figure 7, the Chernoff faces are used for representing simultaneously a set of 6 variables over a territory segmented in 8 regions: population density, household size, transit share, car ownership, average age, trip rate.

Figure 3 Mode trip rates (person trips on transit and car) calculated on small zones (about 3000).




Source: Source: Morency, Chapleau (2002)

Figure 4 Classical example to represent modal split distribution over a study territory (choropleth 3D).

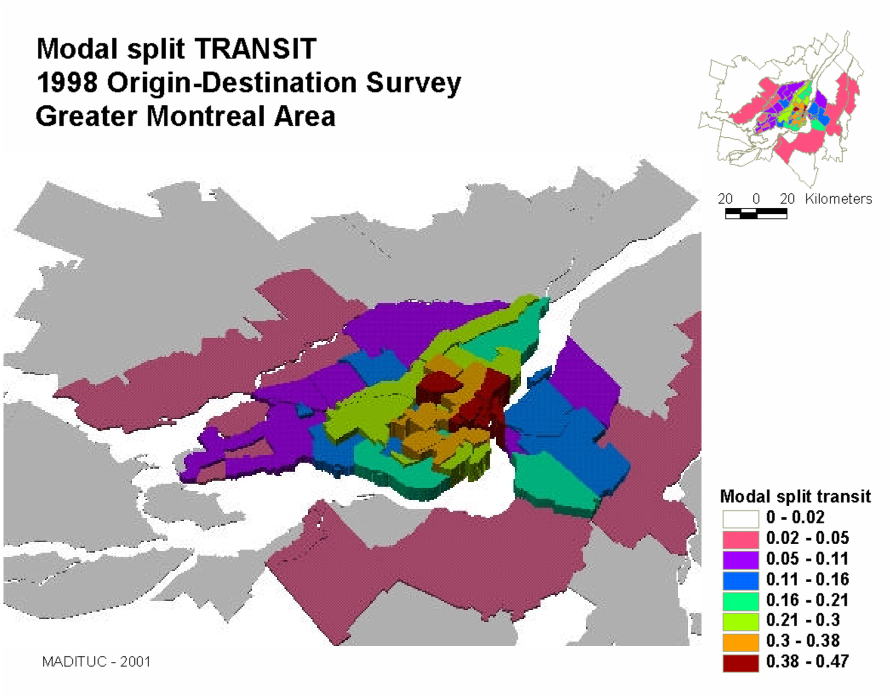



Figure 5 Global relations derived from variables specified at the zone level

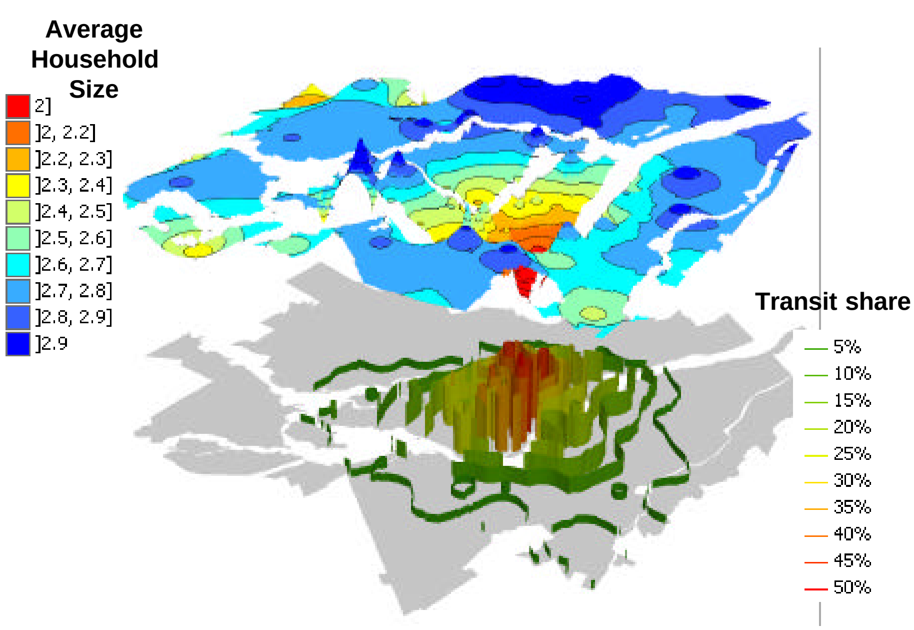


Figure 6 Chernoff faces legend for the analysis of 6 factors : population density, household size, transit share, car ownership, average age, trip rate

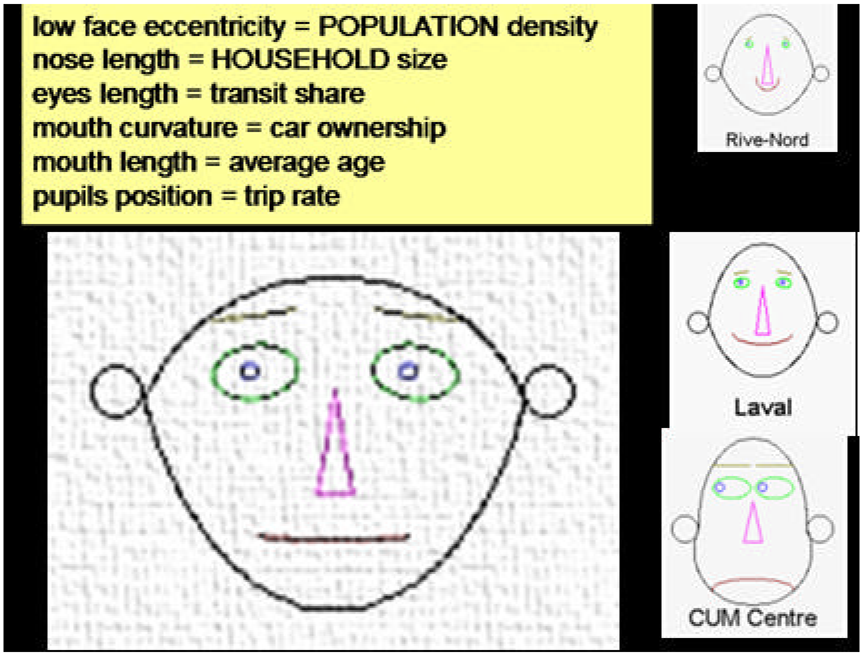
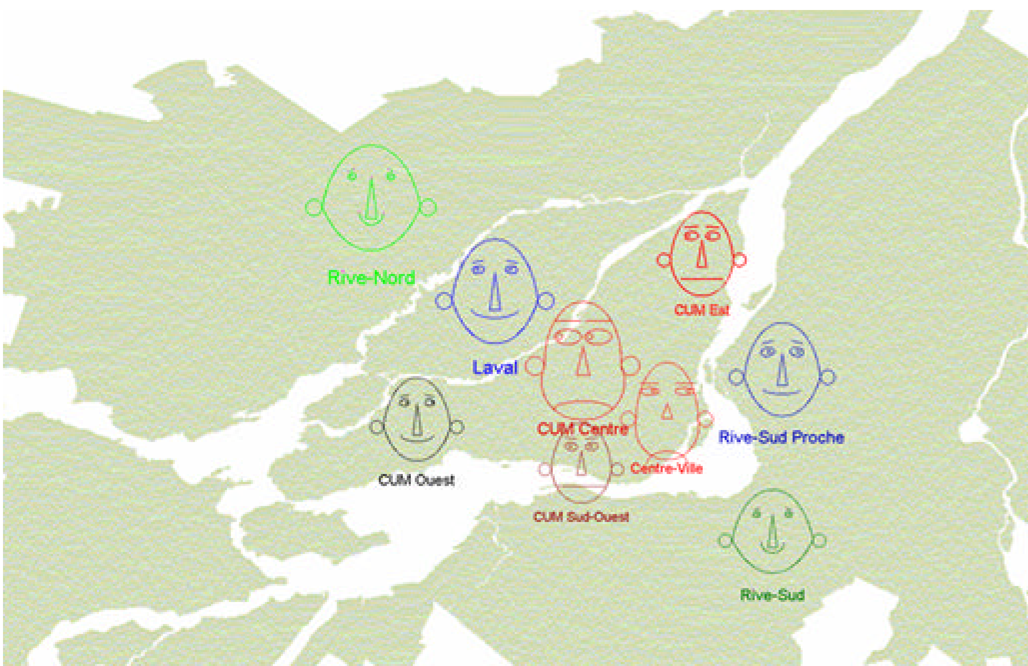



Figure 7 Greater Montreal Area at the 9-region scale; several trends are noticeable in relation with the distance from CBD: population density diminution, household size increase, transit share decline, car ownership increase, age decline and augmenting mobility



# 4. Network analysis visualisation

The disaggregate processing of a trip within a transit trip assignment procedure is conducted according to the elements described in Figure 8. The object-oriented approach is preponderant. The person trip contains geo-referenced origin and destination points, trip components modelled onto, depending on specific circumstances, walk/road/underground and transit networks.

In transportation system analysis and network planning situations, scene visualisation is essential to appreciate complex issues before the modelling step can be undertaken. The following figures (9 to 17) illustrate several questions where disaggregated information has to be illustrated about the network usage. The storyboarding and the rendering of every example are decisively directed to a typical and specific perspective.

- 3D load (ridership on any segment) profile coloured by transit authority (Figure 9)
- 3D representation of an a.m.-peak transit trip assignment (Figure 10)
- load profile with colour distinction for weekday time period (Figure 11)
- subway line load profile for the analysis of breakdown impacts (Figure 12)
- subway usage analysis (origin zones identified by colours) (Figure 13)
- commuter rail lines access modes analysis (colour and symbol) (Figure 14)
- 3D load profile by purpose (Figure 15)
- Accessibility of a transit network (bus stops) to households and cars (Figure 16)
- Bus occupancy analysis, over transit network links, and on surfaces (Figure 17)

Figure 8 Disaggregate processing of a single trip links to other transport objects

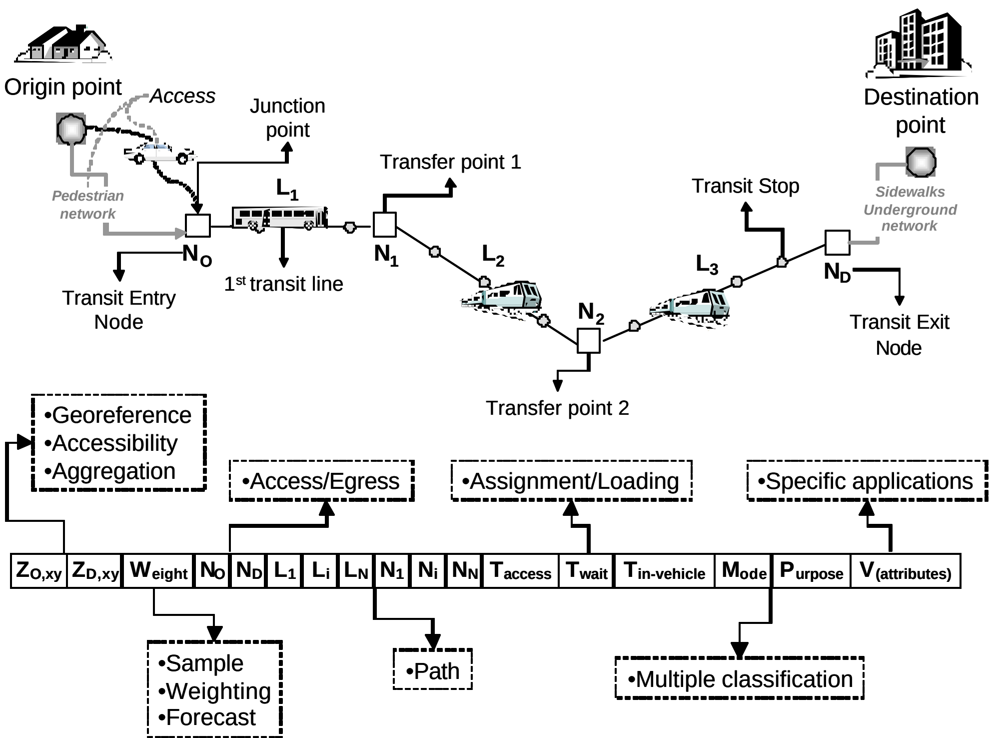



Figure 9 3D load profile for the A.M. peak period, coloured by transit mode-operator (train, subway, bus) and transit authority, transit trip data extracted from the Montreal 1998 O-D survey.

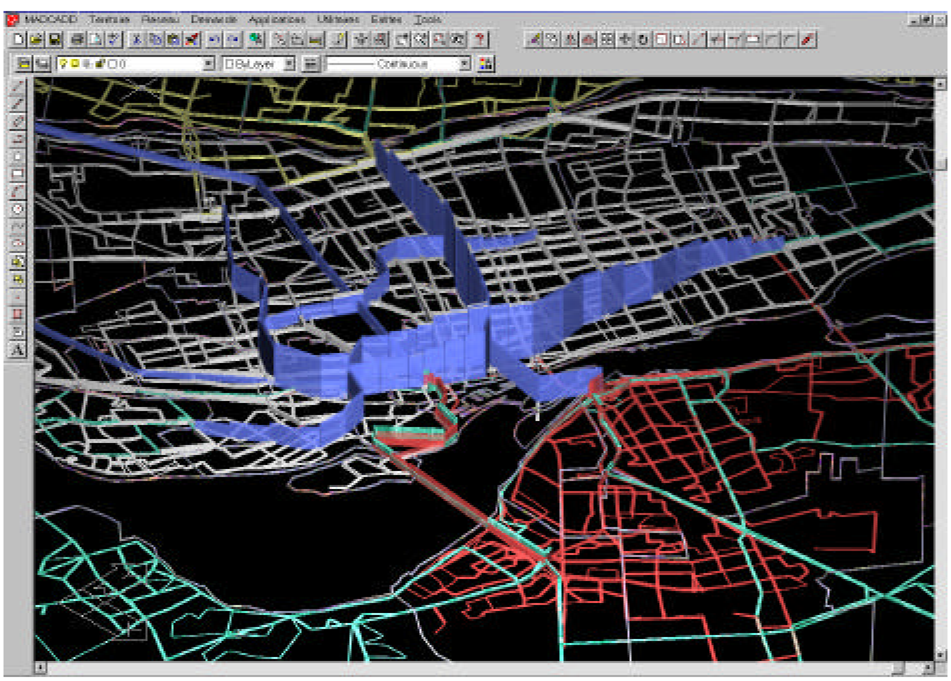


Figure 10 Extracts from a transit trip assignment result for the Montreal subway (entry, exit, load); a.m. peak period, 1993 survey data.

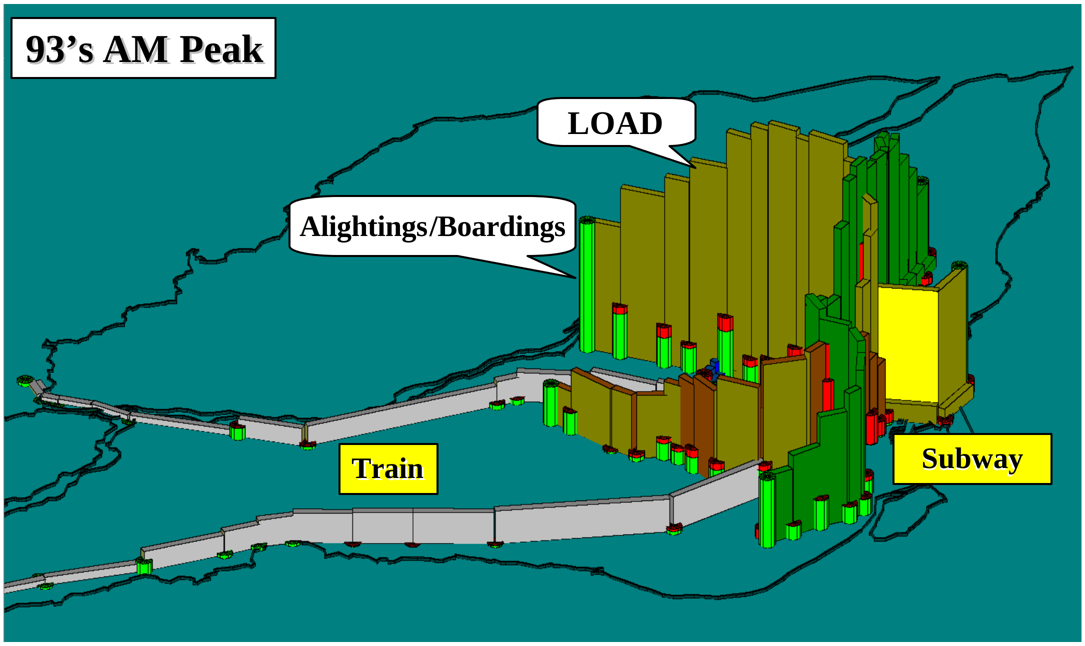



Figure 11 24-hour weekday load profile of the Montreal subway; temporal distribution by colour (red: a.m. peak, blue: p.m. peak, yellow: other time periods)

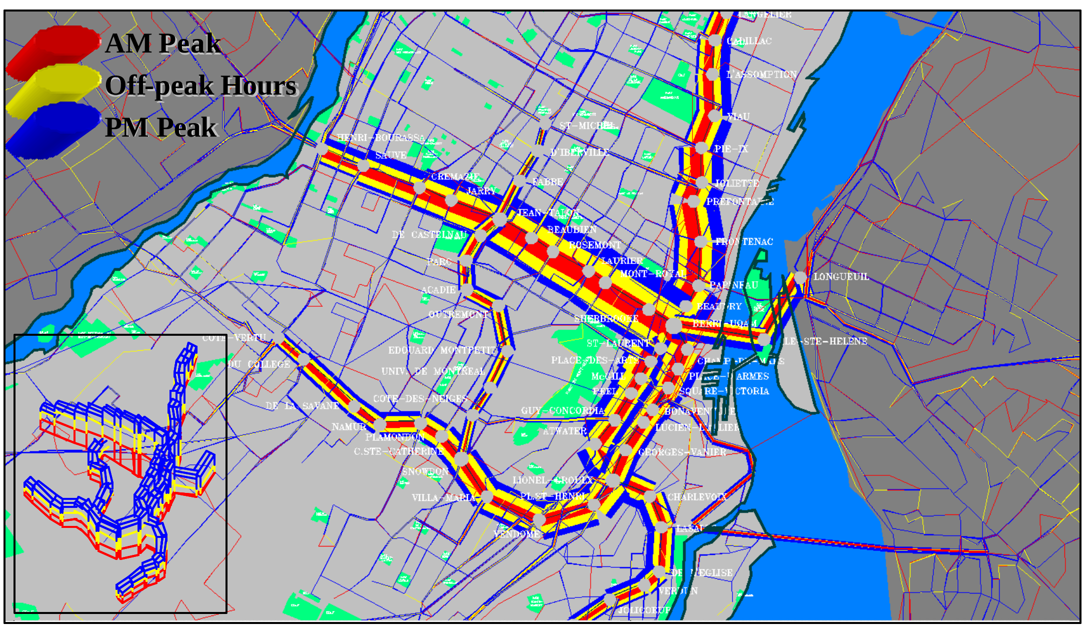


Figure 12 Temporal data synthesis to study subway line security: number of riders by direction in boarding and alighting phases, with the time profile (by half hour) of the number of passengers involved w ithin the subway system.

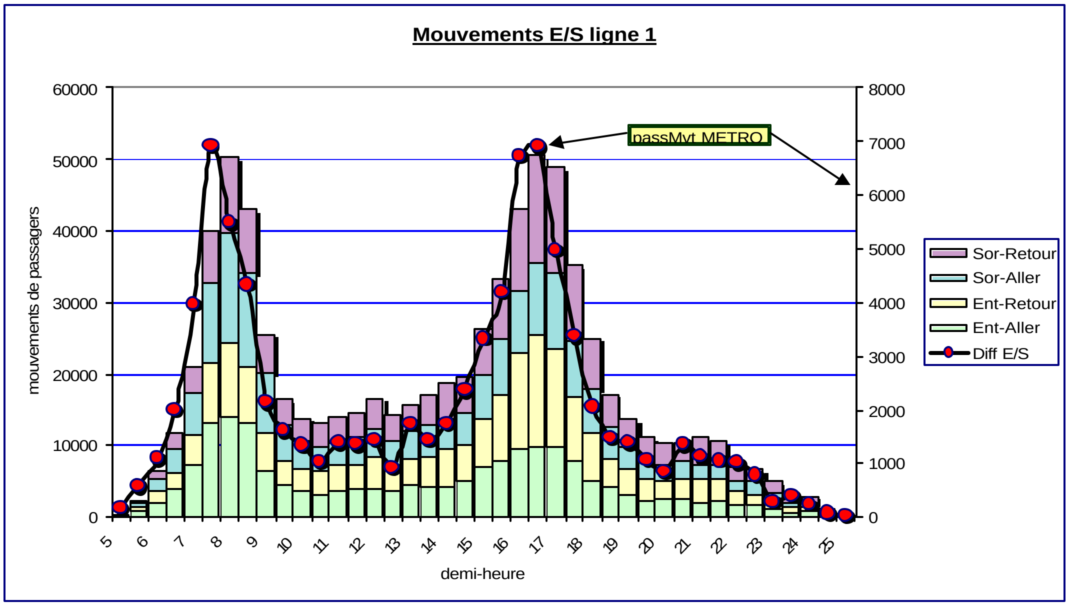



Figure 13 Load profile from the trip assignment procedure about the travellers originating from the different Laval sectors (non-residential riders), in a context of fiscal analysis (cost and revenue allocation between transit operators).

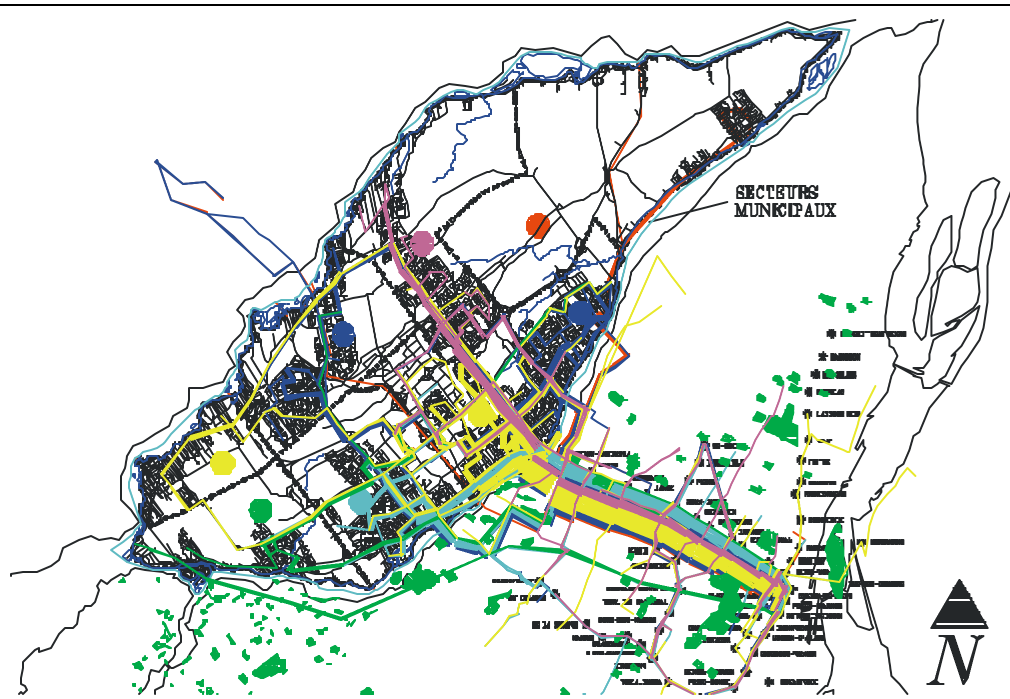


Figure 14 Study of the access and egress modes to the commuter rail lines, in Montreal (a.m. peak, 1987 travel survey data); color - train line, symbol character - access - modes.

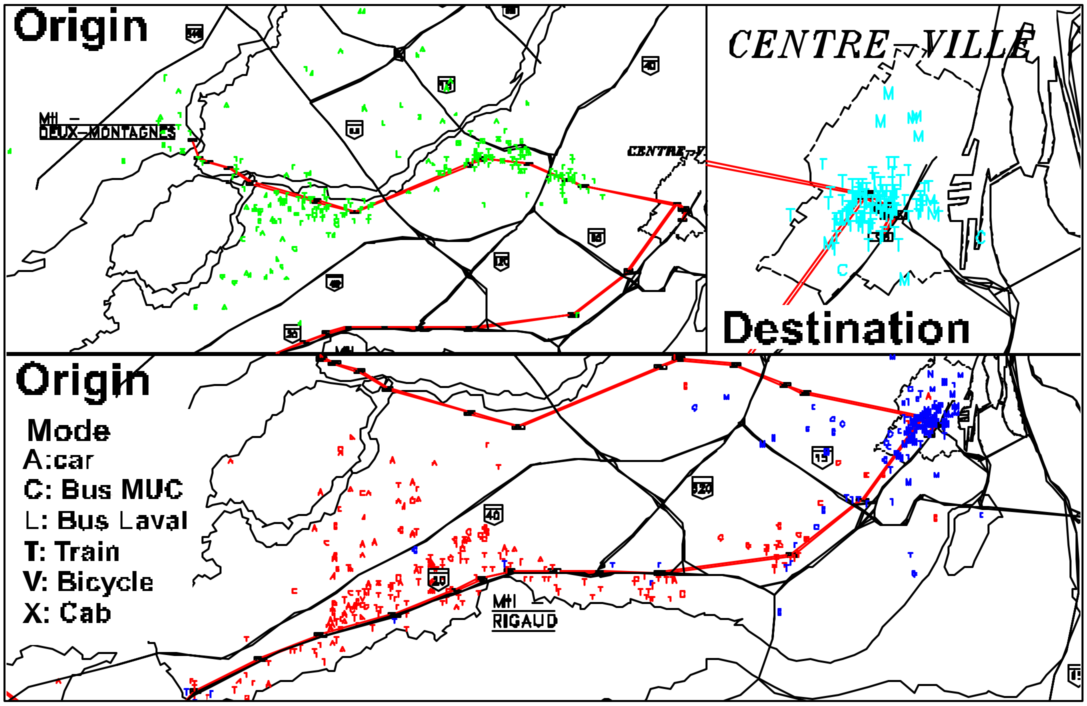
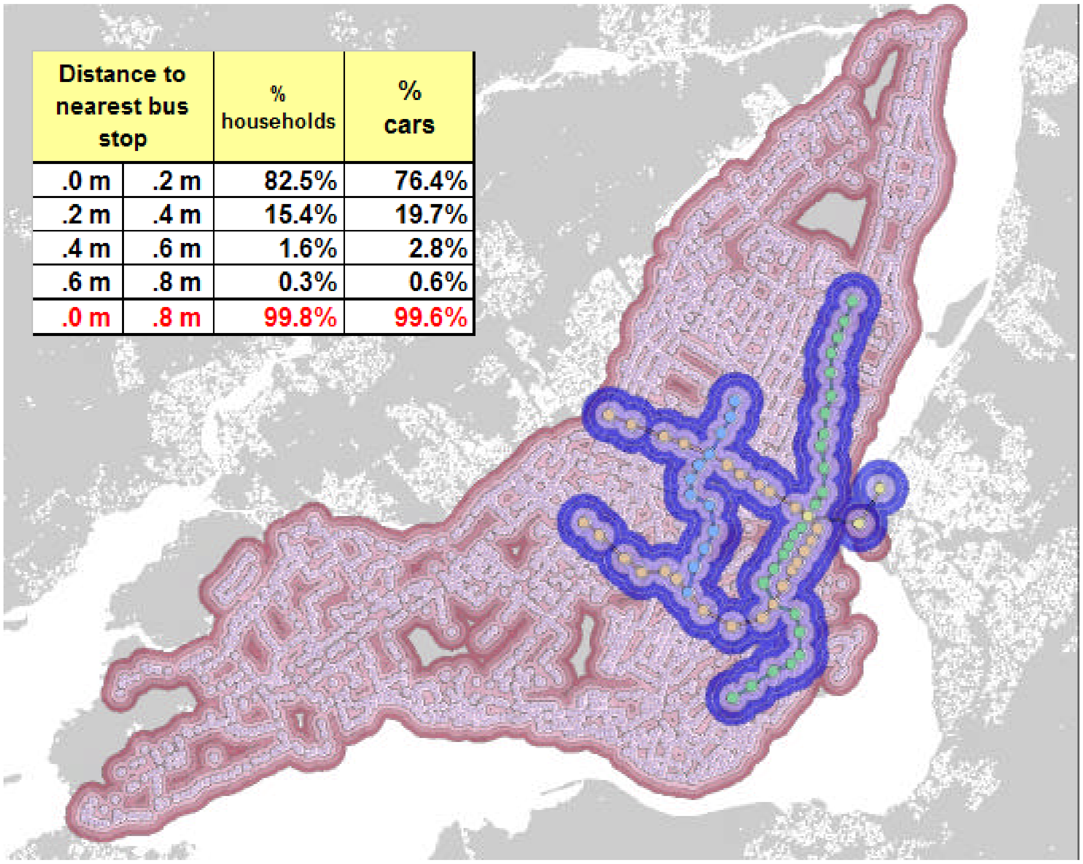


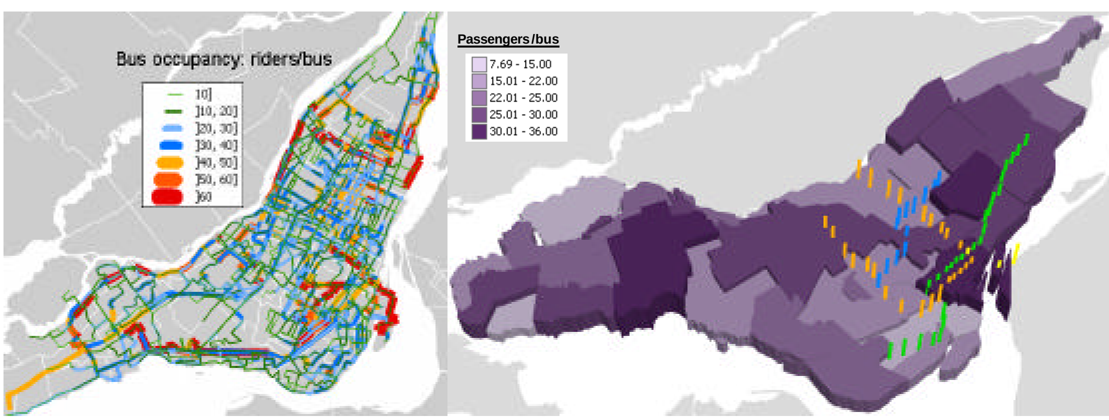

Figure 15 3D subway load profile by trip purpose (red=work, green=study, etc…).

Figure 16 Transit network accessibility for households and cars (Montreal Transit Authority, 1998 O-D travel survey data).



| Distance to nearest bus stop | | % households | % cars |
|---|---|---|---|
| .0 m | .2 m | 82.5% | 76.4% |
| .2 m | .4 m | 15.4% | 19.7% |
| .4 m | .6 m | 1.6% | 2.8% |
| .6 m | .8 m | 0.3% | 0.6% |
| .0 m | .8 m | 99.8% | 99.6% |

Figure 17 Bus occupancy by network link, and measures aggregated over municipal sectors.



# 5. Interactive Origin-Destination survey data sharing

More and more, it is needed to disseminate the household travel survey reports to larger and more analytically sophisticated audience. Paper and table-organised reports, even produced on CD, are becoming insufficient to answer complex and relevant questions. Providing the original trip files and metada ta (GIS database, transit and other modes networks, aggregation dictionaries) to non-technical personnel may constitutes a substantial burden. The solution developed in the Montreal area has consisted to design an interactive data visualisation instrument which can integrate the best available data already processed within the totally disaggregate context. In summary, a chosen set of attributes are mixed from census database, trip assignment procedures (transit and road networks), and GIS-oriented processing for trip attractors. Then, aggregated results are deducted for a 100 municipal sectors zone analysis. The local calculation power comes from a Microsoft Excel VisualBasicApplication.

The following figures illustrate some of the multiple perspectives and choices made to visualise the most interesting data:

- Figure 18: Introduction screen conducting to various analysis types;
- Figure 19: Screen for the presentation of a specific study area and sample characteristics
- Figure 20: Screen about households and dwelling units statistics
- Figure 21: Example of several selections to study household car ownership
- Figure 22: Screen about the demographics and mobility
- Figure 23, Figure 24: Relations between demographics and mobility
- Figure 25: Statistics on travelled distances for every mode
- Figure 26: Statistics on residence-activity links
- Figure 27: Statistics on most important trip generators
- Figure 28: 3D visualisation of most important trip generators

Figure 18 Presentation screen for the interactive analysis of Origin-Destination household travel data at the municipal sector scale (Greater Montreal Area travel Survey, 1998).

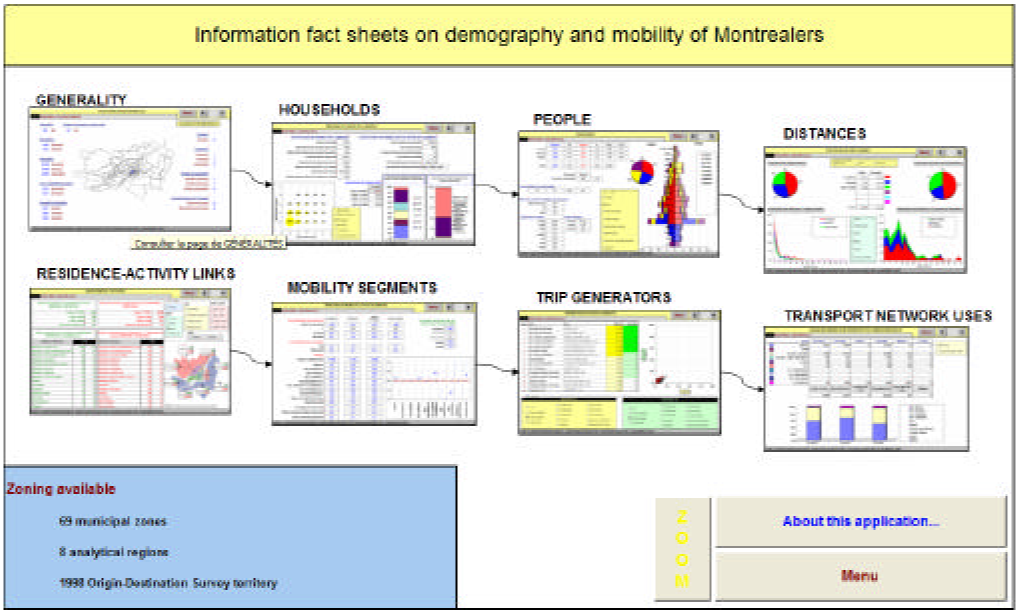



Figure 19 General statistics about a specific study area chosen: people, household, cars, average sample, and density.

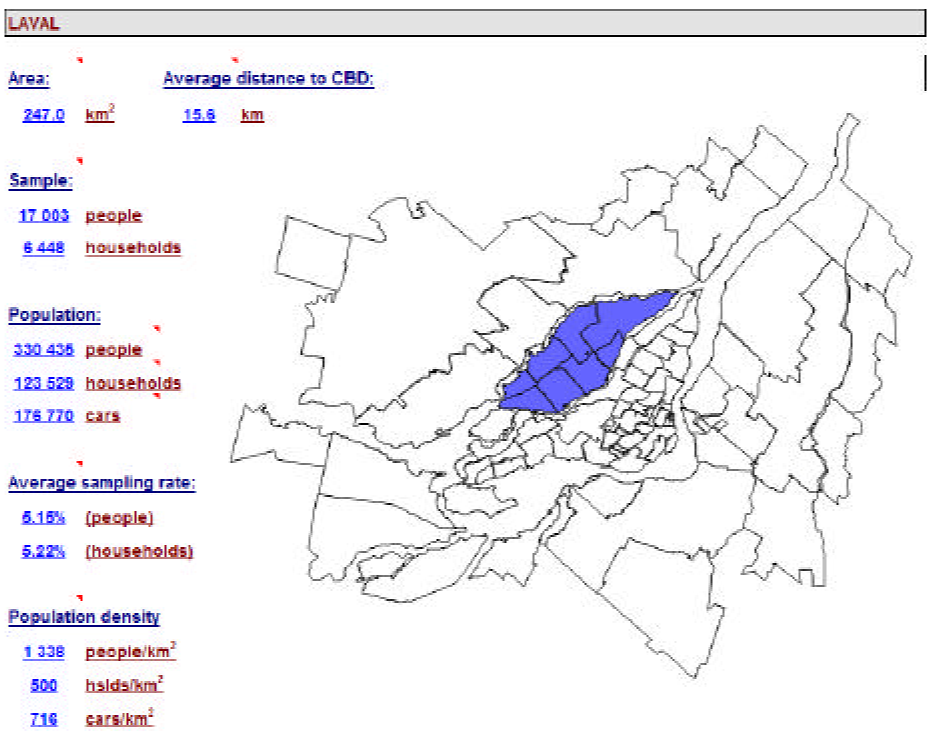


Figure 20 Statistics on households and dwelling units: car ownership and household size, household income, dwelling unit value, proportion of owned dwellings, dominant period of construction.

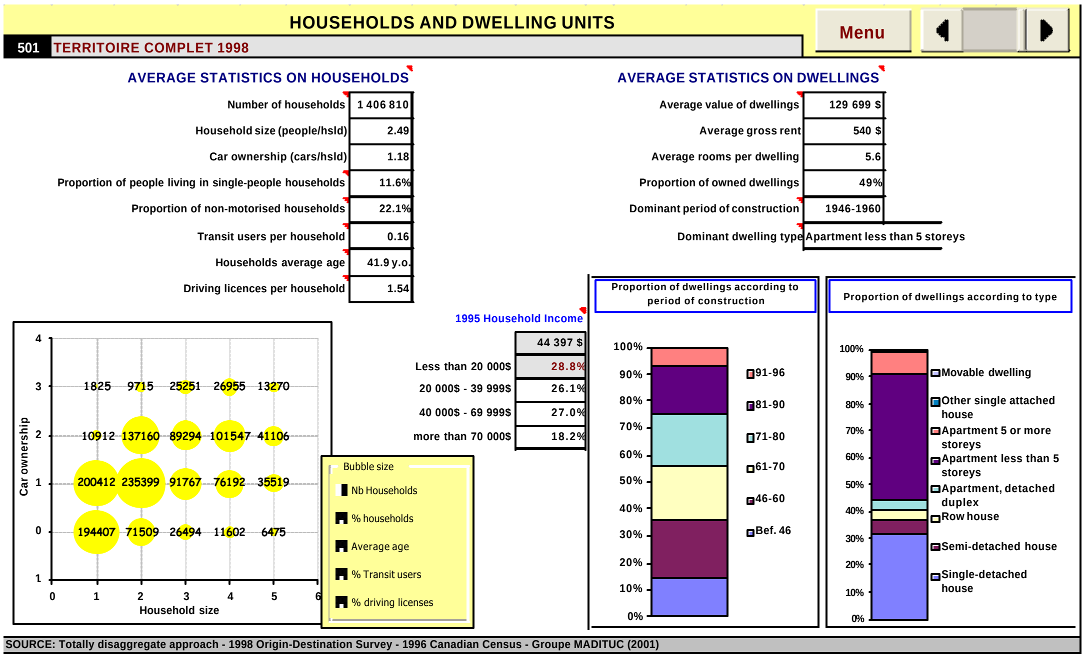



Figure 21 Analysis of car ownership and household size in relation with: % transit riders, number of households, % driving licenses, average age.

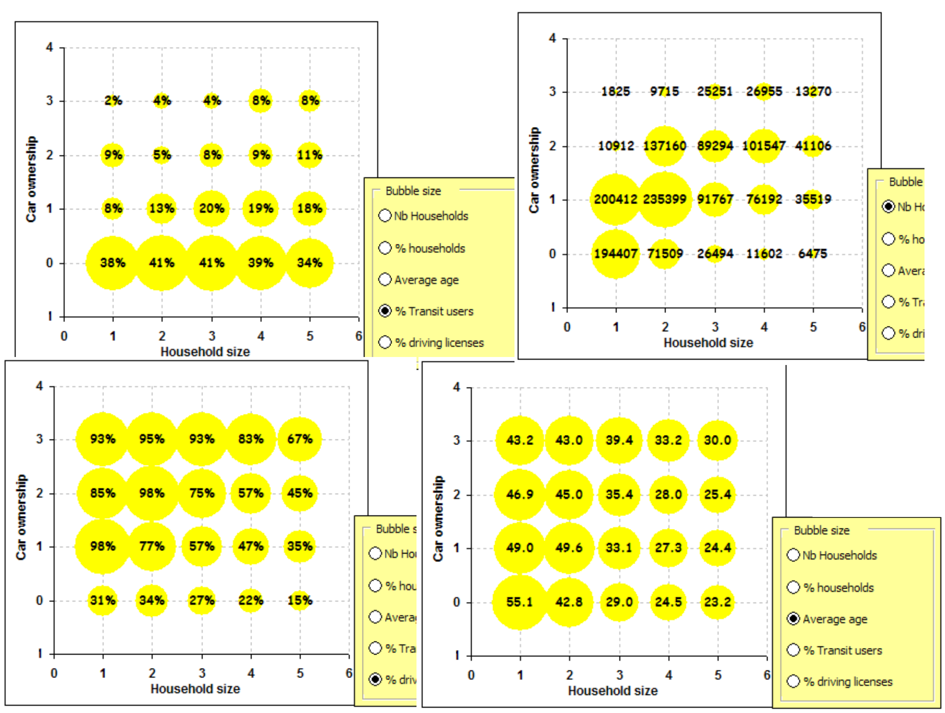


Figure 22 Demographics and mobility general screen: degree of schooling, home language, interview language, and household car ownership.

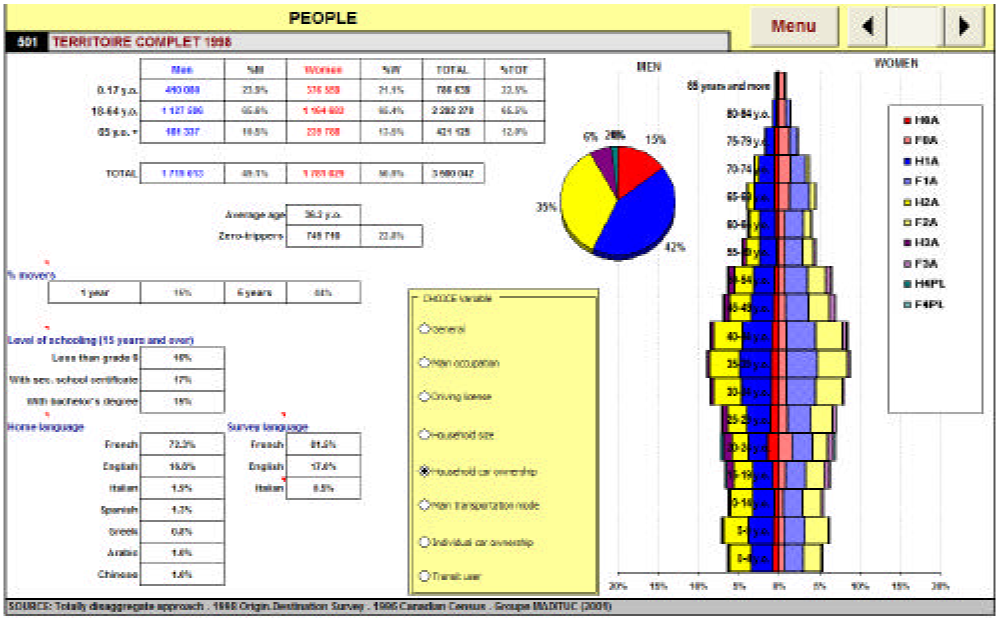


Figure 23 Demographics of workers/students/mobiles/zero-trippers; demographics of driver licenses; demographics of households.

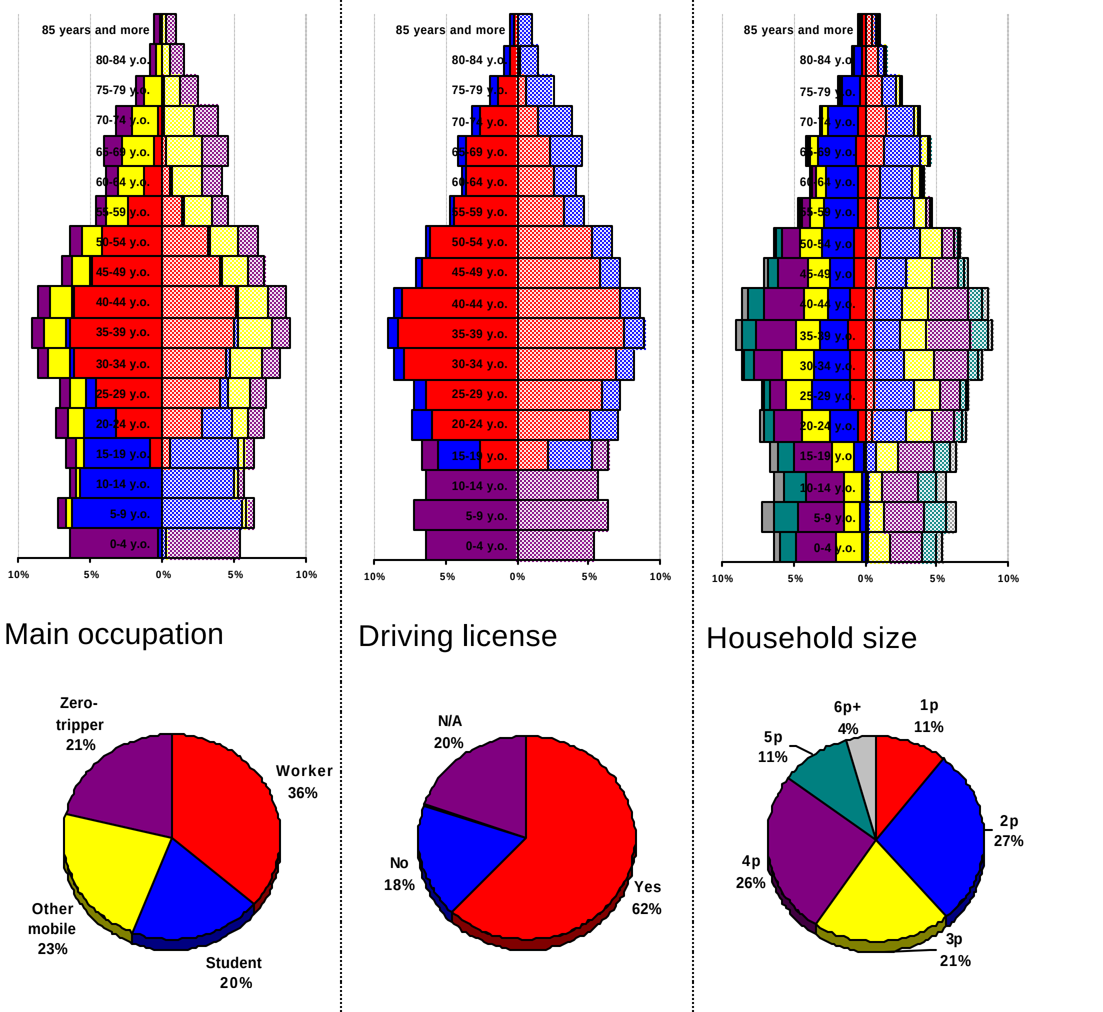


Figure 24 Demographics of car ownership; demographics of travel modes; demographics of transit.

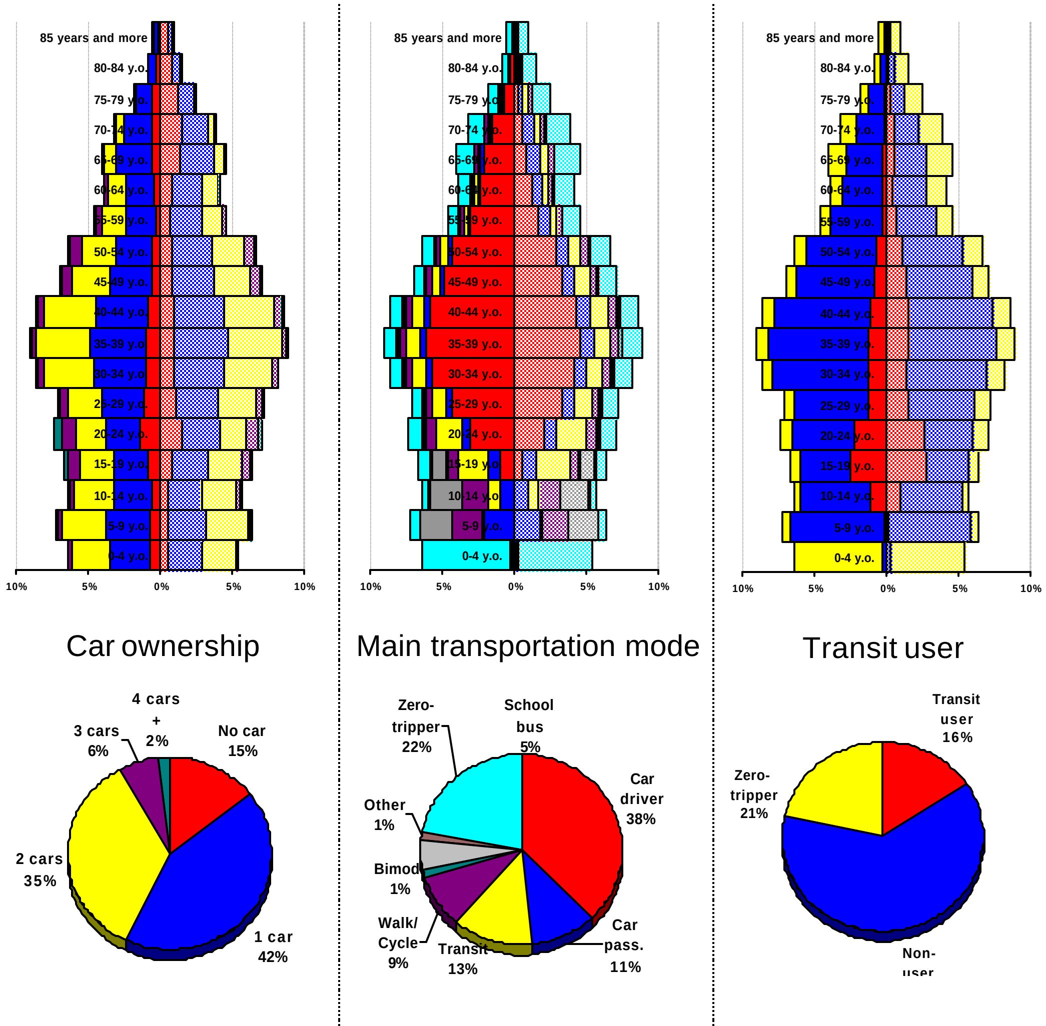


Figure 25 Statistics on travelled distances for every mode (disaggregate calculation on every transport network) for residents, or those who originate or have a destination.

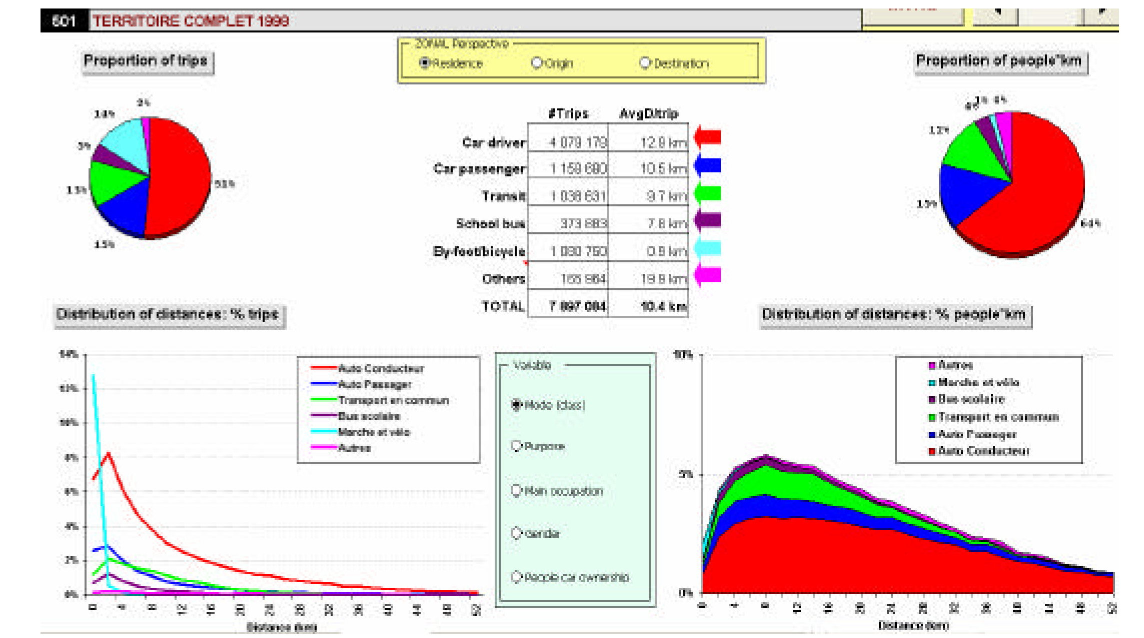



Figure 26 Statistics on residence-activity links with identification of main destinations.

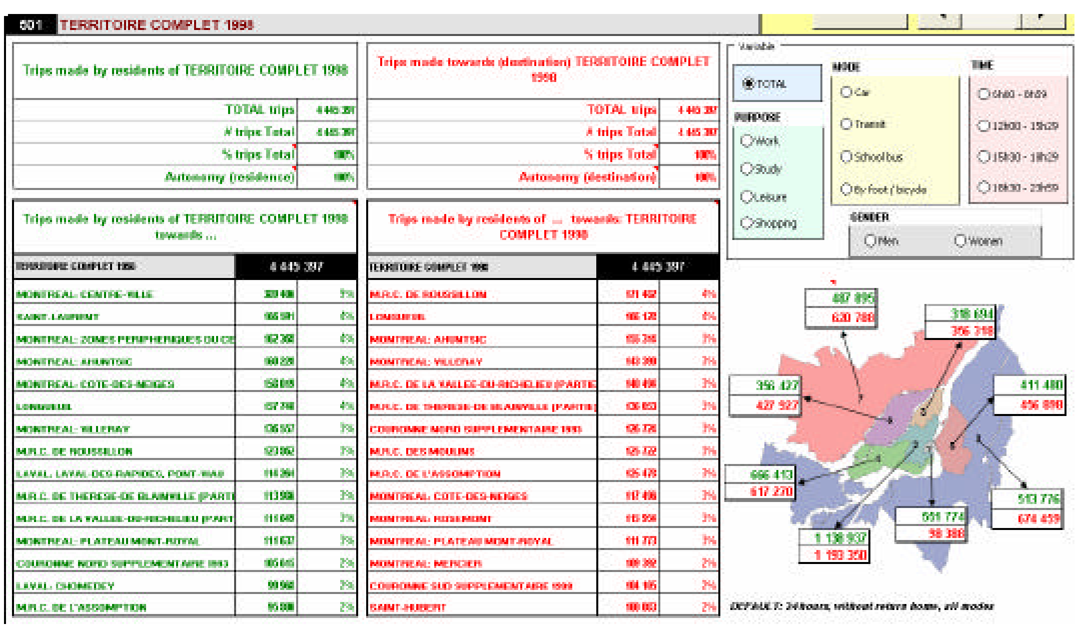
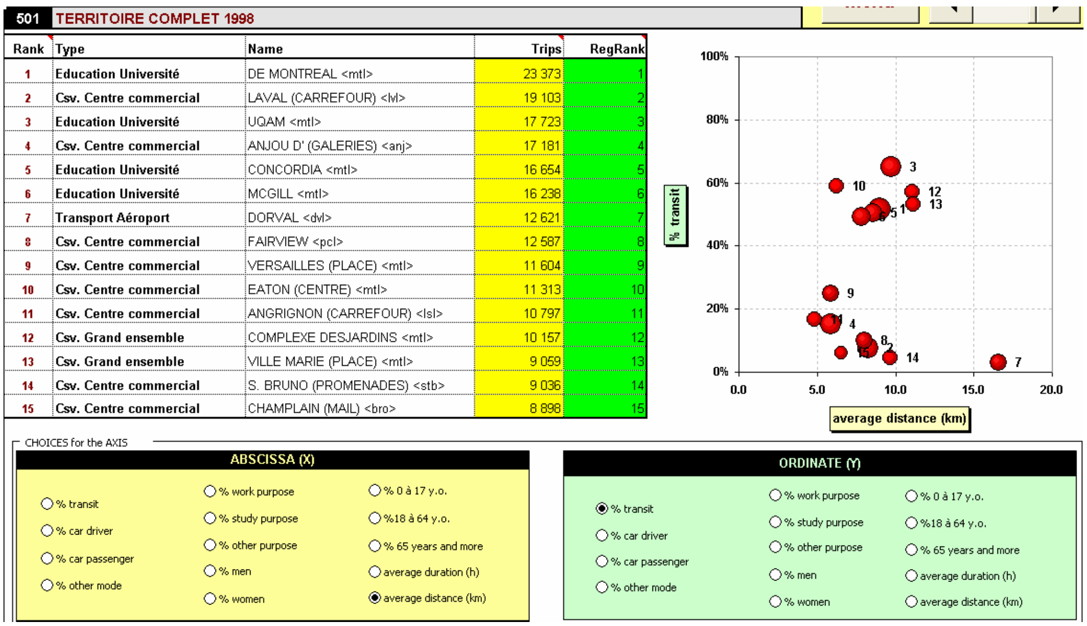


Figure 27 Statistics on most important trip generators coupled to a scattergram for the analysis of 14 variables related to the trip generators; here, relative transit usage vs travelled distance.



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| Rank | Type | Name | Trips | RegRank |
|---|---|---|---|---|
| 1 | Education Université | DE MONTREAL <mtl> | 23 373 | 1 |
| 2 | Csv. Centre commercial | LAVAL (CARREFOUR) <lvl> | 19 103 | 2 |
| 3 | Education Université | UQAM <mtl> | 17 723 | 3 |
| 4 | Csv. Centre commercial | ANJOU D' (GALERIES) <anj> | 17 181 | 4 |
| 5 | Education Université | CONCORDIA <mtl> | 16 654 | 5 |
| 6 | Education Université | MCGILL <mtl> | 16 238 | 6 |
| 7 | Transport Aéroport | DORVAL <dvl> | 12 621 | 7 |
| 8 | Csv. Centre commercial | FAIRVIEW <pcl> | 12 587 | 8 |
| 9 | Csv. Centre commercial | VERSAILLES (PLACE) <mtl> | 11 604 | 9 |
| 10 | Csv. Centre commercial | EATON (CENTRE) <mtl> | 11 313 | 10 |
| 11 | Csv. Centre commercial | ANGRIGNON (CARREFOUR) <lsl> | 10 797 | 11 |
| 12 | Csv. Grand ensemble | COMPLEXE DESJARDINS <mtl> | 10 157 | 12 |
| 13 | Csv. Grand ensemble | VILLE MARIE (PLACE) <mtl> | 9 059 | 13 |
| 14 | Csv. Centre commercial | S. BRUNO (PROMENADES) <stb> | 9 036 | 14 |
| 15 | Csv. Centre commercial | CHAMPLAIN (MAIL) <bro> | 8 898 | 15 |



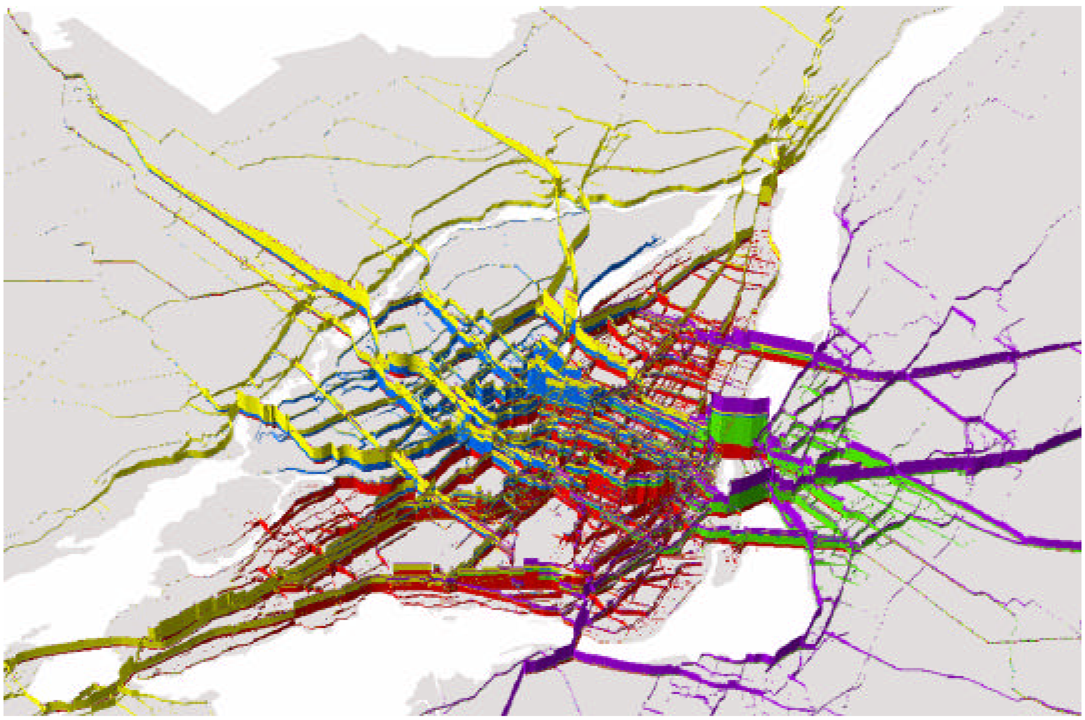
Figure 28 3D visualisation of most important trip generators.

## 6. Conclusion

The numerous aforementioned images are just the “tip of the iceberg” of the visualisation cases that have been recently developed. The actual era is mostly devoted to animation and virtual reality just to show more temporal and more complex analyses.

The Figure 29 shows an example of presentation of successive network loading for several origin zones. Then infrastructure usage is scrutinized for cost and revenue allocation.

Figure 29 3D visualisation car drivers’ network loading with distinct colour according to the residence zone (Greater Montreal Area 1998 travel survey).



The next two figures show the use of virtual reality in two contexts. Figure 30 shows the micro-detail of a subway station with its numerous connections to trip generators; incidentally, it could be used as a travel information system for orienting people going to these destinations.

Figure 31 shows new ways to present travel and trip data interactively, with the aid of Virtual Reality Modeling Language. Several interactions are then possible. It shows clearly how, in the future, there will be no boundary between travel, census and GIS databases, and much less boundary to the dissemination and accessibility of such transportation data.

Figure 30 Subway station McGill: VRML scene to orient the transit user to destinations.

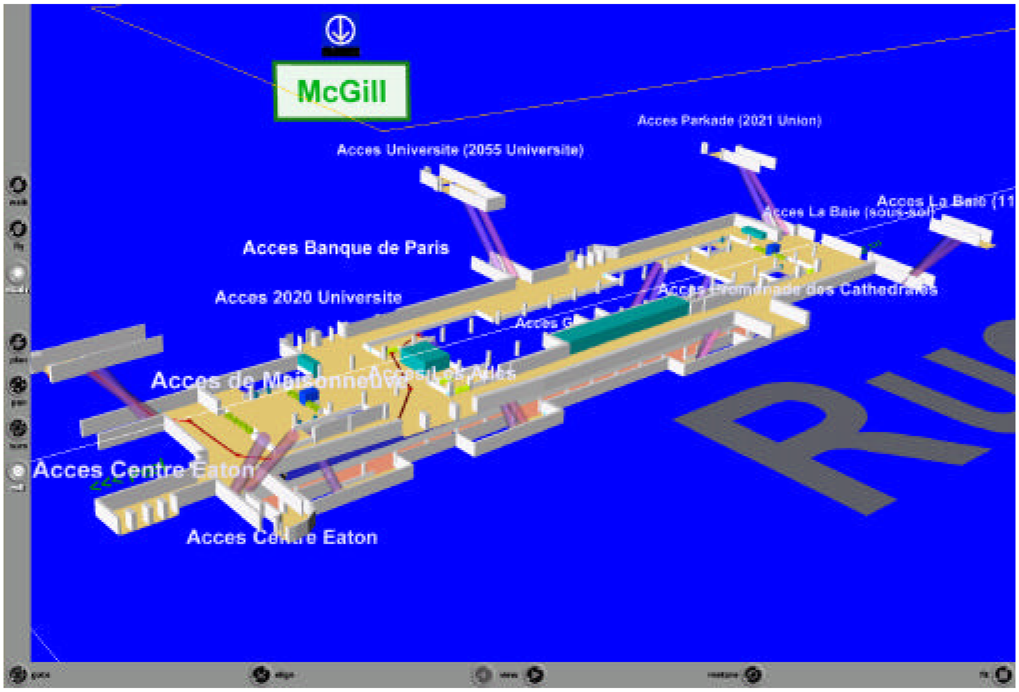
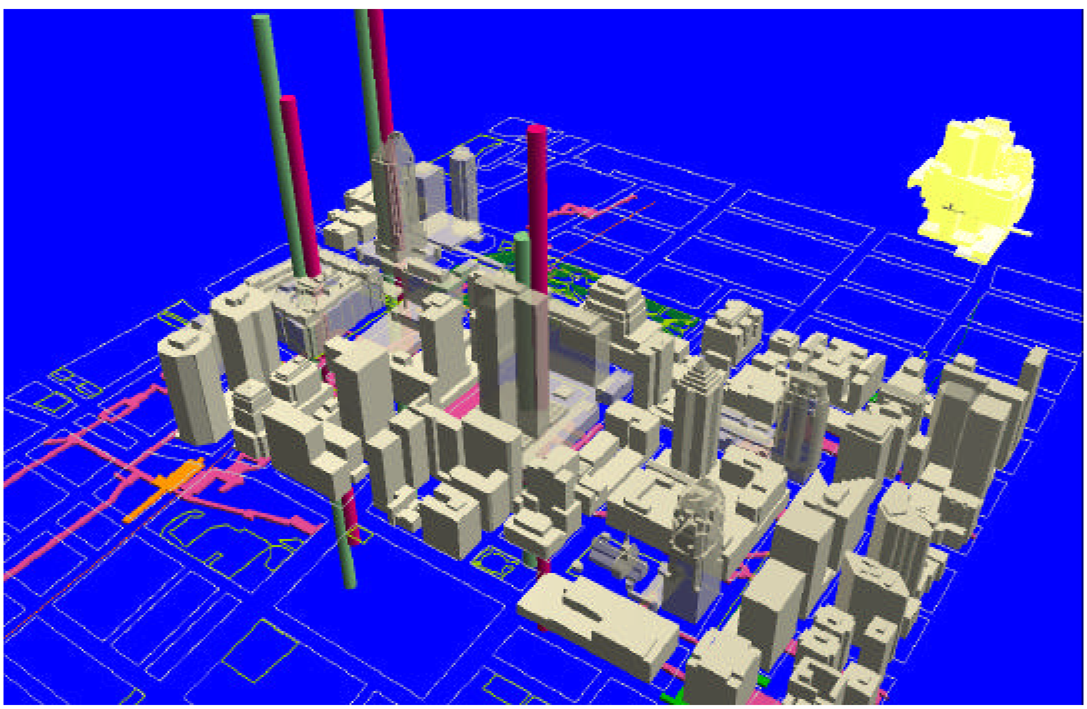



Figure 31 A virtual reality scene of the Montreal Central Business District –***courtesy of Chaos Technologies***-, where road, pedestrian and subway underground networks have been added, and where the trip generators can be interactively interrogated to obtain O-D survey data information.



As an evolving conclusion, one must consider this quote:

"*L'image est un acte et non une chose. L'image est conscience de quelque chose*."

Sartre, J.P. (l'Imagination -IMAGINATION: A PSYCHOLOGICAL CRITIQUE), 1936.

"*The image is an act, and not a thing. The image is conscience of something*".

## ACKNOWLEDGMENTS

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# APPENDIX A

Figure 32 and Figure 33 show a MS Excel visualisation of the household trips:

Figure 32 An Excel viewer for post-validating the disaggregate information of person trips of an interviewed household: 1) complete description of a specific trip; 2) temporal distribution of people in the dwelling; 3) time-use derived from trip purpose.

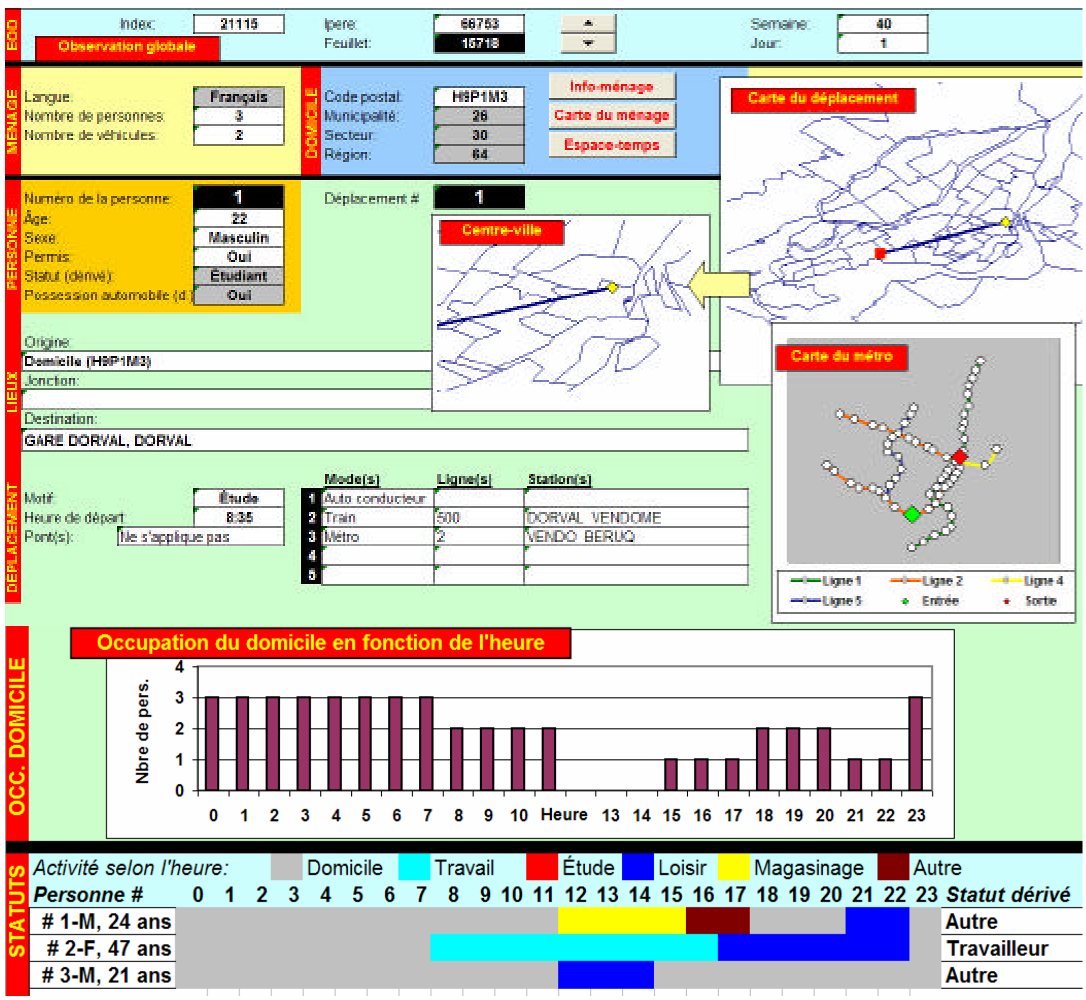
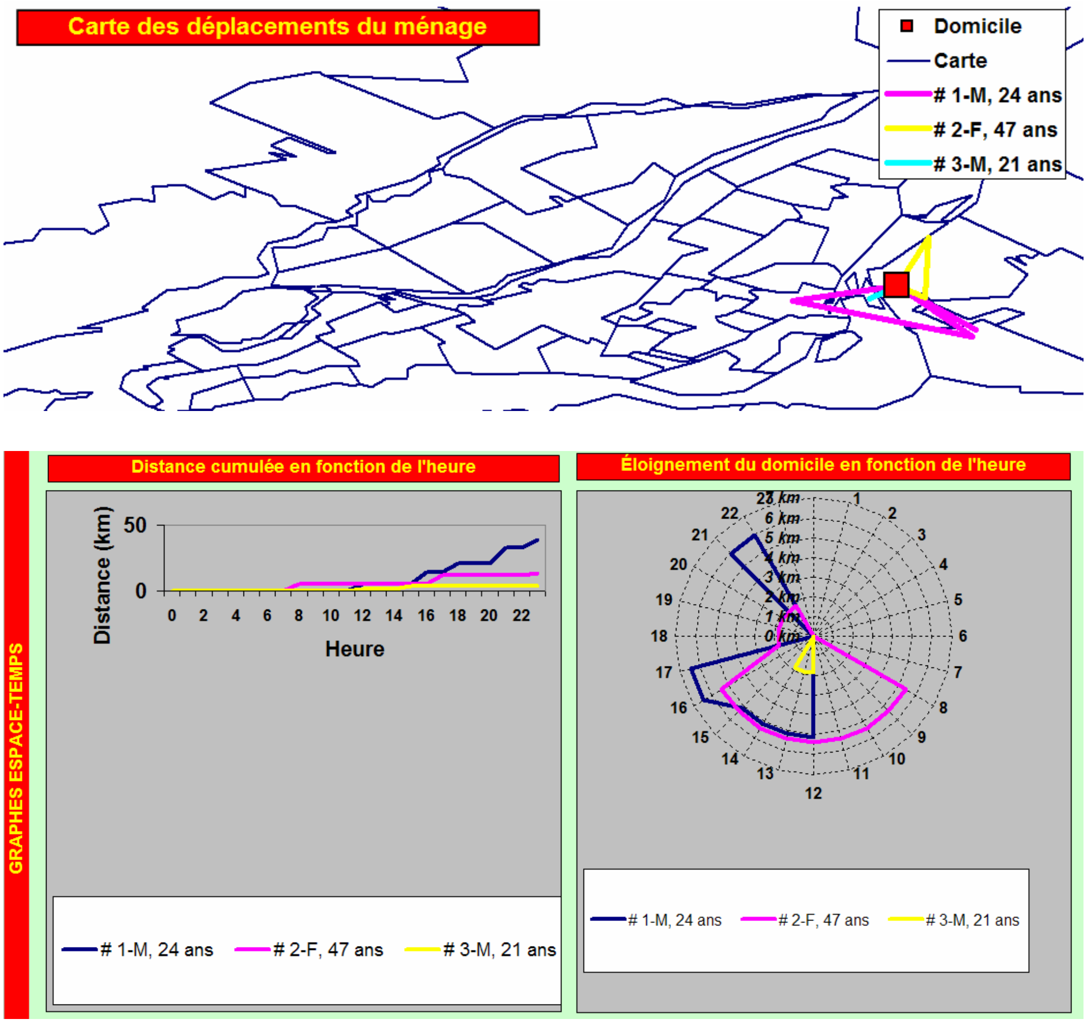


Figure 33 An Excel viewer screen to show spatial itineraries and traveled distances.




Source: Chapleau and Trepanier (1997), as shown at the IATBR meeting