UNIVERSITÉ DE MONTRÉAL

# GROUND ACCESSIBILITY TO MONTREAL'S INTERNATIONAL AIRPORTS: A DISAGGREGATE ANALYSIS

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**GROUND ACCESSIBILITY TO**
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**A DISAGGREGATE ANALYSIS**

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***In Memory of Apu***

***The Road Less Travelled***

*Two roads diverged in a yellow wood,*
*And sorry I could not travel both*
*And be one traveler, long I stood*
*And looked down one as far as I could*
*To where it bent in the undergrowth;*

*Then took the other, as just as fair,*
*And having perhaps the better claim,*
*Because it was grassy and wanted wear;*
*Though as for that the passing there*
*Had worn them really about the same,*

*And both that morning equally lay*
*In leaves no step had trodden black.*
*Oh, I kept the first for another day!*
*Yet knowing how way leads on to way,*
*I doubted if I should ever come back.*

*I shall be telling this with a sigh*
*Somewhere ages and ages hence:*
*Two roads diverged in a wood, and I -*
*I took the one less traveled by,*
*And that has made all the difference.*

**- Robert Frost**

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# RÉSUMÉ

L'objectif de ce mémoire est d'établir une méthodologie d'analyse qui serait utilisée comme encadrement pour modéliser l'accessibilité terrestre aux deux aéroports de Montréal en utilisant les données d'enquête Origine-Destination obtenues suite à une enquête réalisée par Dessau Inc. pour le compte de l'administrateur *Les Aéroports de Montréal* (ADM) (juin 1993). L'approche totalement désagrégée selon le concept MADITUC (Modèle d'Analyse Désagrégée des Itinéraires de Transport Urbain Collectif) a été utilisée pour le développement de cette méthodologie. Cette approche est retenue pour son habileté à conserver, lors d'analyses, tous les attributs propres à chaque déplacement. Un sous-échantillon des déplacements d'accessibilité terrestre extrait de l'enquête OD 1993 de la STCUM-MTQ a été utilisé pour comparer la méthodologie d'enquête et la structure des données puisque les données de cette enquête ont contribué au développement de l'approche totalement désagrégée.

La méthodologie d'analyse proposée consiste en: l'analyse et la validation des échantillons de données, le calcul de facteurs d'expansion, la dérivation de nouvelles variables, l'extraction des déplacements d'accessibilité terrestre, la compilation des données d'enquête et la simulation des déplacements extraits à l'aide du système MAD(Strat)$^2$.

L'analyse des déplacements des passagers originant et se destinant aux aéroports internationaux de Montréal a montré des caractéristiques comportementales d'accessibilité terrestre similaires à celles de la plupart des villes Nord-Américaines tel que le rapporte la littérature. La distribution des origines et des destinations des passagers résidants est plus dispersée à travers la GRM que celle des non-résidants qui originent ou se destinent en majorité vers le centre-ville. De plus, les passagers résidants utilisent de façon prédominante les modes

privés tels que l'automobile alors que les non-résidants utilisent les modes publics plus que les résidants tels que le service d'autocar.

Les trois plus grands générateurs de déplacements aéroportuaires sont sur une période de 24 heures: le centre-ville de Montréal avec 25 468 déplacements, la CUM-Centre avec 19 785 déplacements et la CUM-Ouest avec 16 113 déplacements.

Le temps moyen et la distance moyenne de parcours à l'aéroport de Dorval obtenus à partir de simulations avec MAD(Strat)$^2$ sont de 25,72 min et 34,34 km respectivement, basés sur les chemins obtenus de la simulation avec MAD(Strat)$^2$. De la même façon, le temps moyen et la distance moyenne de parcours à l'aéroport de Mirabel sont de 35,76 min et 49,01km. L'expérimentation avec le système MAD(Strat)$^2$, qui utilise le réseau analytique de transport développé pour l'analyse du transport des marchandises dans la Grande Région de Montréal pour le compte du Ministère des Transports de Québec, n'a pas bien réussi. Le temps de parcours est une fonction de la distance parcourue et la vitesse des liens de l'itinéraire simulé. Une déficience de la codification du réseau routier, particulièrement aux alentours de l'aéroport de Dorval, démontre un impact sur les itinéraires des voyageurs et, conséquemment sur la distance et le temps parcourus à l'aéroport.

Divers indicateurs de performance ont été étudiés pour mesurer le niveau d'accessibilité terrestre aux deux aéroports à partir d'un découpage territorial en 10 secteurs de la GRM. Deux indicateurs ont particulièrement été investigués: un indice d'accessibilité et la vitesse moyenne d'accès à chaque aéroport. Ces deux indicateurs prennent en compte le temps et la distance de parcours ainsi que le volume de voyageurs. Une comparaison des indicateurs de performance de l'accessibilité terrestre a montré que la vitesse moyenne d'accès était un indicateur plus fiable que l'indice d'accessibilité.

Malgré sa distance du centre-ville de Montréal, l'aéroport de Mirabel est trouvé comme étant plus accessible en terme de vitesse moyenne d'accès que l'aéroport de Dorval, puisque celui-ci est localisé dans la partie ouest de la GRM et qu'il est accessible par des routes et autoroutes à vitesse réduite. La vitesse moyenne d'accès à l'aéroport de Mirabel est de 84 km/h tandis que la vitesse moyenne d'accès à l'aéroport de Dorval est de 57 km/h. Les voyageurs du centre-ville de Montréal et de la Rive-Sud (incluant la Proche Rive-Sud) bénéficient d'une vitesse d'accès à l'aéroport de Dorval respectivement de 60 km/h et 62 km/h tandis que les voyageurs de la CUM-Ouest subissent une vitesse d'accès à l'aéroport de Dorval inférieure (44 km/h). Une analyse de résultats d'une simulation sous congestion devrait révéler si ces zones maintiennent les mêmes niveaux d'accessibilité terrestre aux aéroports de Dorval et de Mirabel.

Alors des analyses futures de l'accessibilité aéroportuaire devraient inclure des effets de conditions de pointe sur le temps d'accès et la vitesse spécifiquement à l'aéroport de Dorval où, dans un futur immédiat, on prévoit une augmentation du trafic. Ceci implique d'augmenter la taille de l'échantillon des passagers pour être capable d'analyser adéquatement des déplacements d'accès aéroportuaires durant la période de pointe (pointe AM). Aussi, les planificateurs d'aéroport et de transport devraient examiner plus à fond l'accès à l'aéroport de Dorval et aux alentours puisque la CUM-Ouest est l'un des 3 plus importants générateurs de trafic aéroportuaire.

# ABSTRACT

The purpose of this research analysis, was to establish an analysis methodology that would establish the groundwork for further analysis including modelling of passenger and greeter airport access trips to both Dorval and Mirabel Airports using the origin-destination survey data obtained from the Origin-Destination and Modal Choice Survey of Passengers and Employees conducted for *Les Aéroports de Montréal* (ADM) by Dessau Inc. in June 1993. The totally disaggregate approach for transportation systems analysis (MADITUC) was used to develop this methodology. This informational approach was selected for its ability to retain all the travel characteristics of each recorded trip throughout the analyses. An extracted subsample of airport-ended trips from the 1993 MUCTC-MTQ regional O-D survey data was used to compare survey methodology and data structure since the data from this survey was instrumental in the development of the totally disaggregate approach.

The proposed methodology consisted of the examination and correction of data samples, the calculation of expansion factors, the derivation of variables, the extraction of ground access trips for further analysis, the compilation of the survey data and the simulation of the extracted trips using the MAD(Strat)$^2$ system.

Analysis of passenger trips to and from Montreal's International Airports showed ground access behaviour characteristic of most North American cities according to the literature. Namely, resident passenger airport trip origins or destinations showed more dispersion throughout the Greater Montreal Area compared to nonresident passenger airport trip origins or destination was Downtown Montreal. Also, resident passengers predominantly used private modes such as the automobile, whereas nonresidents used public modes such as the autocar airport shuttle service.

The top three generators of trips to and from both Dorval and Mirabel Airports were Downtown Montreal with 25 468 trips, the MUC-Centre with 19 785 trips and the MUC-West with 16 113 trips during a 24-hour period.

The average travel time and distance to each airport was determined from the simulation of airport access trips with MAD(Strat)$^2$. The average travel time and distance to Dorval Airport was calculated as being 25.72 min and 34.32 km. The average travel time and distance to Mirabel Airport was found to be 35.76 min and 49.01 km.

This experimentation with MAD(Strat)$^2$, using the spatial referencing system developed for the Quebec Ministry of Transport's urban goods movement analysis within the Greater Montreal Area, was not successful for the analysis of access trips to Dorval and Mirabel Airports. The simulated travel times are a function of both the distance travelled and the speed of the links in the simulated path. An incompletely coded network, particularly in the vicinity of Dorval Airport, therefore affects the itineraries assigned to airport tripmakers and consequently the distance and time travelled to the airport.

An examination of performance indicators to measure the level of accessibility to both Dorval and Mirabel Airports for the ten zones of the Greater Montreal Area (GMA) was also conducted. Two possible indicators in particular were examined: an accessibility index and the average speed to each airport. Both measures factor in the travel time and distance and the volume of tripmakers affected. Comparison of the two proposed measures of ground accessibility revealed that the average access speed for each zone was a more suitable, independent indicator for the level of ground access than the accessibility index.

Despite its distance to the centre of Montreal, Mirabel Airport was found to be more accessible in terms of average speed than Dorval Airport, which is nestled in the western part of the GMA and is surrounded by lower speed roads, highways and traffic circles. The average access speed to Mirabel is 84 km/h, while the average access speed to Dorval is 57 km/h. Downtown Montreal and South Shore tripmakers experienced a high access speeds to Dorval Airport (60 km/h and 62 km/h respectively), whereas MUC-West tripmakers experienced the lowest average access speed to Dorval Airport (44 km/h). Further analysis of paths simulated under peak traffic conditions should reveal whether these zones maintain their level of ground accessibility to Dorval Airport.

In conclusion, future analysis of airport access should include the effect of peak conditions on the access time and speed, particularly with the scheduled increase in traffic at Dorval Airport in the near future. This implies increasing the passenger sample size to be able to adequately analyze airport access trips during the (morning) peak period. Also, transportation and airport planners should further examine the access to Dorval Airport in the vicinity of the airport, since the MUC-West is one of the three important generators of airport traffic.

# CONDENSÉ DU MÉMOIRE INTITULÉ:

## GROUND ACCESSIBILITY TO MONTREAL'S INTERNATIONAL AIRPORTS: A DISAGGREGATE ANALYSIS

### INTRODUCTION

La grande région de Montréal (GRM) est actuellement desservie par deux aéroports internationaux: Dorval et Mirabel. Le trafic aérien de l'aéroport de Dorval est de nature national (vols domestiques) et transfrontalier tandis que celui de l'aéroport de Mirabel est plutôt de nature international et nolisé. L'amélioration de l'accessibilité terrestre aux aéroports de Dorval et de Mirabel, aussi bien qu'entre eux, est l'une des préoccupations de l'administrateur *Les Aéroports de Montréal* (ADM). À cet égard ADM réalise périodiquement des enquêtes Origine-Destination (OD) qui permettent de recueillir entre autres les informations suivantes à l'égard des passagers: mode emprunté, origine, destination, motifs, etc.

L'objectif de ce mémoire est d'établir une méthodologie d'analyse qui serait utilisée comme encadrement pour modéliser l'accessibilité terrestre aux deux aéroports de Montréal en utilisant les données d'enquête Origine-Destination obtenues suite à une enquête réalisé par Dessau inc. pour le compte d'ADM (juin 1993). L'approche totalement désagrégée selon le concept MADITUC (Modèle d'Analyse Désagrégée des Itinéraires de Transport Urbain Collectif) a été utilisée pour le développement de cette méthodologie. Cette approche est retenue pour son habileté à conserver, lors d'analyses, tous les attributs propres à chaque déplacement.

Divers indicateurs de performance ont été étudiés pour mesurer le niveau d'accessibilité terrestre aux deux aéroports à partir du découpage territorial en 10 secteurs de la GRM. Deux indicateurs ont particulièrement été investigués: un indice d'accessibilité et la vitesse moyenne d'accès à chaque aéroport. Ces deux indicateurs prennent en compte le temps et la distance de parcours ainsi que le volume de voyageurs.

Ce mémoire se subdivise en cinq volets. La première partie aborde les concepts essentiels à la compréhension de la problématique de l'accessibilité terrestre aux aéroports. La seconde partie présente la méthodologie d'analyse des déplacements d'accessibilité terrestre à Dorval et Mirabel. Ceci inclut une revue de la méthodologie d'enquête d'ADM en la comparant avec celle de la STCUM sous les aspects de la méthodologie, des structures de données et des procédures de traitement des données. Dans la troisième partie, on retrouve la caractérisation des déplacements typiques des passagers et des accompagnateurs. Quant à la quatrième partie, elle présente les résultats, notamment le temps et la distance de parcours suite à la simulation des itinéraires d'accès aux aéroports en utilisant le système MAD(Strat)[2] (Modèle d'Analyse Désagrégé Stratifié et Stratégique). De plus, cette partie traite aussi du choix de deux indicateurs de performance. Finalement, les conclusions mises en évidence par cette recherche sont présentées dans le dernier volet.

Un bref sommaire de chacun des volets suit.

## PROBLEMATIQUE ET REVUE DE LA LITTERATURE

Ce chapitre présente les concepts essentiels à la compréhension de la problématique de l'accessibilité terrestre aux aéroports. Pour établir le contexte analytique de l'accessibilité terrestre aux aéroports internationaux de Montréal, on doit mettre en présence l'offre et la demande d'accessibilité terrestre.

Les usagers des aéroports et plus particulièrement les passagers aériens sont plus sensibles aux retards dus à la congestion routière à cause de l'important coût associé au risque de manquer leur vol.

Une combination d'éléments physiques et non-physiques influence le choix modal d'accessibilité terrestre aux aéroports. Les éléments physiques incluent les modes disponibles, les réseaux associés et la localisation géographique des origines et des destinations. Les éléments non-physiques comprennent les attributs de service du système de transport, les caractéristiques socio-démographiques des voyageurs ainsi que le motif de déplacement.

La littérature a aussi révélé que les modes associés à l'automobile sont les plus fréquemment utilisés en Amérique du Nord. Les transports collectifs ne sont pas souvent empruntés à cause, principalement, du temps de déplacement et de l'encombrement des bagages.

La distribution géographique des origines et des destinations des déplacements dépend de l'aménagement et de la superficie du territoire métropolitain, de la localisation géographique de l'aéroport par rapport au centre-ville ou à d'autre pôles importants d'attraction, de l'importance économique, politique et culturelle d'une ville et de la proportion de non-résidants parmi les usagers des aéroports.

La littérature a révelé que les non-résidants se logent en majorité dans le centre-ville d'une ville, Par conséquent, on s'attend à ce qu'un fort pourcentge de déplacements aéroportuaires soit réalisé par des non-résidants entre le centre-ville de Montréal et les deux aéroports internationaux.

L'approche d'analyse retenue est l'approche totalement désagrégée. Cette approche est selectionnée pour son habileté à identifier et à analyser différentes classes de la clientèle aéroportuaire et ce, tout en conservant, tout au long du processus analytique, toutes les informations individuelles.

## METHODOLOGIE D'ANALYSE

Deux ensembles de données ont été utilisés pour l'analyse des déplacements d'accessibilité terrestre aux aéroports internationaux de Dorval et de Mirabel. Le premier ensemble de données vient de l'Enquête OD et choix modal mandaté par ADM en juin 1993. Le deuxième ensemble de données est un sous-ensemble de données extrait de l'enquête OD régionale de la STCUM - MTQ réalisé à l'automne 1993.

La méthodologie proposée comprend quatre grandes étapes: l'analyse de la méthodologie d'enquête d'ADM, la validation des données utilisées, la caractérisation des déplacements aéroportuaires terrestres et la simulation de ces déplacements à l'aide du système MAD(Strat)[2] .

L'analyse de la méthodologie d'enquête d'ADM inclut une comparaison avec l'enquête OD de la STCUM sous deux aspects: l'aspect méthodologique et l'aspect structure des données. Ceci fut fait puisque les données d'enquêtes de la STCUM ont contribué au développement de l'approche totalement désagrégée. Les points forts de chacune des méthodes de cueillette de données furent identifiés. De plus, l'analyse de la structure des données de chacun des échantillons a permis de déterminer les procédures de traitement requis.

La vérification des données et du traitement s'est effectué selon les étapes suivantes. Premièrement, chaque échantillon de données fut examiné dans le but de s'assurer qu'il n'y avait plus d'inconsistence. Deux anomalies majeures ont été découvertes: une impliquait l'irrégularité entre l'heure enquêtée et l'heure arrivée à l'aéroport et la seconde a permis d'identifier l'absence de coordonnées x-y pour certaines des origines et/ou destinations des déplacements. Ces coordonnées sont pourtant essentielles à la simulation avec le système MAD(Strat)[2]. Dans le premier cas, 3% des enregistrements de la base de données des passagers au départ et 5% des enregistrements de la bases de données des accompagnateurs furent éliminés. Dans le deuxième cas, 25% des enregistrements de la base de données des passagers au départ, 38% des enregistrements de la base de données des passagers à l'arrivée et 42% des enregistrements de la base de données des accompagnateurs ont été récupérés en attribuant aux coordonnées manquantes les coordonnées x-y associés au centroïde du secteur municipal soit d'origine et/ou de destination.

Ensuite, des facteurs d'expansion basés sur la population estimée des passagers et des accompagnateurs pendant la période d'enquête et pour le motif du déplacement aérien ont été calculés pour les trois bases de données d'ADM en utilisant trois méthodes différentes. La première méthode utilise pour calculer les facteurs d'expansion des passagers nationaux et transfrontaliers les volumes obtenus des entrevues de calibration pendant la période de l'enquête. La seconde méthode a permis de dériver les facteurs d'expansion des passagers internationaux à partir de l'achalandage annuel des passagers internationaux à Mirabel. La troisième méthode a permis de calculer les facteur d'expansion des accompagnateurs aux passagers à l'arrivée à partir d'une estimation d'une population d'accompagnateurs dérivée des bases de données des passagers à l'arrivée et des accompagnateurs. Ces facteurs d'expansion ne sont que des estimés et doivent être traités comme tels.

De nouvelles variables ont été ensuite dérivées pour ajouter une nouvelle dimension à l'analyse des déplacements aéroportuaires. Pour les passagers, un statut résidentiel basé sur le lieu de résidence déclaré et un statut passager en fonction du motif du déplacement aérien ont été dérivés. Pour les données de la STCUM-MTQ un «statut aéroport» identifiant une catégorie spécifique pour l'analyse des déplacements aéroportuaires a été dérivé en considérant l'origine et la destination de chaque déplacement en fonction et du motif déclaré.

Finalement, les déplacements ont été extraits de chacune des bases de données (ADM, STCUM-MTQ). Pour les bases de données ADM, les déplacements avec coordonnées à l'origine et à la destination ont été extraits pour être utilisés pour des analyses plus poussées et la simulation avec MAD(Strat)[2]. Seulement les déplacements à l'intérieur de la GRM ont été extraits. Pour l'échantillon de la STCUM-MTQ, seulement les déplacements des accompagnateurs de passagers à l'arrivée ont été extraits puis qu'ils representent le plus grand pourcentage de déplacements aéroportuaires identifiés lors de l'enquête OD de la STCUM-MTQ. L'analyse des accompagnateurs des passagers selon les données de la STCUM-MTQ est accessoire et donc ne fait pas partie de l'analyse intégrale des déplacements d'accès terrestre aéroportuaire aux aéroports de Dorval et de Mirabel. Pour cette raison, cette analyse accessoire des accompagnateurs se trouve en annexe.

Ce chapitre conclut avec l'examen de l'importance statistique des échantillons extraits. L'erreur associée aux échantillons passagers d'ADM a été calculée comme étant à l'intérieur de la marge d'erreur acceptable (5%) à un niveau de confiance de 95%. Cependant, l'erreur associée à l'échantillon des accompagnateurs était le double (11%) de la marge d'erreur tolérée au même niveau de confiance. De la même façon, l'erreur associée à l'échantillon de la STCUM-MTQ se situe dans le même intervalle que l'échantillon des accompagnateurs -passagers d'ADM.

## ANALYSE DES DEPLACEMENTS D'ACCES TERRESTRE

Les déplacements d'accès terrestre effectués par les passagers et les accompagnateurs à l'arrivée ont été caractérisés et des profils du passager et de l'accompagnateur ont été brièvement présentés dans ce chapitre.

L'analyse du profil des passagers utilisant les aéroports internationaux de Montréal a montré que 49% de tous les passagers étaient des résidants de la GRM, et que dont la majorité demeurait dans la CUM-Centre. La majorité des passagers d'affaires non-résidants venaient principalement des autres provinces tandis que les passagers loisirs non-résidants provenaient de partout dans le monde. De plus, il a été observé que les voyages pour le motif affaires prédominent à l'aéroport de Dorval et que les voyages pour le motif loisirs prédominent à l'aéroport de Mirabel, tous passagers confondus.

Durant la période enquêtée (juin 1993) il y avait quotidiennement 25 527 déplacements passagers en partance de Dorval et 9 146 déplacements passagers en partance de Mirabel, 18 007 déplacements passagers à l'arrivée à Dorval et 9 029 déplacements passagers à l'arrivée à Mirabel.

Le passager résidant typique a initié de, ou terminé son déplacement aéroportuaire à sa résidence dans la CUM-Centre tandis que le passager non-résidant typique a initié, ou terminé son déplacement aéroportuaire soit à un hôtel, soit dans un autre une autre lieu au centre-ville de Montréal. Ceci est vrai pour les passagers des deux aéroports.

L'heure de pointe pour les déplacements passagers au départ de l'aéroport Dorval était 6h00. Quarante pourcent (40%) des déplacements des passagers au départ se destinant à l'aéroport de Dorval se sont effectués durant la période de pointe du matin soit entre 6h00 et 9h00. L'heure de pointe pour les départs des passagers à l'aéroport de Mirabel était 16h00. L'heure de pointe d'arrivée des passagers à l'aéroport de Dorval était 17h00 tandis que l'heure de pointe d'arrivée des passagers à l'aéroport de Mirabel était 16h00.

Le choix modal s'est effectué en fonction du statut résidentiel du passager, du motif de déplacement et de l'aéroport. Les modes privés ont généralement été préférés aux modes publics pour accéder à l'un ou l'autre des aéroports. Cependant, on note une tendance à l'utilisation des modes publics pour accéder à l'aéroport de Mirabel. En outre, les passagers non-résidants sont plus prédisposés à utiliser les modes publics que les passagers résidants. De plus, on observe chez les passagers d'affaires une tendance à sélectionner des modes à coûts plus élevés tel que le taxi pour accéder à l'aéroport.

Les trois plus grands générateurs de déplacements aéroportuaires sont sur une période de 24 heures: le centre-ville de Montréal avec 25 468 déplacements, la CUM-Centre avec 19 785 déplacements et la CUM-Ouest avec 16 113 déplacements.

L'automobile (49%), le taxi (32%) et les autos louées (10%) sont les trois modes les plus utilisés pour accéder à l'aéroport de Dorval tandis que l'automobile (66%), l'autocar (11%) et le taxi (8%) sont les trois modes les plus populaires parmi les passagers pour accéder à l'aéroport de Mirabel.

Le temps d'attente des passagers à l'aéroport varie en fonction de la destination du vol. Les passagers nationaux attendent 72,3 min. et les passagers transfrontaliers attendent 84,4 min. à l'aéroport de Dorval avant leurs vols. D'autre part, les pasagers internationaux attendent 166,5 min. à l'aéroport de Mirabel avant leurs vols. Cependent, on ne note aucune corrélation entre la distance d'accès à l'aéroport et le temps d'attente à l'aéroport avant l'envol.

Parmi les accompagnateurs aux passagers à l'arrivée, seulement 18% sont venus accueillir un membre de leur famille. Quarante et un pourcent (41%) des passagers accueillis étaient des résidants. L'analyse des déplacements des accompagnateurs a montré l'existence d'une symétrie dans les déplacements: 49% des accompagnateurs sont retournés à leur point d'origine, 15% sont retournés à leur résidence telles que dérivées de la résidence du passager, 14% sont retournés à la résidence du passager et 22% se sont déplacés vers une autre destination.

Le nombre moyen d'accompagnateurs par passager a varié entre 0,80 pour les passagers nationaux et 1,81 pour les passagers internationaux. Il a aussi été observé que les passagers d'affaires avaient moins d'accompagnateurs par passager (1,33) que les passagers loisirs (1,41).

La majorité des déplacements accompagnateurs à l'aéroport de Dorval originait de la CUM-Ouest et se destinait au centre-ville de Montréal. Cependant, la majorité des déplacements accompagnateurs à l'aéroport de Mirabel originait et se destinait à la CUM-Centre. L'heure de pointe des déplacements accompagnateurs se destinant à l'aéroport de Dorval est 7h00, tandis que l'heure de pointe des déplacements originant de l'aéroport de Dorval est 12h00. L'heure de pointe des déplacements accompagnateurs se destinant à l'aéroport de Mirabel est 15h00 alors que celle des déplacements originant de l'aéroport de Mirabel est 16h00. La durée moyenne de l'activité accompagnement a été estimée à 58 min. pour l'aéroport de Dorval et à 97 min. pour l'aéroport de Mirabel. Le mode privilégié de l'accompagnateur est l'automobile; 89% des déplacements à Dorval et 96% des déplacements à Mirabel sont des déplacements automobiles.

## SIMULATION ET ANALYSE AVEC MAD(STRAT)$^2$

Malgré sa distance du centre-ville de Montréal, l'aéroport de Mirabel est trouvé comme étant plus accessible en terme de vitesse moyenne d'accès que l'aéroport de Dorval, puis que celui-ci est localisé dans la partie ouest de la GRM et qu'il est accessible par des routes et autoroutes à vitesse réduite. La vitesse moyenne d'accès à l'aéroport de Mirabel est de 84 km/h tandis que la vitesse moyenne d'accès à l'aéroport de Dorval est de 57 km/h. Les voyageurs du centre-ville de Montréal et de la Rive-Sud (incluant la Proche Rive-Sud) bénéficient d'une vitesse d'accès à l'aéroport de Dorval respectivement de 60 km/h et 62 km/h tandis que les passagers et les accompagnateurs de la CUM-Ouest subissent une vitesse d'accès à l'aéroport de Dorval inférieure (44 km/h). Une analyse de résultats d'une simulation sous congestion devrait réveler si ces zones maintiennent les mêmes niveaux d'accessibilité terrestre aux aéroports de Dorval et de Mirabel.

Une comparaison des indicateurs de performance de l'accessibilité terrestre a montré que la vitesse moyenne d'accès était un indicateur plus fiable que l'indice d'accessibilité puisque ce dernier indentifie les zones qui sont très importantes en termes de volume de déplacements aéroportuaires.

Le temps moyen et la distance moyenne de parcours à l'aéroport de Dorval obtenus à partir de simulations avec MAD(Strat)$^2$ sont de 25,72 min. et 34,34 km. respectivement, basé sur les chemins obtenus de la simulation avec MAD(Strat)$^2$. De la même façon, le temps moyen et la distance moyenne de parcours à l'aéroport de Mirabel sont de 35,76 min et 49,01km.

L'expérimentation avec le système MAD(Strat)$^2$, qui utilise le réseau analytique de transport développé pour l'analyse du transport des marchandises dans la Grande Région de Montréal pour le compte du Ministère des Transports de Québec, n'a pas bien réussi. Le temps de parcours est une fonction de la distance parcourue et la vitesse des liens de l'itinéraire simulé. Une déficience de la codification du réseau routier, particulièrement aux alentours de l'aéroport de Dorval, démontre un impact sur les itinéraires des voyageurs et, conséquemment sur la distance et le temps parcourus à l'aéroport.

## CONCLUSION

La méthodologie d'analyse proposée dans ce mémoire a établi les fondements d'analyses futures et permettent éventuellement la modélisation des déplacements d'accessibilité terrestre. La méthodologie a consisté en l'analyse et la correction des échantillons de données, le calcul des facteurs d'expansion, la dérivation des variables, l'extraction des déplacements d'accessiblité terrestre en vue de faire des analyses, la compilation de données d'enquête et la simulation à l'aide du système MAD(Strat)$^2$.

L'analyse des déplacements d'accessibilité terrestre provenant des données d'enquête OD d'ADM a révelé que les passagers ont le comportement typique décrit dans la littérature. Les passagers non-résidants originent ou se destinent au centre-ville de Montréal tandis que les origines ou les destinations des passagers résidants sont dispersées à travers la GRM. De plus, on observe un comportement typique de sélection modale: les résidants de façon prédominante utilisent les modes privés pour accéder aux deux aéroports tandis que les non-résidants privilégient de façon caractéristique les modes publics.

L'analyse de l'accessibilité aux aéroports de Dorval et de Mirabel à partir des 10 zones de la GRM a montré que, généralement, l'aéroport de Mirabel a une meilleure accessibilité en terme de vitesse moyenne (84 km/h) comparativement à l'aéroport de Dorval (57km/h) attribuable principalement à la hiérarchie des routes qui entourent l'aéroport de Dorval. Le centre-ville de Montréal et la Rive-Sud profitent de meilleures vitesses moyennes d'accès à l'aéroport de Dorval. Cependant ces vitesses ont été obtenues à partir de simulation avec des conditions optimales. Par ailleurs, la CUM-Ouest présente une plus faible vitesse d'accès à l'aéroport de Dorval due en grande partie à la plus basse vitesse des routes d'accès aux alentours de l'aéroport.

Cependant, une éventuelle analyse de l'accessibilité terrestre en période de pointe devrait révéler si le même comportement est observé sous des conditions de circulation plus réalistes.

Dès lors, les analyses futures de l'accessibilité aéroportuaire devraient inclure des effets de conditions de pointe sur le temps d'accès et la vitesse spécifiquement à l'aéroport de Dorval où, dans un futur immédiat, on prévoit une augmentation du trafic. Ceci implique d'augmenter la taille de l'échantillon des passagers pour être capable d'analyser adéquatement des déplacements d'accès aéroportuaires durant la période de pointe (pointe AM). Aussi, les planificateurs d'aéroport et de transport devraient examiner plus à fond l'accès à l'aéroport de Dorval et aux alentours puisque la CUM-Ouest est l'un des 3 plus importants générateurs de trafic aéroportuaire.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ADM | Les Aéroports de Montréal |
| CBD | Central Business District |
| GMA | Greater Montreal Area |
| LAA | Local Airport Authority |
| MFA | Major Federal Airport |
| MADEOD | Modèle d'Analyse Désagrégée des Données d'Enquêtes Origine-Destination |
| MADITUC | Modèle d'Analyse Désagrégée des Itinéraires de Transport Urbain Collectif |
| $MAD(Strat)^2$ | Modèle d'Analyse Désagrégée Stratifiée et Stratégique |
| MTQ | Ministry of Transportation of Quebec |
| MUC | Montreal Urban Community |
| MUCTC | Montreal Urban Community Transit Corporation |
| O-D | Origin-Destination |
| PAX | Passenger |
| NRB | Nonresident Business Passenger |
| NRL | Nonresident Leisure Passenger |
| RB | Resident Business Passenger |
| RL | Resident Leisure Passenger |
| YUL | Dorval Airport |
| YMX | Mirabel Airport |

# LIST OF APPENDICES

# INTRODUCTION

The demand for ground access to airports is derived from the decision need to travel to another city by air. People decide to conduct interurban travel by air modes due to the ability of aircraft to travel long distances in a relatively short amount of time. However, while technological advances in the aeronautics industry and improvements on processing techniques have decreased the flight time and the passenger processing components of the total air trip respectively, the total travel time still has not changed. This is primarily due to ground access problems.

The total travel time of a person travelling to another city by air mode includes access time from the person's last destination to the transportation network, in-vehicle travel time, parking - if applicable, access to the terminal, processing time including checking-in and baggage handling, security check, pre-boarding time, boarding, flying time, and vice-versa upon arrival at the destination city.

Difficulty in co-ordinating flow patterns and activities between airports and transportation networks leads to ground access problems for the users of an airport. One of the challenges of ground access to airports includes the mix of airport-generated traffic with regular activity-generated traffic, such as work or school, which increases the traveller's trip time. The situation is further amplified when there are two airports serving a region, since transfer activity between the airports must also be taken into consideration as well as the activity between the urban centre and the airports individually.

The Greater Montreal Area is presently served by two international airports: Dorval and Mirabel International Airports. Dorval Airport serves the domestic and transborder air passenger traffic, while Mirabel handles mostly scheduled international and charter traffic. Improving ground access to both airports as well as between them is one of the principal objectives of the Montreal airport authority, *Les Aéroports de Montréal* (ADM). As part of their commitment to improving airport ground access, ADM periodically conducts origin-destination (O-D) surveys of passengers which provide information on the modal choice, origin and destination of airport-ended trips as well as other relevant trip attributes.

The purpose of this research analysis is to establish an analysis methodology to be used as a framework for modelling passenger and greeter airport access trips to both of Montreal's International Airports - Dorval and Mirabel using origin-destination survey data obtained from the Origin-Destination and Modal Choice Survey of Passengers and Employees conducted for ADM by Dessau Inc. in June 1993. The totally disaggregate approach for transportation systems analysis (MADITUC) is used to develop this methodology. This approach was selected for its ability to retain all the travel characteristics of each recorded trip throughout the analyses.

An examination of performance indicators to measure the level of accessibility to both Dorval and Mirabel Airports for the ten zones of the Greater Montreal Area (GMA) is also conducted. Two possible indicators in particular are examined: an accessibility index and the average speed to each airport. Both measures factor the travel time and distance and the volume of tripmakers affected by similar access conditions.

This thesis is composed of five parts. The first part describes the key concepts necessary to the understanding of the issues surrounding ground access to airports. The second part presents the methodology used to analyze ground access trips to Dorval and Mirabel Airports, which includes an examination of the ADM survey methodology, a comparison with the MUCTC O-D survey methodology and data structure, and a description of the procedures used to process the data. The third part characterizes the profile of the ground access trip for passenger and passenger greeters. The fourth part presents the results, namely the time and distance travelled to the airport based on the path obtained from the simulation of airport access trips to Dorval and Mirabel Airports using the MAD(Strat)$^2$ system. The development of the two performance indicators is also presented in this chapter. The conclusions derived from this research are presented in the final chapter.

# CHAPTER ONE

# CONTEXT AND REVIEW OF LITERATURE

Transportation planners faced with the task of analyzing and evaluating a transportation system such as an airport ground access system are presented with two challenges: a substantive one and a methodological one (MANHEIM, 1984). The former requires an understanding of the activity systems of a society or one of its subsegments in order to comprehend its transportation needs; the latter requires an appropriate analysis approach to be selected to resolve the transportation issue at hand. The selected approach depends to a certain extent on the data available and the level of precision required.

This chapter focuses on the definition of ground access to an airport. The components of a ground access system are defined and the problems associated with airport ground access are presented. The two airports and the ground access system being studied in this research analysis are then presented followed by an overview of the available analysis approaches, which concludes this chapter.

## 1.1 GROUND ACCESS: PROBLEM OR NOT?

Ground access issues are subject to differences in opinion and perception over whether or not ground accessibility is problematic (PENDAKUR 1974; DE NEUFVILLE 1976). To the air passenger who directly experiences delays resulting from ground transportation inefficiencies, ground access is a definite problem. Similarly, ground access is a specific issue for airport authorities who have a vested interest in providing a high level of efficient service to their clientele for the intermodal transfer from ground to air modes. To other organizations, institutions and governments, ground access to airports is another transportation-related problem. For the general public, the magnitude of the problem depends on the frequency with which air travel or airport trips are made and the location of their residence with respect to the airport.

Population growth, increase in disposable income, faster airplanes and declining fares all explain the boom in air travel which has occurred since the beginning of civil aviation in the 1940s (PENDAKUR, 1974). PENDAKUR(1974) and COOK(1970) argue that despite technological advances in the aeronautics industry and improvements to passenger service, which have all contributed to the decrease in air travel and passenger processing times, little has been done to facilitate the ground trip to the airport.

DE NEUFVILLE (1976) outlines three elements which airport developers believe constitute the 'airport access problem':

1) air passengers value their time highly;
2) congestion on the roadways cause delays to air passengers;
3) a large number of people are assumed to want to travel between the city centre and the airport.

His interpretation brings to light the particularities of the airport ground access trip for air passengers, and to a certain extent, the people who either see them off or greet them at the airport.

### 1.1.1 Value of Time and Ground Transportation Delays

The high cost associated with a missed flight makes all air passengers more sensitive than regular activity tripmakers to delays caused by inefficient ground transportation. Business air travellers are generally perceived to be even more sensitive to ground transportation delays than their leisure traveling counterparts. Further, because of the higher cost of air travel and the risk of missing the flight, departing passengers might value their time differently than arriving passengers. This may explain why different types of air passengers attribute different value to their time.

Moreover, delays due to ground transportation vary according to the time of day at which travel to the airport occurs which in turn depends on the flight departure time, and the access mode used. Passengers using road-based modes, regardless of whether the mode is private or public, are more apt to experience delays if they must travel to the airport during peak periods.

### 1.1.2 Origin and Destination of Ground Access Trips

The geographical distribution of airport-ended trips depends on the size and structure of the metropolitan area, the economic, political and cultural significance of the central city, the distance between the airport and the central business district (CBD), the location of the airport with respect to major activity centres, and to a certain extent, on the percentage of nonresidents among the passenger population.

### 1.1.3 Nonresidents and Ground Access Trips

Nonresidents among the airport tripmaking population have slightly different demands on the ground access system. Nonresidents are usually unfamiliar with the city and tend not to venture beyond the city centre, especially if they are not visiting anyone from the region. A large proportion of nonresidents among the passenger population will therefore generate a greater flow between the city centre and the airport.

### 1.1.4 Baggage and Access Modes

An obvious particularity of airport access trips is that airport tripmakers, particularly air passengers, carry baggage with them to and from the airport. For this reason passengers often prefer the convenience of modes that offer door-to-door service such as private modes.

### 1.1.5 Jurisdiction Over Airports and Ground Access Issues

Even though providing good access is an important issue for airport authorities it is one over which they do not have direct decision-making power. Operation and maintenance of the highway and local road network providing access to the airport is usually the responsibility of governmental agencies, often with limited budgets and a wide range of priorities to consider.

In Canada, air transportation is under the jurisdiction of Transport Canada, a federal agency. As of 1991, the federal government owned and operated 226 airports, either solely or with other municipalities, provinces, territories, or private management firms (TRANSPORT CANADA, 1991 IN HIRSHHORN, 1992). In 1987, the federal government amended its airport policy to allow the transfer of major federal airports (MFA) to local airport authorities (LAA) (HIRSHHORN, 1992). As a result of this policy, LAAs in four major Canadian cities - Calgary, Edmonton, Vancouver and Montreal, assumed responsibility for the day-to-day operations and long-term development of their respective airports. In Montreal the local airport authority *Les Aéroports de Montréal* (ADM), came into being in 1989 and took over operations at both Dorval and Mirabel International Airports in August of 1992 (Aéroports de Montreal, 1993a). ADM consults with the *Société de promotion des aéroports de Montréal (SOPRAM)* on all issues concerning the development of Montreal's International Airports. *SOPRAM* is a regional cooperation agency made up of representatives from the Board of Trade of Metropolitan Montreal, the *Chambre du Commerce du Montréal métropolitain*, the Conference of Suburban Mayors, the *Corporation de promotion à Mirabel*, the cities of Montreal, Laval, and Longueuil together with the *Société montérégienne de développement* (Aéroports de Montréal, 1993a). ADM was formed after *SOPRAM*, successfully campaigned the federal government to allow the operations and management of Montreal's International Airports to be transferred to a local airport authority.

ADM's main objective is to manage and develop Montreal's International Airports in the best interest of the Greater Montreal Region (Aéroports de Montréal, 1993a). Part of their development plan includes the improvement of access to the airports. To do this, ADM formed partnerships with the provincial government, the City of Montreal and the Montreal Urban Community (MUC) who each have different roles and responsibilities concerning the transportation network. The responsibility of operations and management of the highway network is relegated to the provincial government. The local road network however in each municipality is the responsibility of the municipal government. The following table summarizes the role of each level of government and authority in ground access issues.

**Table 1. 1: Jurisdiction Over Air Transportation and Ground Access Issues in Canada** (HIRSHHORN, 1992)

| LEVEL OF GOVERNMENT/ ORGANIZATION | DESCRIPTION OF ROLE |
|---|---|
| ***Local Airport Authority*** | • 60-year lease with federal government;<br>• Assumes responsibility over the daily operations and long-term development of the airport. |
| ***Federal*** | • Landlord for MFAs that are run by LAAs;<br>• Continued responsibility over air navigation, safety, and other general regulatory functions. |
| ***Provincial*** | • Assumes responsibility over the operations and maintenance of the highway road network. |
| ***Municipal*** | • Assumes responsibility over the operations and maintenance of the local road network (service roads, arterials, collector and local streets) connecting to and from the highway facilities. |

MFA: Major federal airport
LAA: Local airport authority

## 1.2 SOLUTIONS FOR IMPROVING AIRPORT ACCESS

Solutions for improving airport access are unique to each airport system. It is impossible to simultaneously improve access for all passengers, employees and visitors because of the dispersion of ground trip origins and destinations. In most cases, the efforts involve improving the access between the central business district (CBD) and the airport, or other major activity centres that are likely to attract or produce the greatest proportion of airport ended trips.

In his examination of airport access, PENDAKUR (1974) states that exclusive access facilities, such as airport parkways or rapid transit lines, as a solution to general congested traffic conditions face two limitations: 1) only the highest concentrations of air passenger origins and destinations would be linked; 2) the capacity of an exclusive ground-access facility is too large to accommodate passengers only. Due to their capital-intensive nature, this type of solution is often not cost-effective.

In his study of American and European airports, COOGAN (1995) revealed that rail-based alternatives work best when they are connected to the national railway network as opposed to being an exclusive link. For example, Amsterdam, Zurich, Munich, Frankfurt, London - Heathrow, London-Gatwick, Paris-Orly, Paris-de Gaulle and Brussels all have railways integrated into the terminal which are also connected to the national railway system.

In Montreal, the airport authority, ADM, has proposed short, medium and long-term solutions for improving airport access to Dorval and Mirabel Airports which would also benefit the region (HORNBLOWER, 1994). In the short term, ADM proposed high occupancy vehicle (HOV) reserved lanes on two highways: 1) Highway 13 to facilitate access between Dorval and Mirabel Airports, as well as between Mirabel Airport and Downtown Montreal; and 2) Highway 20 to facilitate access between Dorval Airport and Downtown Montreal.

Other projects that ADM proposes for the improvement of access to its airports include in the medium term, a rail link connecting to the suburban commuter line operated by the Montreal Urban Community Transit Corporation (MUCTC), and in the long term, a high speed train in the Quebec-Windsor corridor that would include a stop at Mirabel Airport.

## 1.3 FUNCTIONAL COMPONENTS OF AN AIRPORT ACCESS SYSTEM

The functional components of an airport ground access system consist of the available modes, the transportation infrastructure, the landside elements of an airport including the terminal building and curb, and remote facilities.

### 1.3.1 Access Modes

Airport access modes can be categorized as either road-based or rail-based. Table 1.2 summarizes the characteristics of these modes. Road-based modes include private modes such as automobiles, taxis, rental cars and limousines; and public modes such as transit buses. Rail-based alternatives include conventional railways - where an airport station is integrated into the national railway network; urban rail rapid transit - where an airport station is part of the urban rapid transit system; and exclusive service railways - where there is non-stop service from the city centre to the airport (COOGAN 1995).

Alternative modes to road- or rail-based modes also exist. These include vertical-take-off and landing (VTOL) modes, such as the helicopter, and waterborne modes such as the hydrofoil. These modes however are not frequently used.

### 1.3.2 Transportation Networks

A network of highway and street links, intersections, transfer points and terminals provide the means for modes to travel to and from the airport. Street intersections, highway access points, local, collector arterial and highway links grouped together in a hierarchical order of function and speed form the highway network. The urban transit network is composed of access points (bus stops, subway or train stations) and route links. The urban transit network can also be multimodal, as in the case of Montreal's transit network, grouping together surface transit (bus), subsurface (metro) and rail transit modes.

**Table 1.2: Classification of Airport Access Modes** (COOGAN, 1995; ASHFORD and WRIGHT, 1979)

| CATEGORY | TYPE | DESCRIPTION |
|---|---|---|
| *1. Road-Based:* | a) Private Modes: | a) Automobile, Taxi, Rental Car, Limousine; |
| | b) Public Modes: | b) Urban Transit, Special Bus, Chartered Bus, Hotel Shuttle. |
| *2. Rail-Based:* | a) Conventional rail; | a) Airport station located on the national railway network. Predominant in Europe; |
| | b) Conventional urban rapid transit; | b) Airport station located on the rapid rail transit network. Predominant in the U.S.; |
| | c) Specialized rail and high speed ground transport. | c) Monorail - Haneda Airport in Tokyo, TGV |

## 1.3.3 Airport Grounds

Figure 1.1 illustrates the functional components of an airport. Within the airport boundary, ground access elements consist of approach roads, circulation and distribution roads around the terminal and parking areas.

### 1.3.3.1 Terminal Building

The terminal building is the key transfer point for passengers transferring from land modes to an air mode. It contains the terminal curb, transition areas, airline facilities, terminal circulation, passenger amenities, departure lounges, customs and immigration operations, airline operations, airport operations and government offices. There are several possible configurations for terminals. Different configurations have different impacts on the ground transportation services. Passengers, visitors and employees need easy access to each terminal as well as to the ground transportation facilities. A prime example of one having a great impact on ground transportation is the multiple terminal configuration. In this case, the coordination of ground transportation is especially crucial for transferring passengers.

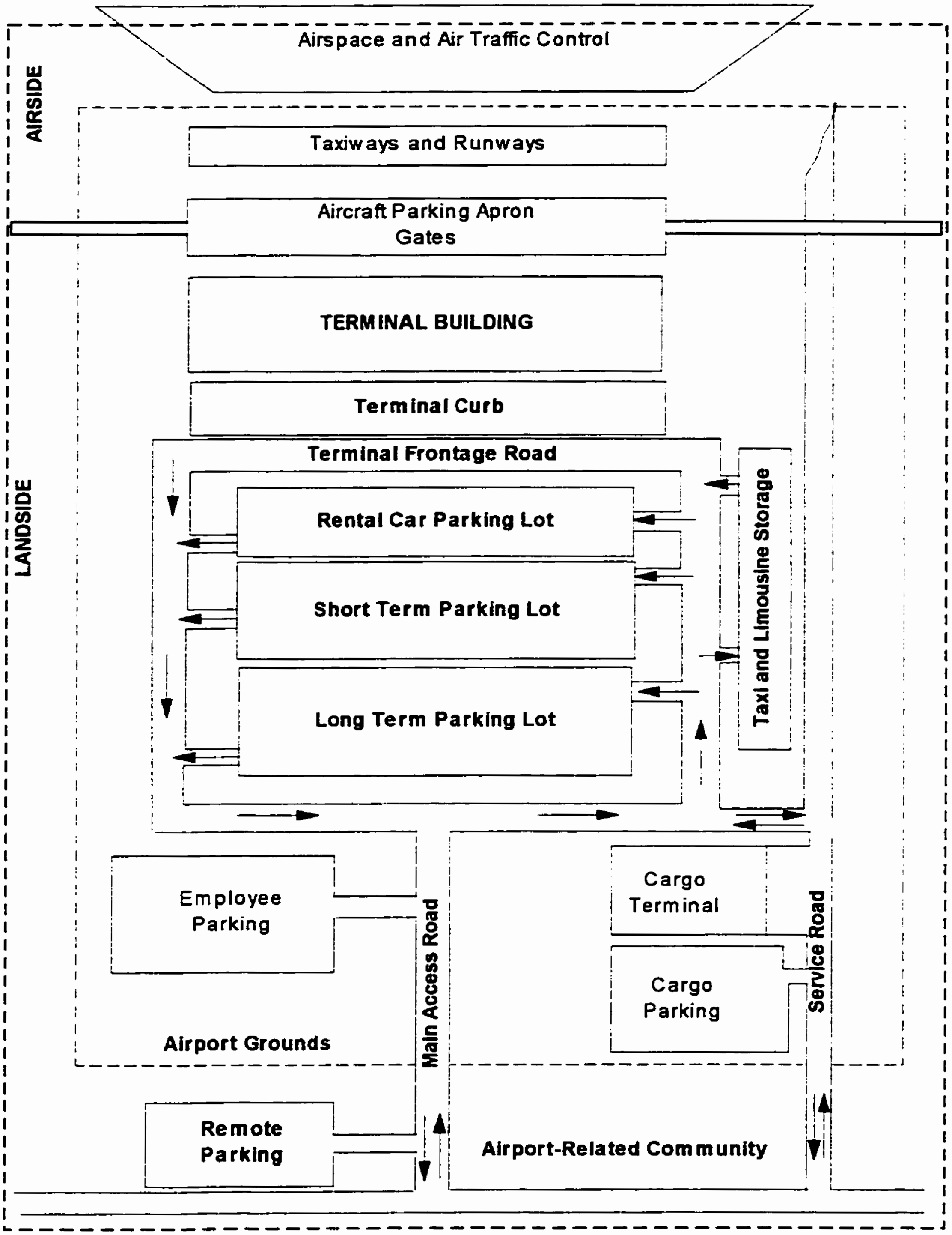



**Figure 1.1: Functional View of an Airport** (Adapted from TRANSPORT CANADA (1984))

#### 1.3.3.2 Terminal Curb

The terminal curb is the intermodal interface where originating passengers transfer from land modes such as the private vehicle, taxi, limousine, transit or shuttle, to air modes (and vice-versa for terminating passengers). It is a dynamic area of the airport which sees constant activity throughout the day, but especially prior to or immediately following a scheduled flight. The level of the activity is usually dependent upon the peak hour(s) for each flight sector for both departures and arrivals.

### 1.3.4 Remote Facilities

Remote facilities include remote air terminals and parking lots. Remote terminals provide advance check-in services which reduce some of the passenger processing operations that the passenger must complete prior to departure. These terminals are usually located in the city centre and offer a shuttle service from the remote terminal to the airport.

Remote parking lots are located in the vicinity of the airport but off airport grounds. These alleviate the parking traffic at the airport and offer parking at a lower rate. A shuttle provides service directly to the door of the terminal.

## 1.4 Factors Affecting Ground Access Modal Choice

Once a tripmaker decides to travel from point A to point B for a specific trip purpose, a combination of physical and nonphysical elements are taken into account in the selection of a route and a mode. Physical elements include the available modes and corresponding networks, and the geographical location of the points of origin and destination. Nonphysical elements include the service attributes of the transportation system, and the socioeconomic and demographic characteristics of the tripmaker. Service attributes are a combination of perceived and actual characteristics of the trip using a particular mode and includes the following: direct and indirect costs, in-vehicle travel time, walking distance, access time, comfort and preference. Socioeconomic and demographic characteristics include the age, gender, occupation, status, income and car possession of the tripmaker.

The tripmaker's trip purpose also has an effect on modal choice. Business travellers are more apt to select private modes, whereas recreational travellers may use either private or public modes. The choice of an access mode also differs for residents and nonresidents of the region. Nonresidents are more apt to select public modes since they do not have their cars and may prefer not to bother with driving in unfamiliar territory. Furthermore, the geographical location of trip origins and destinations in relation to the airport are different for residents and nonresidents. Trip origins and destinations are more likely to be the city centre for nonresidents, and dispersed throughout the region for residents they are more likely to be dispersed throughout the region.

HARVEY (1986) used the multinomial logit model in the analysis of airport access modal choice for the residents of the San Francisco Bay Area. His results revealed that selection of an airport access mode is greatly dependent on trip purpose, travel time and travel cost. Business travellers were more sensitive to access time and less sensitive to associated costs compared to non-business travellers. His analysis also revealed that more than having one piece of luggage reduced the attractiveness of transit. Further, when the gender of the traveller was considered in airport access modal choice, it was found that women tended to prefer modes that offer door-to-door escorted service.

In North America, the predominant type of mode used to access the airport are road-based private modes such as the personal automobile, taxi, rental car or limousine. COOK (1970) explains that this is due mainly to the geographical distribution of airport-bound trips, the convenience of nonstop, door-to-door service with luggage carrying capabilities, and the ability to avoid vehicle transfers. The disadvantages of private modes include: the operating costs such as parking, taxi fare, or rental fees; the susceptibility to time delays due to mix with regular traffic in the highway network; and the time needed to secure parking at the airport if the private vehicle is used. In his article on ground access to Heathrow Airport in London, HOLE (1970) explains that the propensity to use private modes over public ones in the United States is due mainly to the structure and decentralization of its cities.

While public transportation modes can move more passengers than automobiles and can eliminate the delays and cost due to parking, some of the reasons why transit systems to airports are less favourable and therefore less frequently selected are: the great walking distance, the lack of baggage handling facilities and a lack of knowledge of the transit system. In addition, public transportation modes can also be susceptible to the same delays on the highway network as automobiles.

In contrast, COOGAN'S (1995) analysis of European and American airports revealed that there is an increasing trend in the use of rubber-tired, higher-occupancy access modes such as buses and taxis, and a decrease in the use of the automobile, both private and rented, at Logan International Airport in Boston, Massachusetts and at National Airport in Washington, D.C.. Furthermore, air travellers in larger cities such as New York, Chicago and San Francisco are showing a willingness to pay higher prices for better quality and more direct services like shared-ride services such as hotel shuttle services. Therefore, if the disadvantages of private modes persist and the less favourable conditions of public modes can be improved, perhaps a similar trend can be expected to be arise in other North American cities as well.

## 1.5 MONTREAL'S INTERNATIONAL AIRPORTS

The Greater Montreal Area (GMA) is presently served by two international airports: Dorval and Mirabel International Airports. Dorval serves the domestic and transborder flight sectors, while Mirabel handles mostly scheduled international and charter traffic. This division in flight traffic has been in place since the opening of Mirabel Airport in 1975. In 1997, scheduled international flights will return to Dorval Airport, leaving Mirabel to handle charter flight traffic and air cargo only.

Dorval Airport is one of the top three airports in Canada in terms of the volume of enplaned and deplaned passengers, ranking third after Toronto-Lester B. Pearson International, and Vancouver International Airport (TRANSPORT CANADA, 1993). Mirabel ranks eighth after Calgary, Ottawa, Winnipeg and Halifax International Airports. In 1993, 5.8 million passengers departed and arrived in Montreal through Dorval Airport, while Mirabel Airport handled 2.4 million enplaned and deplaned passengers (ADM, 1993A).

Dorval Airport is located in the City of Dorval which is 22 km west of downtown Montreal. Mirabel Airport is located on the northern shore of Jésus Island (Laval) and the Island of Montreal, approximately 60 km north of downtown Montreal.

A remote airport terminal, the City Centre Air Terminal, exists as of 1995, in downtown Montreal located next to Central Station (VIA Rail). Air Canada offers advanced check-in facilities to its passengers bound for domestic destinations. An airport shuttle transports passengers to both airports from this point.

### 1.5.1 Highway Access

Highway access to Dorval Airport is provided by Highway 520 (Côte-de-Liesse Boulevard) which connects Highways 40 and 20. From Highway 520, Boulevard Romeo-Vachon provides access to the airport grounds. Local road access is also available from Cardinal Avenue in the City of Dorval.

Highway access to Mirabel Airport is provided by Highway 15. The extension of Highway 13 to the north would have provided an alternative to Highway 15, especially for West Island residents. However, the provincial government has placed this project on hold indefinitely. Figure 1.2 shows the highway access routes for both Dorval and Mirabel Airports.

### 1.5.2 Transit Access

Public transit service to Dorval Airport is provided by the Montreal Urban Community Transit Corporation (MUCTC). The No. 204 bus connects Dorval Airport to the commuter rail line, also operated by the MUCTC, which runs from Downtown Montreal to the western suburban community of Rigaud. The No. 204 also provides service to local West Island communities. No public transit service is provided by the MUCTC to Mirabel.

Mass transit service is also provided by ADM's autocar - airport shuttle bus operated by Autocar Connaisseur. The autocar provides service between Downtown Montreal and each airport, as well as service between the airports.

Other forms of mass transit include hotel shuttles which are independently run by each hotel, located in the proximity of the airport. Table 1.3 summarizes the ground transportation services available at each airport.

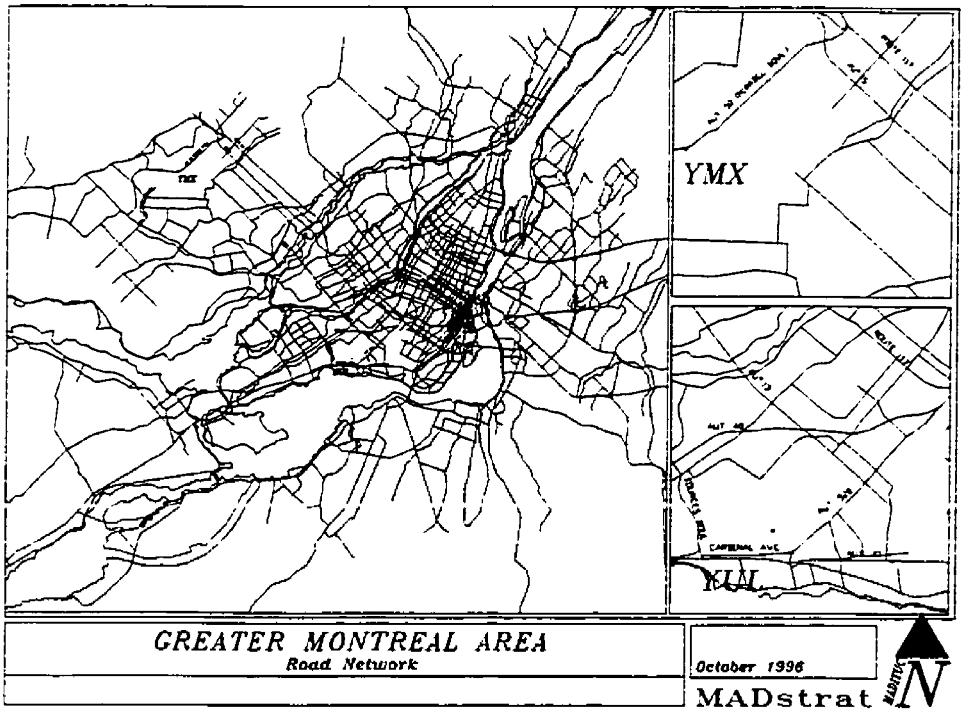



**Figure 1.2: Highway Access to Dorval and Mirabel International Airports** (MADITUC, 1996)

### 1.5.3 Parking Facilities

Dorval Airport has two parking lots: a multilevel interior parking structure adjacent to the terminal and an exterior lot adjacent to the multilevel parking structure. The lower level of the parking structure is reserved for rental car drop-off areas and parking lots. The lower level also accommodates, as of 1995, short-term (one-hour) parking and a valet parking service. Long-term parking is also available at Dorval Airport as of 1996.

Mirabel Airport also has two parking lots: a multilevel interior parking structure used for short-term parking which is located adjacent (north) of the terminal; an exterior long-term parking lot on the east side of the terminal.

Remote parking lots are available at the Airport Dorval Hilton located on the airport grounds, and at the Dorval VIA Rail station located approximately one kilometre south of the airport.

**Table 1.3: Ground Transportation Services Available at Montreal's International Airports**

| MODE | DORVAL - YUL | MIRABEL - YMX |
|---|---|---|
| ***Automobile*** | Parking facilities:<br>Multi-level<br>Exterior<br>Short-Term<br>Long-Term[1]<br>Valet[2] | Parking facilities:<br>Short-Term<br>Long-Term |
| ***Rental Car*** | Five car rental agencies are present. | Five car rental agencies are present. |
| ***Taxi*** | Approximate fare (1993):<br>• Dorval to Downtown: $24.00<br>• Dorval to Mirabel: $55.00 | Approximate fare (1993):<br>• Mirabel to Downtown: $58.00<br>• Mirabel to Dorval: $55.00 |
| ***Chartered Bus*** | Operated by air chartered companies. Cost included in price of airfare/package deal. | Operated by air chartered companies. Cost included in price of airfare/package deal. |
| ***Autocar - Airport Shuttle Service*** | Operated by Connaisseur Autocar[3].<br>• Daily service to and from downtown Montreal with stops at 3 hotels and the Voyageur Bus Terminal.<br>• Daily service to and from Mirabel Airport.<br>• The inter-airport shuttle is free for passengers in transit, and for children under the age of 4.<br>• Upon request, passengers may be dropped-off and picked up at a number of hotels in the downtown-area. | Operated by Connaisseur Autocar[2].<br>• Daily service to and from downtown Montreal with stops at the City Terminal and the Voyageur Bus Terminal.<br>Mirabel - Quebec City<br>• La Québécoise operates a bus service from Mirabel to Quebec City on a daily basis.<br>Mirabel - Ottawa<br>• Voyageur operates a bus service between Mirabel and Ottawa's Voyageur Terminal. |
| ***Public Transit*** | MUCTC operates a route which serves Dorval Airport. This route connects the airport to the commuter rail system at Dorval Station. | N/A |
| ***Hotel Shuttle*** | Courtesy shuttle service offered by hotels in the vicinity of the airport. | N/A |
| ***Limousine*** | Available. | Available. |

[1] Since 1996.

[2] Since 1995.

[3] Itinerary described is for 1993.

## 1.6 AIRPORT FLIGHT ACTIVITY

The flight activity of an airport is a key factor in its ground access trip production and attraction. Flight activity varies depending on the flight sector (domestic, transborder or international), and on whether it is a departure or an arrival. Domestic and transborder air traffic usually have similar departing and arriving flight schedules spread throughout the day whereas international flights tend to leave in the evening and arrive in the afternoon. There is also a variation in the frequency of flights. Flights to domestic and transborder destinations usually depart and arrive daily, while some international flights depart and arrive only once a week.

The temporal distribution of aircraft movements for both Dorval and Mirabel Airports is shown in Figure 1.3. Domestic and transborder movements are grouped together in this graph. It can be observed that the peak hour of activity at Dorval for both arrivals and departures is 5:00 p.m., while for Mirabel it is 4:00p.m..

The peak period of activity for each flight sector can be observed in Figures 1.4 and 1.5. These graphs show the distribution of departing and arriving flights for each of the three flight sectors. Flight activity in the domestic sector exhibits three peak periods for flight departures (7:00 a.m., 1:00 p.m. and 5:00 - 7:00 p.m.) and two peak periods for flight arrivals (8:00 a.m. and 5:00 p.m.). Transborder departing flights also exhibit a diurnal peak period although less prominent than domestic flight activity, with a significant drop in flight activity after the evening peak. The peak periods for transborder departing flights are 6:00 - 10:00 a.m. and 3:00 - 6:00 p.m.. Transborder arriving flights peak at 12:00 p.m., 4:00 p.m. and 10:00p.m.. The peak period for international departing flights is 7:00-8:00 p.m. while for arriving flights it is 3:00-5:00 p.m..

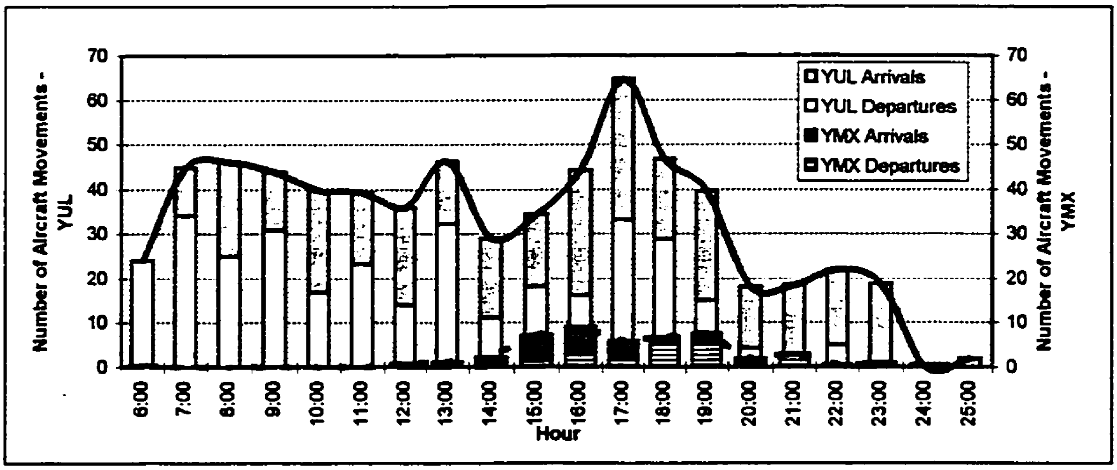



**Figure 1.3: Distribution of Aircraft Movements at Montreal's Airports** (ADM, 1993B)

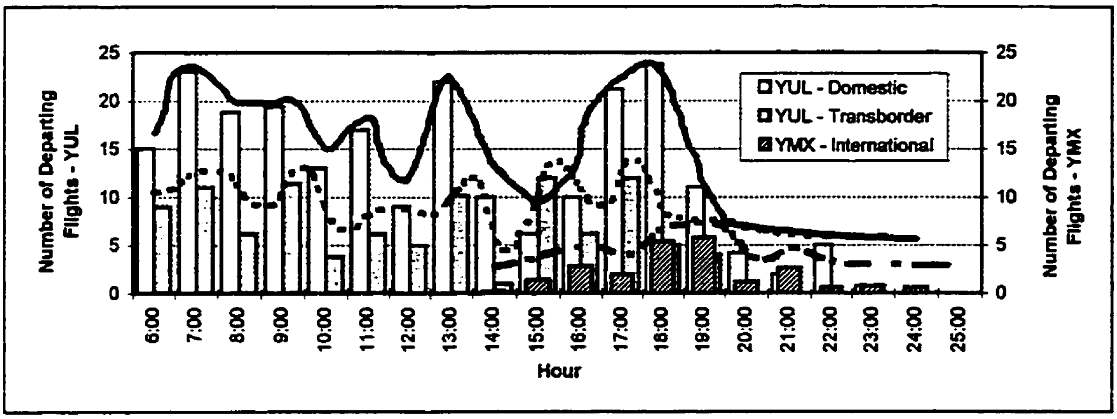



**Figure 1.4: Distribution of Departing Flights** (ADM, 1993B)

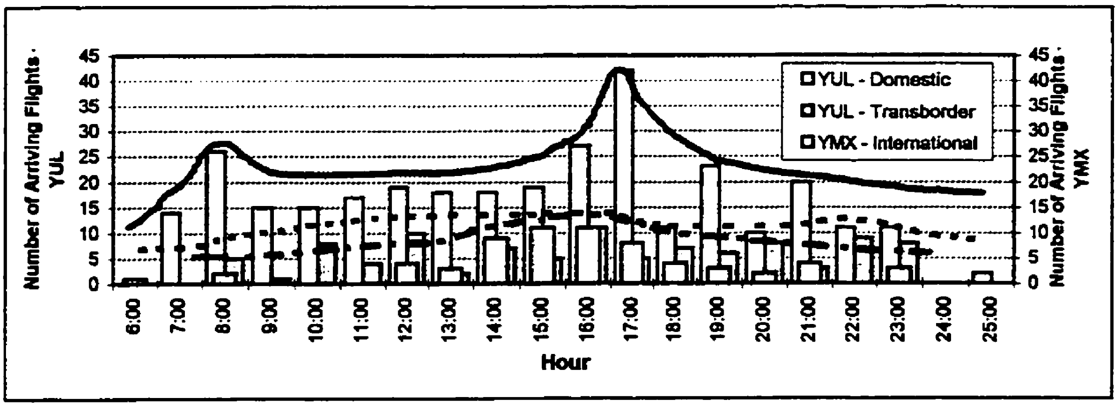



**Figure 1.5: Distribution of Arriving Flights** (ADM, 1993B)

## 1.7 AIRPORT GROUND TRANSPORTATION DEMAND

The previous sections have focused on the supply side of a ground access system. The ensuing sections will examine the demand side of a ground access system which allows the transportation analyst to characterize the trips made by the airport tripmaking population and therefore to understand the mobility needs of each category of tripmaker.

### 1.7.1 Airport Population

Air passengers arriving and departing from a given city's airport form only a portion of the airport population. Passenger well-wishers, visitors, airport employees and service suppliers are the other users of the ground transportation system to an airport. Table 1.4 presents the proportion of each subpopulation type at selected airports.

Each group has its own tripmaking behaviour which means that their needs for the access system are different as well. The diagram in Figure 1.6 illustrates the different combinations of airport-ended trips for each segment of the population. Departing and arriving passengers have open-ended trips; they do not make return trips on the same day they depart or arrive. Well-wishers, greeters, visitors and workers all have pendular-type trip itineraries; their trip chains include trips to and from the airport. The well-wisher's trip chain also depends on whether or not the air passenger is a member of the well-wisher's household. The same is true for passenger greeters. Further, the well-wisher trip chains illustrated in Figure 1.6 are also valid for people who accompany non-passengers such as workers. Visitors can have trip chains similar to well-wishers or greeters, however they do not interact with the passengers. The trip chain for service suppliers is considered typical of urban goods movement trip itineraries.

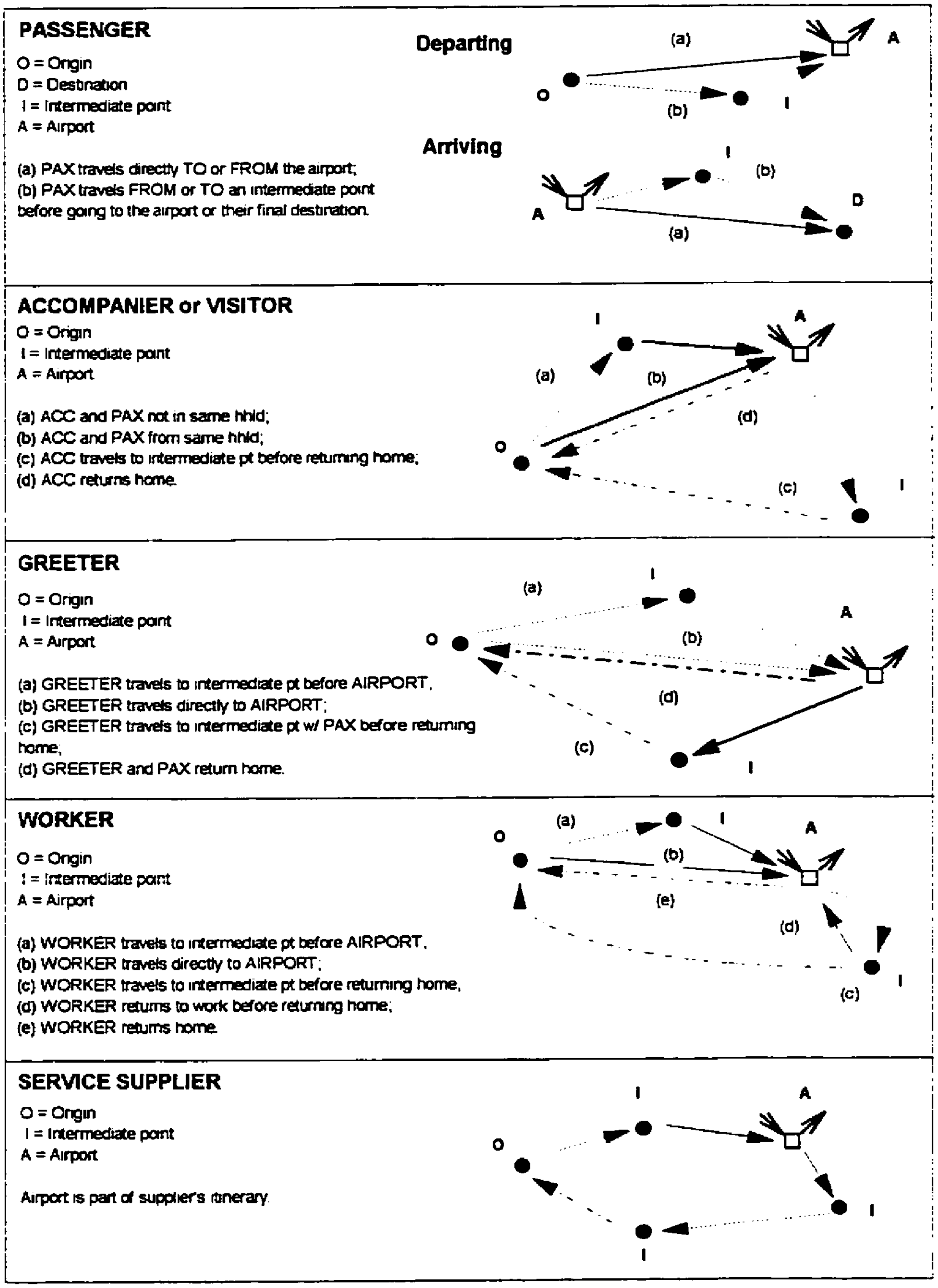



**Figure 1. 6: Tripmaking Behaviour of an Airport Population**

Air travellers are stratified according to their air trip purpose - business or leisure. The level of business air travel activity is influenced by the economic activity of the region served by the airport as well as by the investment and trade activity between two regions. Recreational air travel, on the other hand, is influenced by the amount of disposable income per capita of the city of origin. Business air travel demand is inelastic; the cost of air travel and ground access to the airport have little or no effect on the demand for air travel. Recreational air travel, on the other hand, is elastic. Recreational air travellers are sensitive to the cost of air travel and ground access. This difference is reflected in their travel behaviour both in the air and on ground (KANAFANI 1983).

**Table 1. 4: Proportion of Passengers, Workers, Visitors and Senders/Greeters at Selected Airports** (INSTITUTE OF AIR TRANSPORT SURVEY (1979) in ASHFORD and WRIGHT (1992))

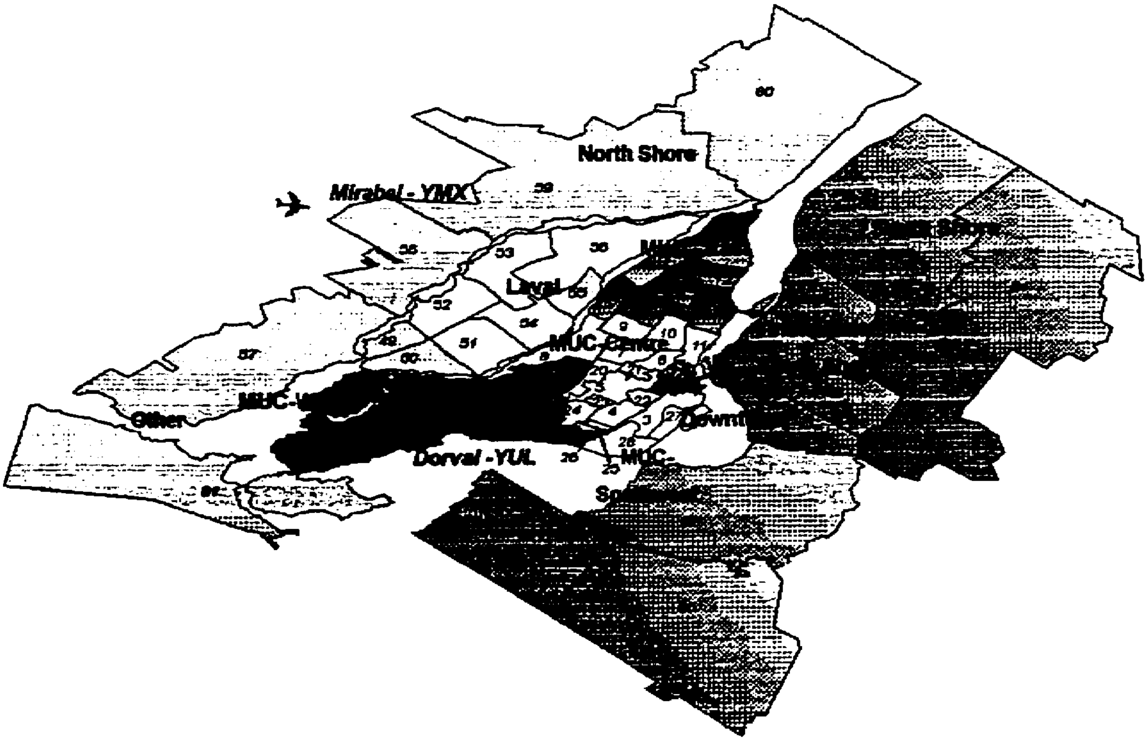
| AIRPORT | PASSENGERS | SENDERS AND GREETERS | WORKERS | VISITOR |
|---|---|---|---|---|
| *New York-JFK* | 0.37 | 0.48 | 0.15 | Not included |
| *Los Angeles* | 0.42 | 0.46 | 0.12 | Not included |
| *Atlanta* | 0.39 | 0.26 | 0.09 | 0.26 |
| *Toronto* | 0.38 | 0.54 | 0.08 | Not included |
| *Frankfurt* | 0.60 | 0.06 | 0.29 | 0.05 |
| *Vienna* | 0.51 | 0.22 | 0.19 | 0.08 |
| *Paris-Orly* | 0.62 | 0.07 | 0.23 | 0.08 |
| *Amsterdam* | 0.41 | 0.23 | 0.28 | 0.08 |
| *Mexico City* | 0.35 | 0.52 | 0.13 | Negligible |
| *Tokyo-Haneda* | 0.66 | 0.11 | 0.17 | 0.06 |
| *Singapore-Paya Labar* | 0.23 | 0.61 | 0.16 | Negligible |
| *Melbourne* | 0.46 | 0.32 | 0.14 | 0.08 |

### 1.7.2 Sociodemographic Characterization of the Greater Montreal Area Population

The territory under study in this research analysis is the Census Metropolitan Area of the Greater Montreal Area (GMA) as defined by Statistics Canada. The GMA accounts for a population of 2.9 million residents from over 100 municipalities which include: the 29 municipalities of the Montreal Urban Community, the City of Laval, and the municipalities of Montreal's North and South Shores. These municipalities are aggregated into a system of 66 municipal sectors as defined by the MUCTC in 1987. These sectors can be further aggregated into 10 zones: Downtown Montreal, MUC-Centre, MUC-East, MUC-West, MUC-SW, Immediate South Shore, Laval, North Shore, South Shore and Other (Figure 1.7).

Sixty-eight percent (68%) of the GMA population reside in the suburban communities of: the MUC-West, the MUC-East, the Immediate South Shore, Laval, the North and South Shores, and Vaudreuil. Analysis of the sociodemographic characteristics of this part of the population revealed that suburban households were larger (2.73 persons/hhld), younger (33.7 years old), wealthier ($47,863/hhld), and possessed more than one automobile per household (1.39 automobiles/hhld), than the central MUC area (Table 1.5).

High average household income and car possession are said to be indicators of increased mobility. In the case of air travel, income is one of the explanatory variables of personal air travel demand. Therefore, it can be expected that the residents of the suburban communities will create a higher demand for air travel. It can also be expected that multiple automobile households will choose the automobile over public modes to travel to either airport.




| MUC-Centre-Ville | MUC-Centre | MUC-East | MUC-West | MUC-Southwest |
|---|---|---|---|---|
| (1) Downtown Mtl<br>(2) Downtown Mtl Periphery | (3) Mtl: Southwest<br>(4) Mtl: N.D.G.<br>(5) Mtl: Côte-des-Neiges<br>(6) Mtl: Plateau Mont-Royal<br>(7) Mtl: Villeray<br>(8) Mtl: Ahuntsic<br>(9) Mtl: Saint-Michel<br>(10) Mtl: Rosemont<br>(11) Mtl: Southeast<br>(20) Mont-Royal<br>(21) Outremont<br>(22) Westmount<br>(23) Hampstead<br>(24) Côte-Saint-Luc | (12) Mtl: Mercier<br>(13) Mtl: Pointe-aux-Trembles<br>(14) Mtl: Rivière-des-Prairies<br>(15) Mtl: Montréal-Est<br>(16) Anjou<br>(17) St-Léonard<br>(18) Montréal-Nord | (19) Saint-Laurent<br>(29) Lachine<br>(30) Dorval<br>(31) Pointe-Claire<br>(32) Dollard-des-Ormeaux<br>(33) Roxboro<br>(34) St-Raphaël-de-l'île Bizard<br>(35) Ste-Genevieve<br>(36) Pierrefonds<br>(37) Kirkland<br>(38) Beaconsfield<br>(39) Baie d'Urfé<br>(40) Ste-Anne-de-Bellevue<br>(41) Senneville | (25) Montréal-Ouest<br>(26) Saint-Pierre<br>(27) Verdun<br>(28) LaSalle |
| **Immediate South Shore** | **Laval** | **North Shore** | **South Shore** | **Other Municipalities** |
| (42) Longueuil<br>(43) St-Lambert<br>(44) Lemoyne<br>(45) Greenfield Park<br>(46) St-Hubert<br>(47) Brossard<br>(48) Boucherville | (49) Laval-Ouest<br>(50) Ste-Dorothée, Laval-sur-le-Lac<br>(51) Chomedey<br>(52) Ste-Rose, Fabreville<br>(53) Vimont, Auteuil<br>(54) Laval-des-Rapides, Pont Viau<br>(55) Duvernay, St-Vicent-de-Paul<br>(56) St-François | (57) Deux-Montagnes<br>(58) Thérèse-de-Blainville<br>(59) Les Moulins<br>(60) L'Assomption | (62) Roussillon<br>(63) Lajemmerais<br>(64) La Vallée du Richelieu<br>(65) Les Jardins-de-Napierville | (61) Vaudreuil-Soulanges<br>(66) GMA |

**Figure 1.7: Greater Montreal Area** (MADITUC)

**Table1.5: Sociodemographic Characteristics of GMA Residents**

| Zone | Population [1] | Population Density[1] | HHLD[1] | Persons/ HHLD | HHLD Income[1] | No.Cars/ HHLD[2] | Average Age[2] | % F[2] |
|---|---|---|---|---|---|---|---|---|
| *Downtown Mtl.* | 62070 | 6145.54 | 34 615 | 1.79 | $ 36,153 | 0.47 | 38.7 | 0.48 |
| *MUC-Centre* | 732172 | 6212.75 | 333970 | 2.19 | $ 39,599 | 0.79 | 37.5 | 0.53 |
| *MUC-East* | 389230 | 3696.74 | 167659 | 2.32 | $ 37,565 | 1.07 | 36.1 | 0.53 |
| *MUC-West* | 314600 | 1471.81 | 115656 | 2.72 | $ 53,948 | 1.31 | 35.3 | 0.51 |
| *MUC-SW* | 145258 | 5121.93 | 62695 | 2.32 | $ 39,897 | 0.96 | 37.4 | 0.52 |
| *Imm. S-Shore* | 346530 | 1492.57 | 129072 | 2.68 | $ 48,348 | 1.32 | 33.9 | 0.52 |
| *Laval* | 257316 | 1040.50 | 89965 | 2.86 | $ 50,196 | 1.44 | 34.4 | 0.51 |
| *North Shore* | 358604 | 340.39 | 121876 | 2.94 | $ 47,777 | 1.63 | 30.9 | 0.50 |
| *South Shore* | 331084 | 213.18 | 113021 | 2.93 | $ 52,069 | 1.65 | 32.0 | 0.50 |
| *Other (Vaudreuil)* | 84503 | 99.16 | 30036 | 2.81 | $ 49,129 | 1.42 | 33.9 | 0.51 |

[1] Statistics Canada (1991)

[2] MADEOD (MUCTC-MTQ 1993 O-D Survey)

## 1.8 ANALYSIS OF AIRPORT GROUND ACCESS

A transportation analyst must select an analysis approach that corresponds to the issue being studied and makes the best use of the available data.

### 1.8.1 The Aggregate Approach

The classical transportation planning approach, first developed in the 1950s, consists of a series of four individual modelling steps:

- Trip generation models determine the number of trips produced and attracted by each zone based on socioeconomic and land-use information.
- Trip distribution models determine origin-destination flows by linking trip productions and attractions in the first step.

- Modal split models determine the percentage of trips that will use given modes (car, transit, etc.).

- Trip assignment assigns a route for all origin-destination flows, for each mode on the respective transportation networks (highway, transit, ...).

The result of this sequential process is a series of link flows for each defined mode.

Aggregate transportation planning and analysis approaches rely on three principal elements: an analytical transportation network on which vehicles operate (highway, transit, multimodal), a system of zones into which the territory under study is divided into, and trip information stored in an origin-destination matrix. All sociodemographic as well as land-use information is aggregated in the form of zonal averages for each respective zone.

Computer-based transportation planning models that are based on the classical, aggregate approach include: UTPS (Urban Transportation Planning System), EMME (*Equilibre Multimodal*, Multimodal Equilibrium) and subsequently its updated version EMME/2, and QRS II (Quick Response System). Also included are models specializing in transit network planning such as NOPTS (Network OPtimization of Transit Systems) and TERESE, as well as models that specialized in highway network planning, such as the DAVIS model.

Aggregate transportation models have been the subject of much criticism by transportation planners over the past 20 years. At issue is the accuracy of the obtained results, the structure of the model as well as the purpose of modelling. The most common criticism of aggregate models is that the resulting model interprets the tripmaking behaviour of the average individual of each zone, and does not take into account the possible variation within the zone. Further discussion on the shortcomings of aggregate models can be found in ATKINS (1986).

Despite much criticism of the aggregate approach by transportation planners, this approach is still used today by transportation planners, probably due to, as SUPERNAK[1] (1982, IN ATKINS, 1986) hypothesizes, to the reluctance of planners to use a new alternative which either may not be better than the old one, or is too complex or requires a large amount of data. Nevertheless, the classical aggregate approach can still help the transportation analyst to fully apprehend the substantive challenges of transportation issues, as well as the methodological challenges transportation planners are faced with.

### 1.8.2 The Disaggregate Approach

In response to the criticism of aggregate models, a new series of behavioural models were developed in the 1970s. Unlike aggregate models, the basic analysis unit in the disaggregate approach is the individual. Choice models are not tied to any particular zone structure, making them theoretically transferable from one city to another. The premise of this type of model is one of utility maximization for a given type of tripmaker. A person will select an alternative from among a set of independent alternatives, from which he can derive the most benefit, or utility. The most common application of choice models to transportation planning has been modal choice modelling (MEYER AND MILLER, 1984). Most of the development of these models can be attributed to WARNER, BEN-AKIVA and MACFADDEN (BONNEL ET AL., 1994).

The multinomial *logit*, the *probit* and the *dogit* models are all examples of disaggregate modal choice models. These models determine the probability that a tripmaker will select a given mode based on a series of utility functions for each available mode.

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[1] Supernak, J. (1982). "Transportation Modelling: Lessons from the past and tasks for the future". PTRC Annual Conference.

As mentioned, planners were reluctant to use these new generation models due to their mathematically-intensive and theoretical nature (HARTGEN[1], 1983 in ATKINS, 1986). Furthermore SUPERNAK(1982 in ATKINS,1986) also noted that new generation discrete mode choice models exhibit weaknesses in the areas of spatial transferability and forecasting ability.

### 1.8.3 The Totally Disaggregate Approach

The totally disaggregate approach to transportation planning analysis is an alternative to aggregate and disaggregate models previously developed and used. This approach does not totally reject the classical sequential approach; instead it offers a better definition of certain elements. The notion of "disaggregate" refers to the systematic processing of individual, trip-related information, as well as to the level of refinement of territorial or zonal divisions to the point of nonexistence.

The totally disaggregate approach embodied in the MADITUC system, created and developed by Professor Robert CHAPLEAU of the *École Polytechnique de Montréal*, replaces the notion of modelling with that of an information system (CHAPLEAU, 1995). The components of such an information system include the following:

1. **Technical Professionals.** Their role is to provide the decision-maker with the relevant technical knowledge for the transportation issue at hand. Their expertise is based on the manipulation of planning instruments and on the validation and interpretation of data.

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[1] Hartgen, D.T. (1983). Executive Summary. Travel Analysis Methods for the 1980s. Transportation Research Board Special Report 201, pp.3-4

2. **Methods and Procedures.** A series of technical methods and analysis procedures specifically related to the transportation issues and planning scope of the problem at hand.
3. **A Computer System.** The system must be able to support both processing, analysis, presentation and diffusion of transportation data.
4. **Software.** Both generic and application software are required to provide a navigational interface for the processing and analysis of the databases as well as for the presentation of results, occasionally in original and creative ways.
5. **Relational databases.** These databases contain information on the study ***territory***, the transportation ***networks*** and the ***demand***, which is defined by socioeconomic, demographic and geomatic data.

For an information system to be 'coherent and integrated' (CHAPLEAU, 1995) the structure of the data must be compatible with that of other sources of data such as, census data, so that additional sociodemographic explanatory variables can be used in the transportation planning analysis.

The totally disaggregate approach was originally applied to the analysis of urban transit network trips. The innovation of the MADITUC system replaces the traditional aggregate planning sequence of ***O-D trip matrix - simulation - network flows,*** with a series of data operators or modules which enrich the O-D trip database. These data operators are:

1. **Validation.** This operator filters out implausible spatial information or connectivity of the subsequent trip chain, and transforms declared information into structured data records.
2. **Access.** This module determines the most likely entry and exit points from the network given the trip origin and destination.

3. **Path.** The path calculation operator uses an impedance function that factors fares, penalties, waiting time, walking, multiple transit systems and mode of transportation.
4. **Load (Assignment):** This module reassigns flows across the network after the fact.
5. **Selection and Extraction.** These procedures enable the decomposition of data in the analysis.

Figure 1.8 illustrates the difference between the aggregate approach and the totally disaggregate approach. Contrary to the aggregate approach which is limited to determining not much more than link flows, the totally disaggregate approach permits the individual treatment of trips as well as the analysis of network elements such as the usage of routes, links and nodes.

The continued research and development efforts of the Groupe MADITUC at the École Polytechnique de Montréal have produced a second software system, MAD(Strat)$^2$. This system applies the totally disaggregate approach to planning and analysis of urban goods movement planning on a road network. It possesses the ability to analyze the movements generated by a multifaceted demand (e.g., multiproduct, multinetwork and multimodal).

The MADITUC-MAD(Strat)$^2$ environment uses the concept of object-oriented modeling in its simulations and subsequent demand analyses. This type of modeling approach uses the notion of objects such as persons, trips or households, as entities with their own set of attributes, and are considered as distinct elements of a modeling system, which are defined by the interrelationships within the system. Two types of objects can be created from an O-D survey database: object-entities and point-entities.

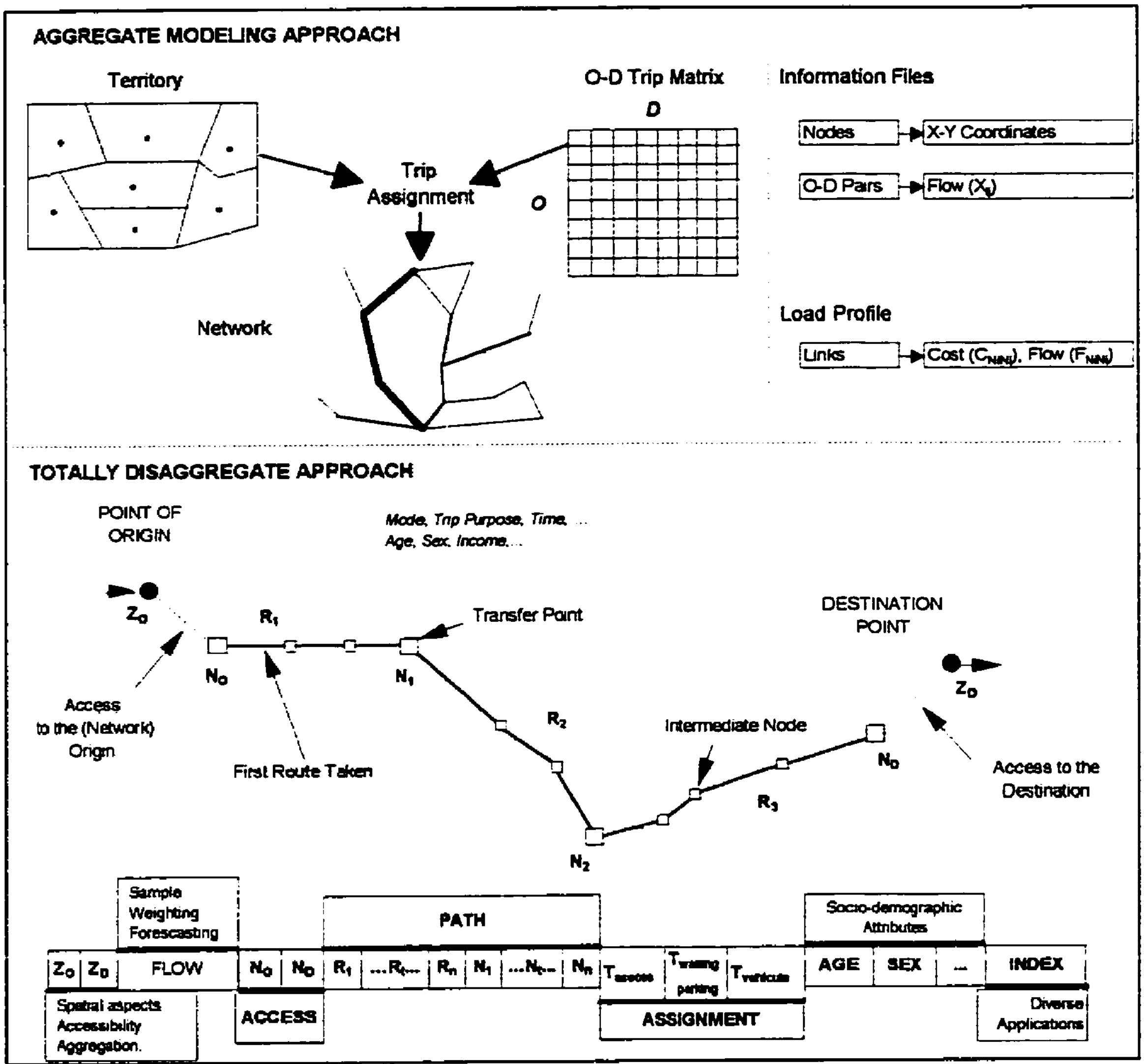



**Figure 1.8: Comparison of Aggregate and Totally Disaggregate Models** (CHAPLEAU, 1994)

- *Object-entities* are entities created by applying logic to a person's trip chain. For example, a status can be attributed to a tripmaker based on his declared activities as defined by the trip purpose, and on the duration of each activity.

- *Point-entities* are entities created by the juxtaposition of trip destinations with trip purpose. For example, a place of employment is determined by relating the declared destination with a work trip purpose.

Further, by relating object-entities to point-entities, two analyses are possible. The first is the analysis of each type of object-entity at each point-entity. The second is the analysis of the number of trips with a destination at a given point-entity, for each trip purpose and mode (CHAPLEAU, 1993). The diagram in Figure 1.9 illustrates the reorganization of the data structure for an O-D survey trip database, such as that of the Montreal Urban Community Transit Corporation's (MUCTC) regional O-D survey, so that the data can be used for MADITUC's Object-Oriented Modelling (MOOM).

The totally disaggregate approach is the selected approach for this analysis of airport ground access trips because of its ability to retain all the information for a given trip throughout all data operations. This type of modelling approach uses the notion of objects such as persons, trips or households as entities with their own set of attributes, and are considered distinct elements of a modelling system affected by interrelationships within the system.

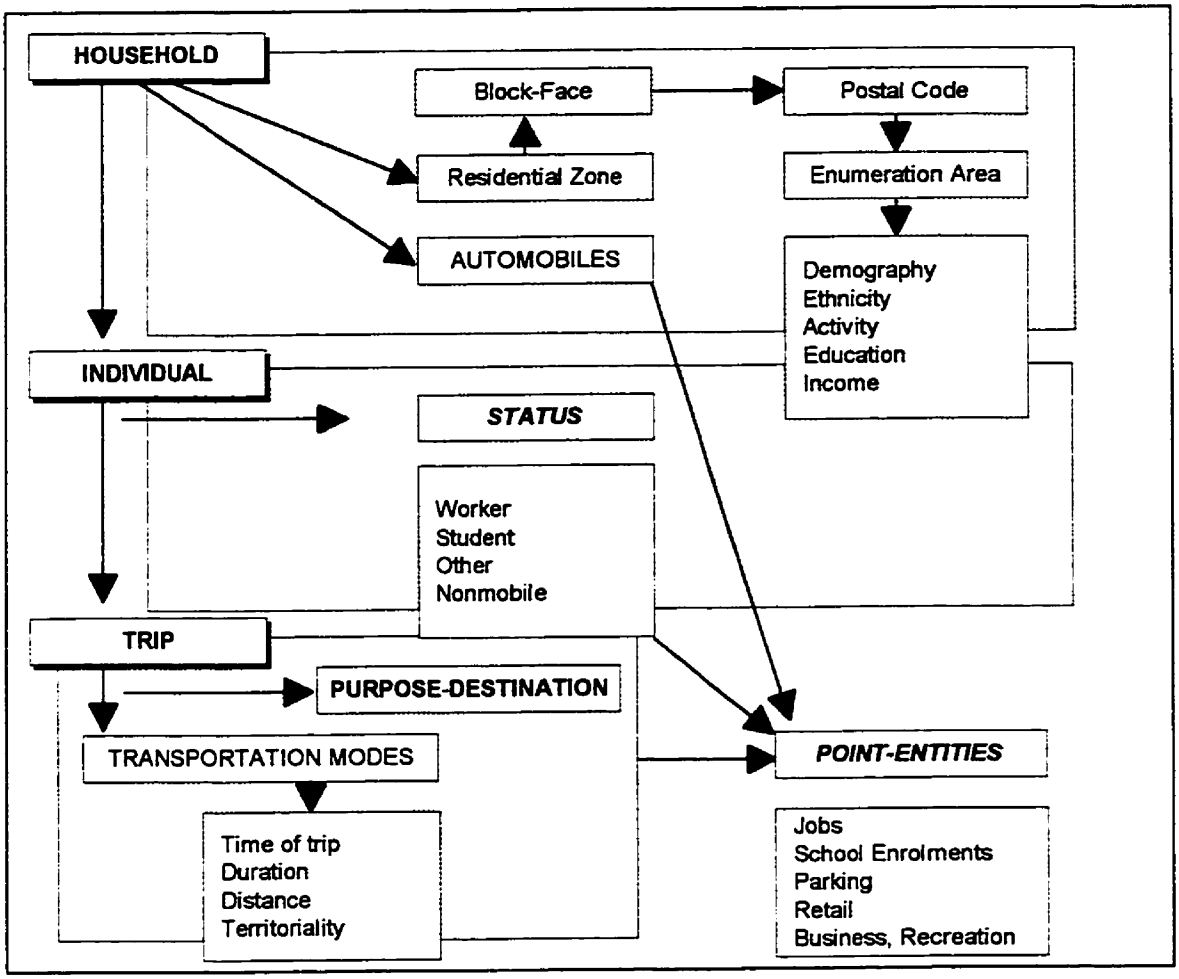



**Figure 1.9: Architecture of Data Used for MADITUC'S Object-Oriented Modelling** (CHAPLEAU, 1995; CHAPLEAU, 1993)

## 1.9 CHAPTER SUMMARY

This chapter presented the concepts essential to understanding the potential problems associated with airport ground access trips. Both the supply side of ground access systems and the demand for ground access were described setting the context for the analysis of ground access trips for the two Montreal International Airports.

In summary, airport tripmakers, particularly air passengers, are sensitive to ground transportation delays due to the high cost associated with the possibility of a missed flight. Furthermore, the geographical distribution of airport trip ends depends on the structure and size of the metropolitan area, the location of the airport with respect to the CBD or other major activity centres, the economic, political and cultural importance of the city, and the proportion of nonresidents among the airport tripmaking population. Passengers usually travel with baggage, which is an added burden to the trip. The multi-jurisdiction of the airport access system and of airport requires the collaboration between different levels of government and other authoritative organizations.

A review of the literature revealed that in general, automobile-based modes are popular access modes in North America. Mass transit alternatives are not selected due principally to increased access time and the burden of luggage.

An overview of the existing analysis approaches was presented along with a discussion of their strengths and weaknesses. The totally disaggregate approach was introduced as the selected approach for this research analysis of ground access trips for its ability to identify and analyze different classes of airport tripmakers, while retaining all individual information throughout all data operations.

# CHAPTER TWO

# METHODOLOGY OF ANALYSIS

While regional origin-destination (O-D) surveys are useful for defining and describing the mobility of a regional population, they are limited in their ability to characterize the ability needs of airport users, given the proportion of nonresidents among airport users. For this reason, site-specific airport users O-D surveys are conducted for use in airport systems planning or analysis.

Nevertheless, it is important to use data from a regional survey such as the one conducted by the MUCTC to analyze the characteristics of airport trips and tripmakers to the extent that is possible since the totally disaggregate approach and the MADITUC modelling system were developed using MUCTC O-D survey data. Analyzing an extracted data subset of the MUCTC O-D survey data provides insight to the data structure necessary for analysis using the totally disaggregate approach.

Therefore, two sets of data were used to analyze airport ground access trips for Montreal's International Airports at Dorval and Mirabel. The first set consisted of data taken from the Modal Choice and O-D Survey conducted for *Les Aéroports de Montréal* (ADM) by Dessau Inc. in June 1993. The second set is a subset of data extracted from the MUCTC-MTQ regional O-D Survey conducted in the fall of 1993.

The methodology used to process and analyze airport access trips consisted of the steps shown in Figure 2.1. First, data records were examined for anomalies and a decision was made whether to correct or reject the record. Expansion factors were then calculated for ADM trips based on the population of each type of airport tripmaker, flight sector and passenger air trip purpose. The data was then compiled and used to describe the profile of the typical passenger and passenger greeter airport access trip. The MUCTC-MTQ data was used to provide a supplementary analysis of passenger greeters to that obtained using the ADM data.

This chapter begins with a review of the methodological elements of a transportation survey. The methodology of the ADM O-D Survey is reviewed and compared with that of the MUCTC-MTQ O-D Survey to identify the strong points and weaknesses of each in characterizing airport trips. Next, the data structure of the two data sets are compared to identify the required type of processing (batch or interactive). The data validation and correction procedures used for both sets of data and development of expansion factors for the ADM databases is then presented, followed by a description of the variables derived for each data set. Classification of the trips to be further analyzed in Chapter 3 and a discussion on the statistical significance of these samples concludes this chapter.

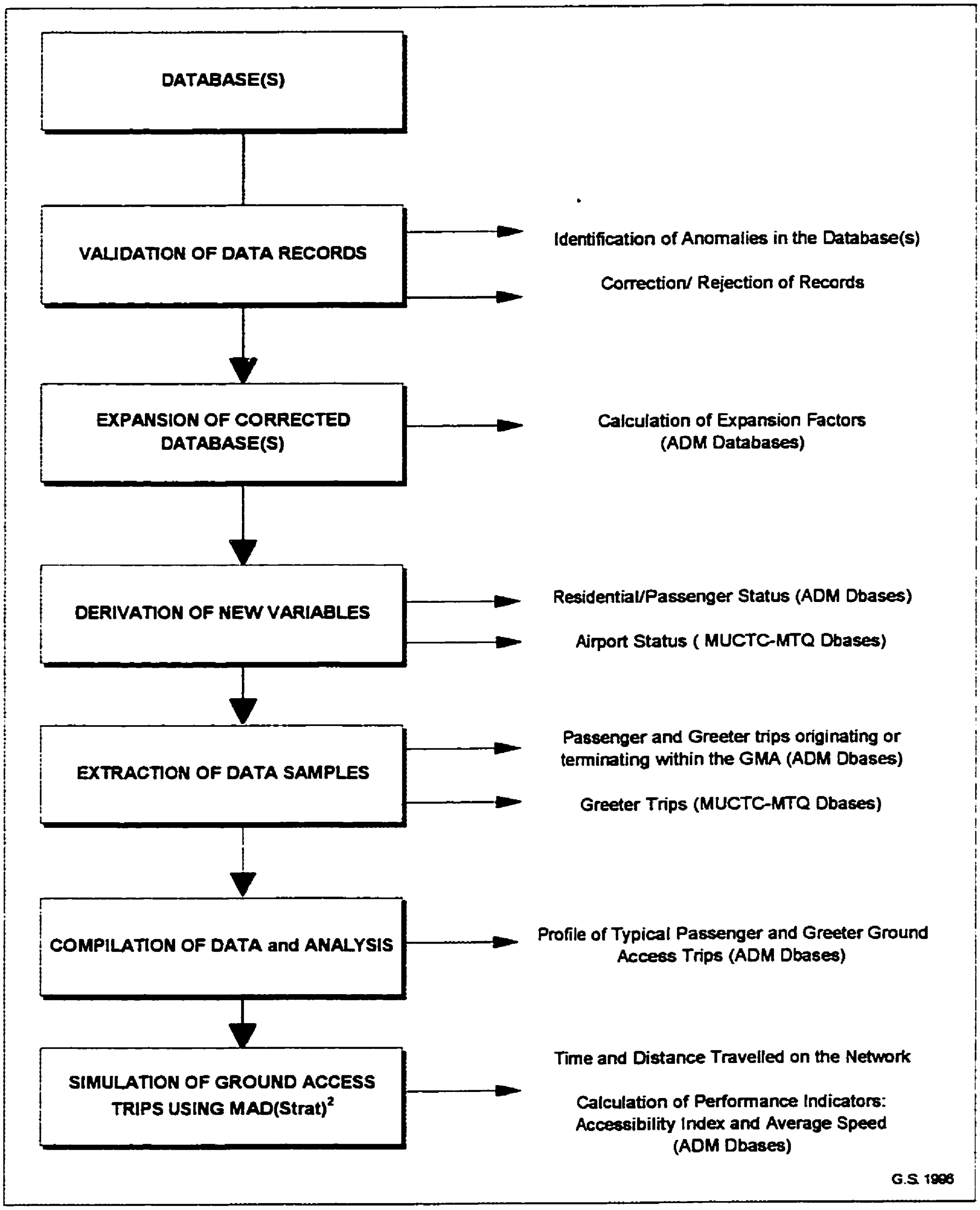



**Figure 2.1: Methodology of Analysis**

## 2.1 METHODOLOGICAL ELEMENTS OF A TRANSPORTATION SURVEY

The survey methodology of both the ADM airport user O-D Survey and the MUCTC O-D Survey follow the standard procedure as outlined in Figure 2.2. First, the objective and focus of the data collection effort must be defined and the type of data required must be identified. These factors influence the sample size and the sampling and surveying methods. Once the study has been designed, the sampling technique is pretested to identify areas that require improvement before the actual survey. During the data gathering phase, quality control measures confirm that the data is collected in a uniform manner, and that it is valid. These measures also reduce the risk of any bias on the part of the surveyors during the data gathering interviews. Collected data is then encoded, transferred to a computer database and checked for inconsistencies. Once validated, the database is ready for compilation and analysis.

## 2.2 AIRPORT USER O-D SURVEYS

Air passenger surveys have been held periodically at Dorval and Mirabel Airports over the past twenty years (TRANSPORT CANADA, 1976, 1983; ADM, 1990, 1993). The objectives of these surveys were, for the most part, to update existing databases of passenger characteristics. In addition to information on the passenger's air trip, airport user surveys gather information on the ground trip that can be used to analyze airport ground access trips.

The two most recent airport user O-D Surveys conducted at Dorval and Mirabel International Airports, held in 1990 and 1993, follow the same methodology. A few changes however, were made to the survey in 1993. First, the 1993 survey population was expanded to include arriving passengers, passenger greeters and airport employees; the 1990 survey only included departing

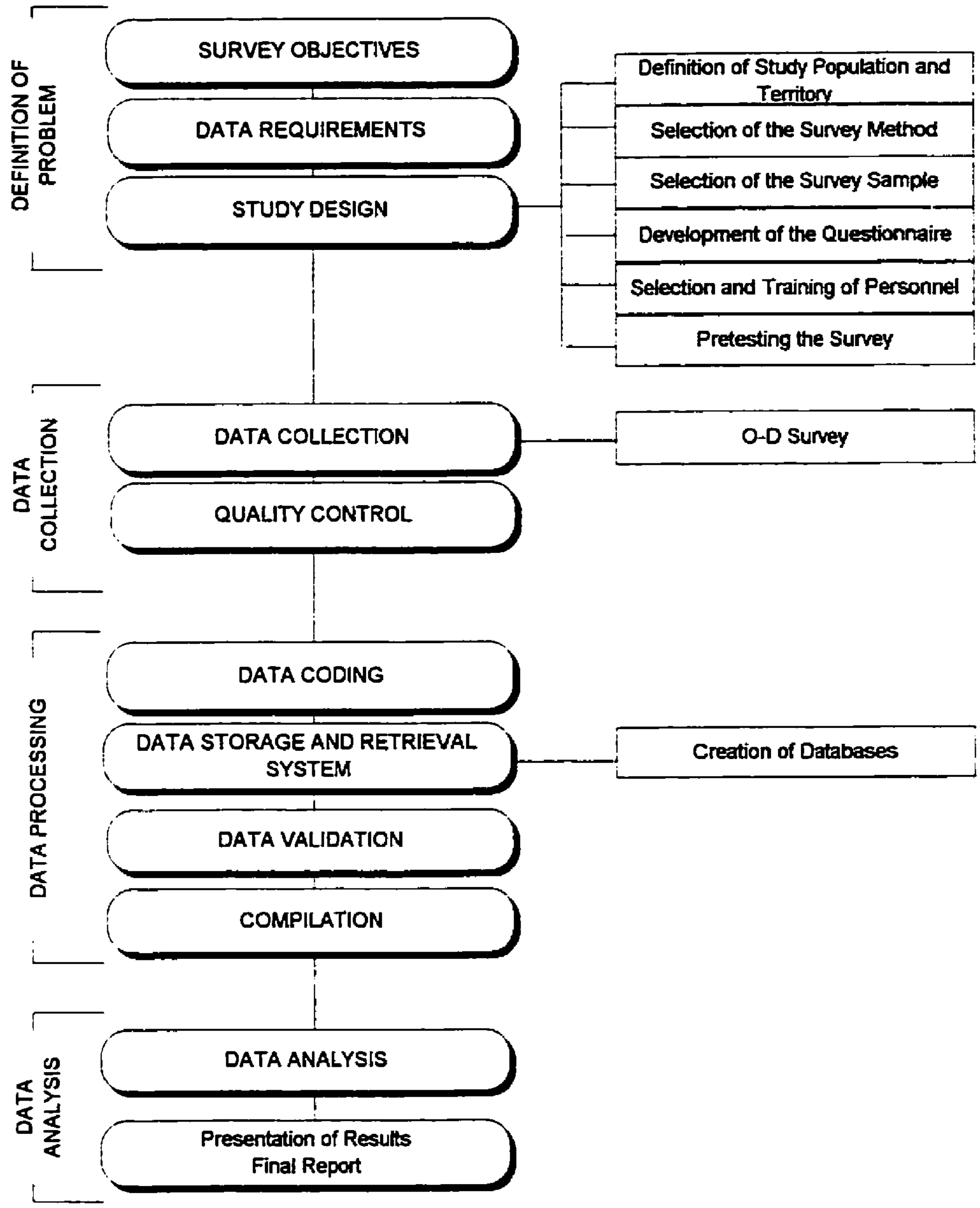



**Figure 2.2: Methodological Components of a Transportation Survey**

passengers. Second, the 1993 survey took place during the month of June, as opposed to February in 1993. Third, trip purpose calibration interviews were only conducted at Dorval Airport in 1993, since international business passengers were considered less likely to refuse being interviewed than domestic or transborder business passengers. Finally, the geocodification of the ground trip origins and destinations was undertaken by the *Groupe* MADITUC of *École Polytechnique de Montréal*. The trip origins and destinations were attributed x-y coordinates in the Universal Transverse Mercator (UTM) coordinate system, and were also classified according to the 66 municipal district system defined by the MUCTC for the 1987 O-D Survey.

The characteristics of each survey as well as the technology used for processing the collected data are summarized in Table 2.1.

**Table 2.1: Summary of Airport User Surveys Conducted in 1990 and 1993 (ADM (1990), DESSAU (1993))**

| YEAR | | CHARACTERISTICS | TECHNOLOGY |
|---|---|---|---|
| 1990 | Objective: | Update available data on air passenger characteristics. | • Data entry and verification using DATA ENTRY software; |
| | Population: | Departing passengers - YUL and YMX | • SPSS-PC statistical software program. |
| | | All flight sectors[1]: 7922 | |
| | Surveyed Passengers: | Domestic: 402 (5.0%) | |
| | | Transborder: 402 (5.0%) | |
| | | International: 407 (5.1%) | |
| | Survey Period: | February 20 - March 3, 1990 | |
| 1993 | Objective: | Origin-Destination and modal choice of airport employees and air passengers | • MADITUC geocoding; • Use of 66 municipal districts (MUCTC-1987). |
| | Population: | Departing and arriving passengers, passenger greeters, airport employees | • Manual data entry; • Spreadsheet and tabulation analysis |
| | | Domestic[1] : 28 330 | |
| | | Transborder[1]: 18 900 | |
| | | International: N/A | |
| | | Greeters: N/A | |
| | | Employees: 15 794 | |
| | Surveyed Passengers: | Domestic: 1185 (4.2%) | |
| | | Transborder: 1324 (7.0%) | |
| | | International: 919 (N/A) | |
| | | Greeters: 465 (N/A) | |
| | | Employees: 912 (5.8%) | |
| | Survey Period: | June 1 - 12, 1993. | |

[1] Population of passengers during survey period obtained from calibration interviews

## 2.3 SURVEY METHODOLOGY OF THE 1993 O-D AND MODAL CHOICE SURVEY OF PASSENGERS AND EMPLOYEES

### 2.3.1 Survey Objective

The principal objective of this data collection exercise was to obtain information on the ground travel behavior of arriving and departing air passengers, and passenger greeters originating from or terminating at either Dorval or Mirabel International Airports (DESSAU, 1993). In particular, the data requirements sought to identify the modal choice of passengers and greeters to travel to or from the airport, as well as establish an origin-destination matrix based on the system of 66 municipal sectors established by the MUCTC for their 1987 O-D Survey.

### 2.3.2 Design of Survey

The direct interview was the selected method for surveying passengers and greeters using a questionnaire. Required samples sizes were established as being 400 to 450 interviews for both arriving and departing passengers and 200 to 250 interviews for passenger greeters for each flight sector. For airport employees, self-administered mail-back questionnaires were randomly sent to 1890 of 15794 employees. The questionnaires and samples size ranges were established by ADM, and were derived from previous O-D surveys.

Three types of questionnaires were created; one for each of the three target groups with some common information sought from all three groups. This information is summarized in Figure 2.3.

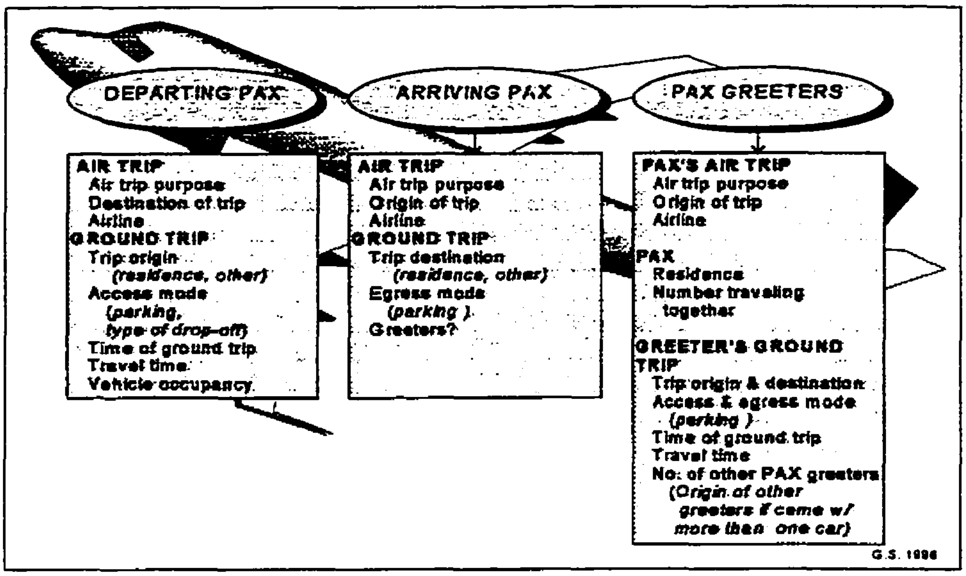



**Figure 2.3:** Content of Airport O-D- Survey Questionnaires

### 2.3.3 Personnel

The survey personnel consisted of fifteen surveyors separated into two teams. A supervisor monitored surveyors to ensure that no bias was incorporated into the survey. Additional staff were also required to enter the collected data to a computer and validate the data.

### 2.3.4 Data Collection

The O-D survey took place during a two week period in June 1993. Interviews occurred everyday except Sunday. Each flight sector was surveyed for two non-consecutive days each week during this survey period. Surveyors were positioned in the departures waiting lounge to interview departing passengers and in the baggage claim area to interview departing and arriving passengers. Greeters were questioned in the waiting area for each flight sector.

At the same time as the O-D survey, trip purpose calibration interviews were conducted to determine the true proportion of business passengers among the passenger population, since business passengers are frequently underrepresented. One in every tenth passenger that entered the survey zone was asked the purpose of their air trip.

### 2.3.5 Processing

The information collected from the questionnaires, was transferred to computer and the end of each day and validated to maintain a certain level of consistency in the collected data. Three databases were created: one for departing passengers, one for arriving passengers and a third for passenger greeters.

Once validated, the databases were transferred to the *Groupe* MADITUC at *École Polytechnique* for the geographic coding of residence and trip origin or destination of the ground trip to or from the airport. Each record was classified according to region and district as well as attributed an x-y coordinate pair (UTM system) using the available spatial information. Only residences and trip origins/destinations within the Greater Montreal Area were attributed an x-y coordinate pair. Figure 2.4 summarizes the steps involved in the processing of the survey data.

The number of records remaining in each database after the processing of is presented in Table 2.2. These processed databases are used as the starting point of this analysis of airport access trips. The databases were again subjected to a validation and correction procedure as part of the methodology of this study to ascertain that no irregularities were still present.

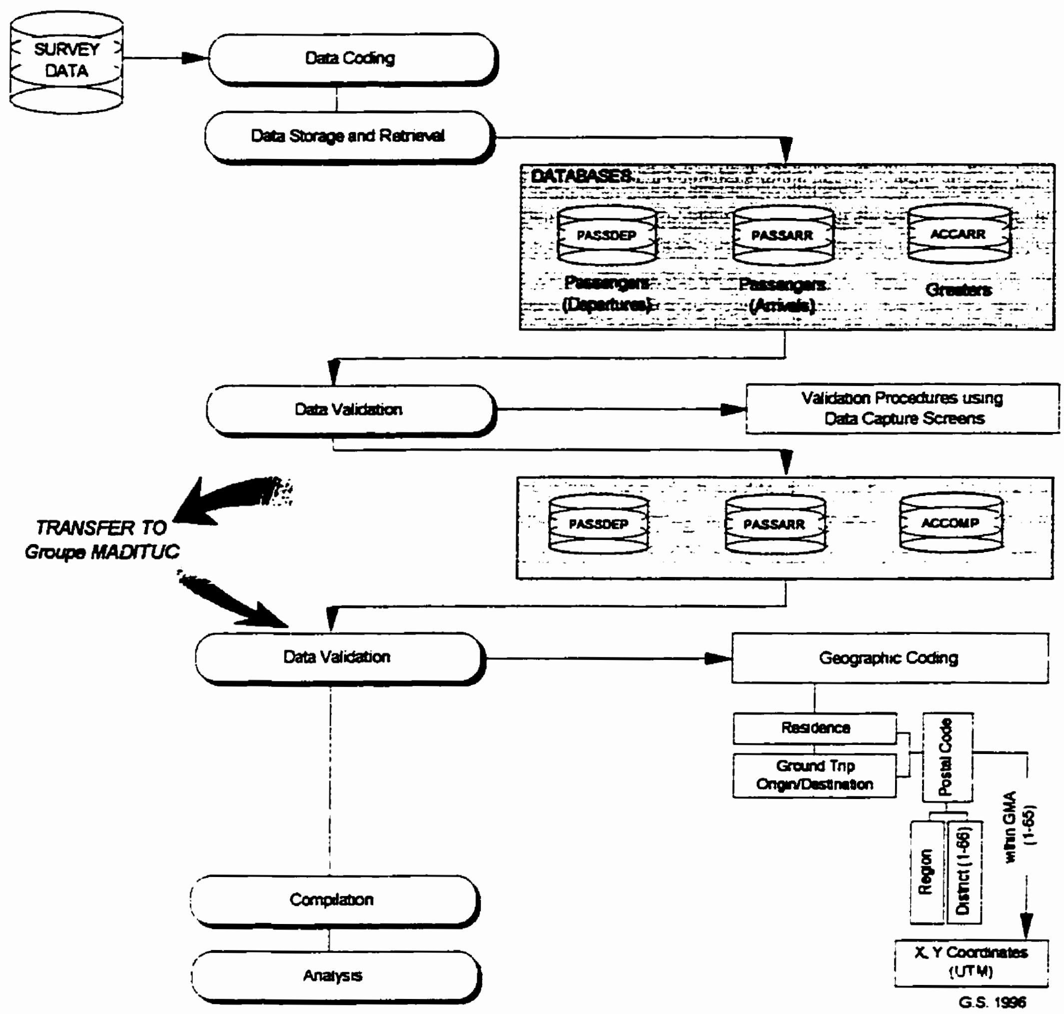



**Figure 2.4: Processing of Airport O-D Survey Data**

**Table 2.2: ADM Data Sample Sizes (DESSAU, 1993)**

| Flight Sector | | DOMESTIC | TRANSBORDER | INTERNATIONAL | TOTAL |
|---|---|---|---|---|---|
| *Departures* | Required | 400 - 450 | 400 - 450 | 400 - 450 | 1200 - 1350 |
| | Remaining | 619 | 609 | 487 | 1715 |
| *Arrivals* | Required | 400 - 450 | 400 - 450 | 400 - 450 | 1200 - 1350 |
| | Remaining | 566 | 715 | 432 | 1713 |
| *Greeters* | Required | 200 - 250 | 200 - 250 | 200 - 250 | 600 - 750 |
| | Remaining | 133 | 148 | 184 | 465 |

## 2.4 Comparison Between the ADM and MUCTC O-D Surveys

Certain aspects of the two O-D survey methodologies and data strictures including the notion of a *trip* are worth comparing to identify the strong points of each data collection effort and the resulting data.

### 2.4.1 Survey Methodology

The MUCTC O-D Survey is an important source of data for transportation planners interested in the mobility needs and tripmaking behaviour of the Greater Montreal Area (GMA). The survey has been linked to the MADITUC system since 1982, when it was used as a codification tool (see Table 2.3). It is now an integral part of the data collection, processing and analysis steps of the survey with the development of spatial equivalency databases, and data capture and validation programs. In 1987, with the decision to adopt postal codes for spatial-referencing of trip origins and destinations in lieu of zones, analysis of specific generators with in the GMA, using the O-D survey data, became a reality.

The MUCTC O-D survey has an established methodology. Consistency in survey methodology facilitates the transferability - spatial or temporal - of transportation demand models as well as the analysis of the evolution of mobility. Few important technological and methodological changes have been made, however the essence of the survey has remained the same. The survey method has been the telephone personal interview since 1970, using the same questionnaire as the interviewing tool. Data collection occurs between the months of September to October, when the population is most likely to conduct regular-activity-generated trips. However, as confirmed by Table 2.4, the extracted data sample from the MUCTC-MTQ O-D survey data is not representative of airport-bound trips since only 0.5% of the total number of surveyed trips were airport trips. This number include trips made by all types of airport tripmakers: passengers, accompaniers or greeters, employees or others. This is the major limit of the use of the MUCTC survey data in analyzing airport ground access trips to Dorval and Mirabel Airports.

A limit of the airport O-D survey is the fact that the survey is valid only for the point-in-time in which the data collection took place. The change in the survey period from February to June changes the frame of reference and therefore prevents an accurate analysis of the evolution of the ground access tripmaking behaviour to be carried out.

Further, as a result of the decision not to conduct calibration interviews at Mirabel airport, the control volume was not known and therefore the representability of the subsample of international passengers could not be directly determined. Similarly, the lack of control volumes for passenger greeters presents the same problem for this type of airport tripmaker.

Table 2.3: **Evolution of MUCTC O-D Survey, 1974-1993** (CHAPLEAU ET AL., 1996)

| YEAR | CHARACTERISTICS | | TECHNOLOGY HARDWARE/SOFTWARE | USE OF SURVEY DATA |
|---|---|---|---|---|
| 1974 | Area: | 2331 km$^2$ | • IBM 360 Model 50 | • Transit network analysis; |
| | Population: | 2 824 000 | • COBOL programming | • Subway extension projects. |
| | Sampling Rate: | 4.78% | • In-house statistical programs | |
| | Surveyed Households: | 43 000 | • TRANSCOM Model | |
| | Surveyed Trips: | 265 000 | | |
| 1978 | Area: | 2331 km$^2$ | • IBM Mainframe; | • Transit network analysis; |
| | Population: | 2 954 000 | • Terminal data validation; | • Network simulation. |
| | Sampling Rate: | 5.31% | • TRANSCOM Model; | |
| | Surveyed Households: | 50 000 | • UTPS Model. | |
| | Surveyed Trips: | 305 000 | | |
| 1982[1] | Area: | 3341 km$^2$ | • Household precoding with postal code; | • Network analysis; |
| | Population: | 2 895 000 | | • Market analysis; |
| | Sampling Rate: | 6.98% | • SAS and SPSS processing; | • User sociodemographic study; |
| | Surveyed Households: | 75 000 | • MADITUC codification. | |
| | Surveyed Trips: | 492 000 | | • Network simulation. |
| 1987 | Area: | 3350 km$^2$ | • AT microcomputer geocodification and validation; | • Sociodemographic analysis; |
| | Population: | 2 900 000 | | • Network simulation and analysis; |
| | Sampling Rate: | 5.0% | • SAS and PC processing; | |
| | Surveyed Households: | 54 000 | • MADITUC on mainframe. | • Transit financing studies. |
| | Surveyed Trips: | 338 000 | | |
| 1993[1] | Area: | 3500 km$^2$ | • Fully computerized survey; | • Transit financing, analysis and simulation; |
| | Population: | 3 263 000 | • GIS-T codification; | |
| | Sampling Rate: | 4.7% | • Microcomputer: FoxPro, AutoCAD, MADITUC. | • Sociodemographic studies; |
| | Surveyed Households: | 61 000 | | • Multimedia data dissemination. |
| | Surveyed Trips: | 350 000 | | |

[1] In conjunction with the Quebec Ministry of Transport

**Table 2.4: Comparison of Survey Methodology - ADM and MUCTC**

| ELEMENT | ADM | MUCTC |
|---|---|---|
| OBJECTIVE: | Modal choice of ground trips, and an O-D matrix based on the 1987 MUCTC 66 municipal sector territorial divisions. | To obtain information on the mobility needs of the population within the GMA. |
| SURVEYING TECHNIQUE: | Personal interview. | Household phone interview. |
| STUDY POPULATION: | Departing and arriving passengers, passenger greeters (employees). | Population of the GMA. |
| STUDY AREA: | Dorval and Mirabel International Airports<br>Greater Montreal Area as per 1987 MUCTC 66 municipal sector territorial divisions.<br>Surface area: 3 350 $km^2$ | Greater Montreal Area. Twenty municipalities added to the survey territory in 1993.<br>Surface area: 3 500 $km^2$ |
| SAMPLE SIZE: | Passengers: 3 428 surveyed trips<br>Greeters: 465 surveyed trips<br>Employees: 912 surveyed trips | Total sample: 350 000 surveyed trips.<br>Extracted sample: 1 782 surveyed trips |
| FREQUENCY | Every 3+ years, exact period varies from survey to survey. | Every 4-6 years, between the months of September to December. |
| PROCESSING: | Manual data entry, coding and validation of data.<br>Geocoding of trip origins and destinations | Direct data entry of survey data.<br>Automatic and interactive codification and validation using computer programs. |

## 2.4.2 Data Structure

The sampling unit for the MUCTC O-D survey is the household. For each person in the surveyed household, the characteristics of all trips conducted the previous day are gathered; each trip is recorded separately. As Figure 2.5 shows, each record in the O-D survey trip file is a vector containing information on the household (number of persons per household, number of automobiles per household), sociodemographic characteristics of the person (age, gender), trip characteristics (origin, destination, trip purpose, mode, transit lines taken (path), time of departure) and database indices which permit each record to be traced back to the main trip file. Each record represents one trip conducted by one member of a household.

On the other hand, the sampling unit for the ADM O-D survey is the person which is either a passenger or a greeter. Each record may represent more than one trip since passengers or greeters can travel with accompaniers. No information however is available on the accompanying person. Furthermore, passenger airport trips consist of only a trip to or from the airport, while greeter airport trips include both. Unlike the MUCTC survey data where each trip is recorded separately, information on both trips is included in the same record. This implies that greeters trips must be split up to represent two separate trips.

The analysis unit of both surveys however, is the trip. There are different ways to compile trips and they differ for each survey. Trips can be compiled either as person-trips or mode-trips. A person-trip is one made by an individual for a specific purpose between an origin and destination; the number of modes used to complete a person-trip is irrelevant. A mode-trip is a trip made using one of many possible submodes to complete a person-trip. If an individual conducts a multimodal trip using the bus, train and subway, this would count as three mode-trips while it would only count as one person-trip. To prevent multiple counting of a single, multimodal trip a modal priority system is used. Mode-trips are usually preferred over person-trips since the complete usage of each mode is known and allows for the estimation of the number of users per mode, the number of transfers, and a more complete modal split (CHAPLEAU, R., LAVIGUEUR, P., 1989).

When the trip purpose is also considered, survey data can be compiled into two other categories: 1) unidirectional trips, or 2) 24-hour trips. Unidirectional trips are principal activity trips - trips conducted for activities such as work, school, shopping, recreation, etc.. In this category return trips to the individual's home are not included since it is argued that most people return to their homes within a 24-hour period. On the other hand, 24-hour trips count all trips made by the individual, including return trips home. Unidirectional trips are used to identify trip producers and attractors, while 24-hour trips show the true mobility of a population.

In the ADM O-D survey data samples, airport access trips are unidirectional, person-trips with only one mode defined for each person surveyed. In the MUCTC O-D survey data sample on the other hand, the trip data include the sequence of modes taken to complete each trip from origin to destination.

Another difference between the two data sets is the trip purpose itself. While the trip purposes for ADM survey trips are characteristic of air travel-related activities - business or leisure, there are six possible trip purposes for MUCTC survey data trips, all of which are characteristic of everyday activities: work school, return, recreation, shopping and other. Therefore, airport workers, passengers, accompaniers and greeters must be identified from the MUCTC data sample using these trip purposes.

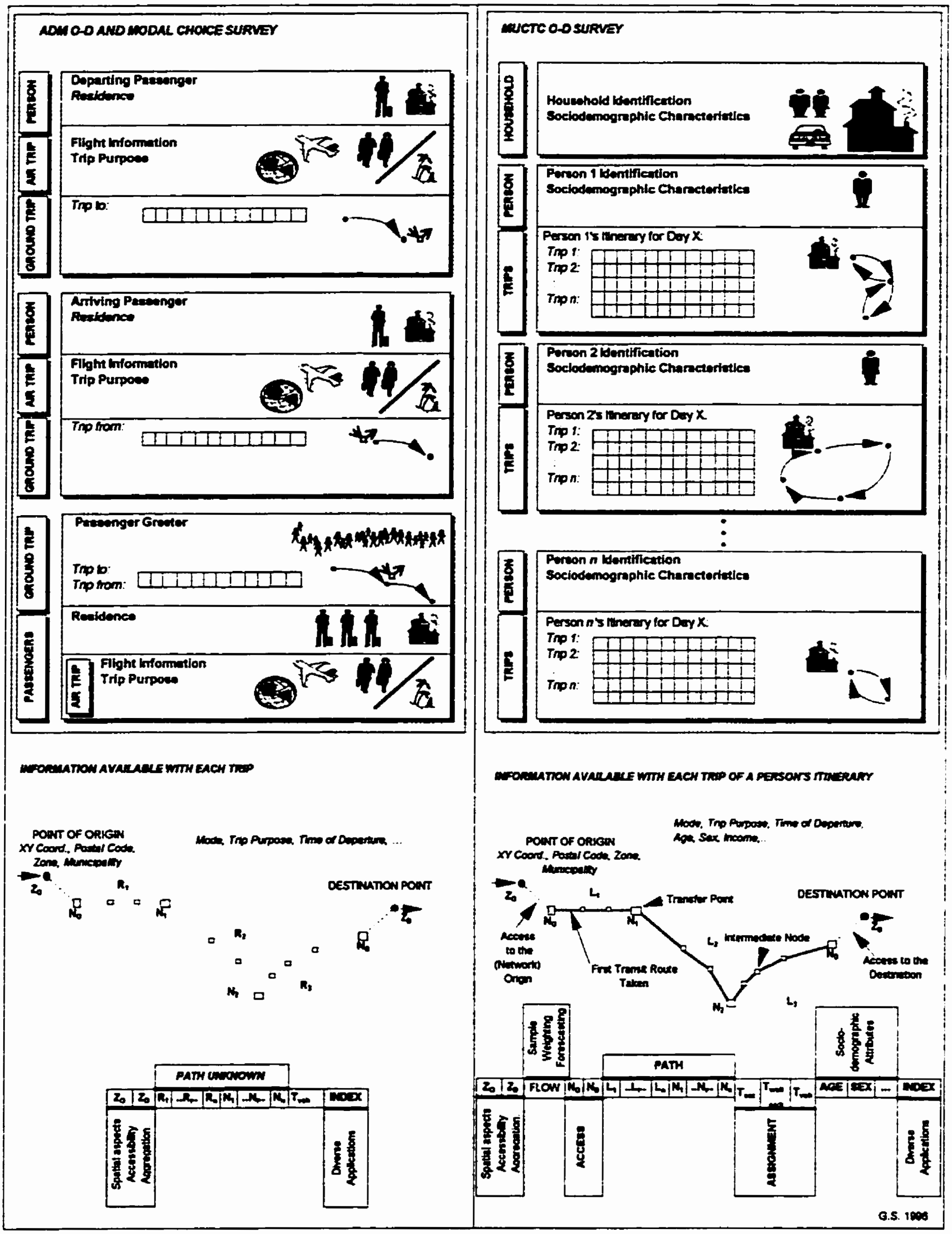



**Figure 2.5: Comparison of Data Structures - ADM and MUCTC Survey Data**

Part of the collected MUCTC trip information includes a description of the transit routes taken to carry out a trip - if the person used any of the available transit modes (MUCTC - bus, metro train, STL (Laval) bus, STRSM (South Shore) bus or CIT bus). However, if private modes are used, no path is recorded. Validation of declared transit itineraries is possible for MUCTC data while validation for private modes are not since private modes are not constrained to a pre-defined schedule. Comparison of simulated and declared transit trips can therefore be compared. No information on the passenger or greeter's selected path was collected and therefore was not available from the ADM data.

Lastly, the MUCTC-MTQ data sample consisted predominantly of coded, numeric variables including spatial variables, and therefore was well-suited for the mechanical processing methods such as computer programs. On the other hand, the greater percentage of character variables in the ADM databases, particularly in the description of spatial variables, required more of an interactive approach with the data processing. For this reason, Microsoft Excel was selected as the processing tool for the ADM samples and FoxPro was selected for the MUCTC data sample.

## 2.5 EXAMINATION OF DATA SAMPLES

Certain irregularities were discovered while examining the data records. A great effort was made to correct and recuperate as many of these records as possible, to maintain a level of significance due to the small size of the data samples. In some cases, however, it was necessary to reject certain records.

### 2.5.1 Validation and Correction of ADM Databases

Two main inconsistencies were discovered in the ADM databases. The first was discovered when the calculated time of arrival at the airport was compared to the time surveyed for departing passengers and greeters. A time of arrival at the airport that was inferior to the time of the survey was expected to be able to compare the declared and simulated travel times as well as to be able to effectively analyze how early departing passengers arrive at the airport prior to their flight. The time of arrival at the airport and the difference between the arrival and survey times were calculated using the following equations:

$$h_{arr} = hr_{dep} + (t_{travel} / 1440)$$

$$\Delta t = (hr_{sur} - hr_{arr}) * 1440$$

where:

$hr_{arr}$ = time of arrival at the airport;

$hr_{dep}$ = declared time departed for the airport;

$hr_{sur}$ = time of survey;

$t_{travel}$ = declared travel time (min);

$\Delta t$ = time difference (min);

A record was eliminated if either the time of departure for the airport or the time of the interview was missing, of if the difference between the arrival and survey times was negative or equal to zero (0) minutes. This inconsistency was present in 3% (n=52) and 5% (n=25) of the records in the DEPARTURES and GREETERS databases respectively.

The second type of inconsistency concerned the geocoding of trip origins and destinations for airport access trips (Figure 2.6). Despite the fact that no trip origins or destinations located outside the GMA were geocoded, it was discovered that an additional 24% of eligible trip records in the DEPARTURES database, 38% in the ARRIVALS database and 42% in the GREETERS database were not geocoded. Closer examination of these records revealed that when precise spatial information such as postal code, address, intersection or trip generator was invalid, incomplete or missing, the trip origin or destination could not be geocoded.

Using the procedure outlined in Figure 2.7, all eligible records from the DEPARTURES, ARRIVALS and GREETERS databases with missing coordinate pairs were recuperated. Records with no spatial information other than the name of the municipality were attributed the coordinates of the corresponding municipal sector centroid. Canada Post's Area Master File for the Province of Quebec was used to attribute coordinate pairs for 5%, 1% and 12.5% of the records in the three ADM databases which had either valid postal codes or addresses.

### 2.5.2 Validation and Correction of the MUCTC-MTQ Data Sample

The principal irregularity discovered in the MUCTC-MTQ survey data set was the lack of declared mode for approximately 2% of the records. Closer examination revealed that these trips, originated or terminated at a point external to the territory. As a result, they are considered as being air trips and were assigned an indeterminate mode (INDET_M).

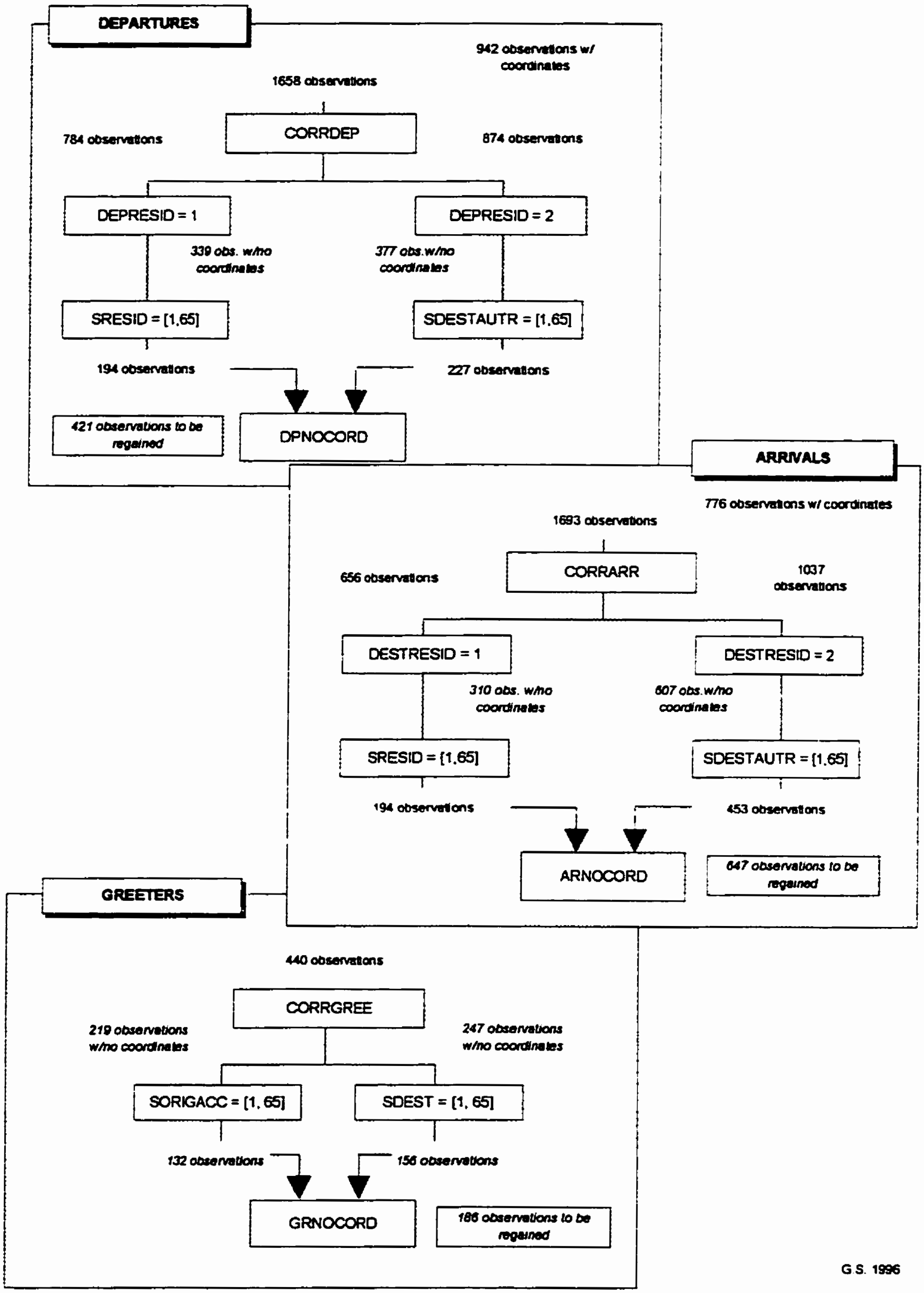



**Figure 2.6: ADM Database Records Without Coordinates**

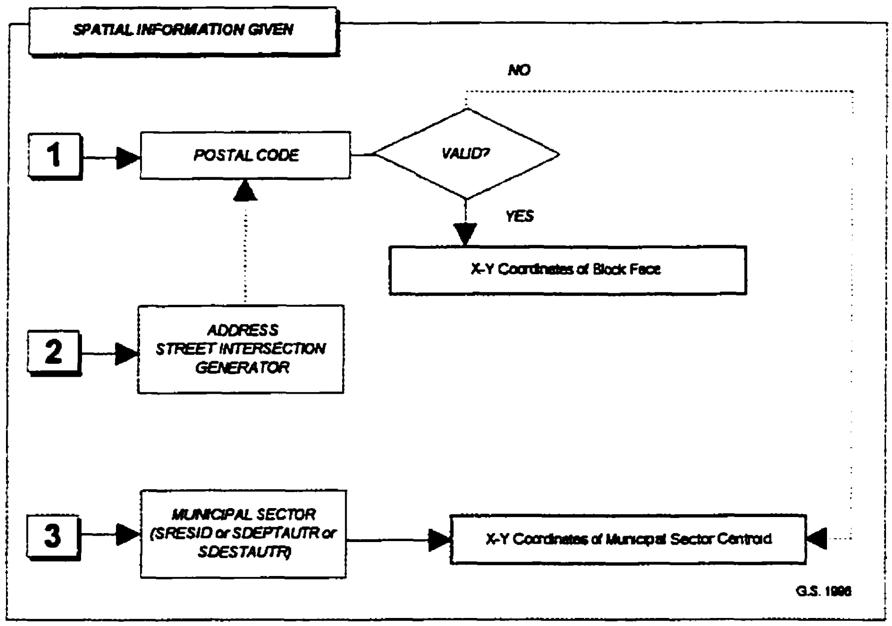



**Figure 2.7: Procedure for Correcting Records with No Coordinates**

## 2.6 EXPANSION FACTORS

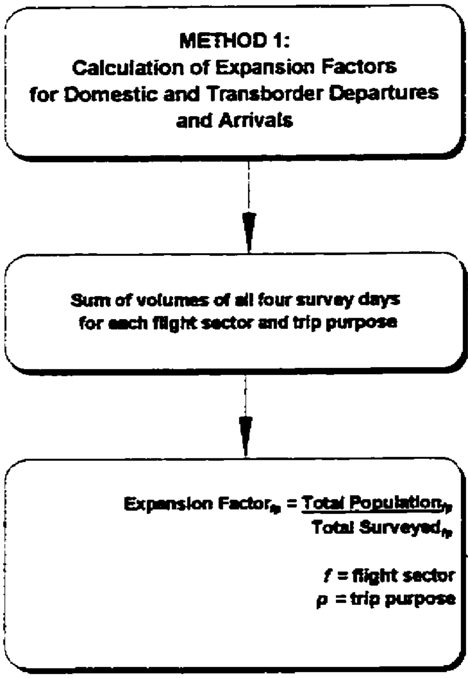
Expansion factors were required to determine the weight of each surveyed trip. In other words, the expansion factor describes the number of similar trips represented by a given data record. The following series of diagrams illustrate the methods used to calculate the expansion factors for each for the three databases.

The volume of passengers obtained during the calibration interviews were assumed to represent the population passengers at Dorval Airport (YUL) during the survey period. Since calibration interviews were held only at YUL, Method 1 (Figure 2.8) was used to calculate expansion factors for domestic and transborder departures and arrivals only. The total population at the airport during the survey period was divided by the number of people interviewed for each trip purpose and for each flight sector. As the table in Figure 2.8 shows, departing leisure travelers in both flight sectors were slightly underrepresented by this survey (3%), as were both departing and arriving domestic business passengers (4%).

Method 2, shown in Figure 2.9, was used to calculate the expansion factors for international departures and arrivals. Since no calibration interviews were conducted at Mirabel Airport (YMX), the population volume during the survey period was estimated for the reported annual volume of enplaned and deplaned passengers for 1993 (ADM, 1993a). These factors are approximate values only.

Method 3 (Figure 2.10), was used to calculate expansion factors for the arriving passenger greeters. Again, no volume counts were collected from which an estimate of greeter population could be obtained. However, the greeter population could be estimated using variables from both the arrivals (ACCEUIL) and greeters database (NBACCOMP, NBVOYAGEUR). Sample calculations for all expansion factors are found in the Appendix.

Using the expansion factors calculated for each for the three ADM databases, the number of airport ground access trips represented by the ADM O-D survey for the period from June 1 to 14, 1993 are shown in the table below. These values are for both airports, and do not include return trips for passenger greeters. Table 2.5 indicates that 28 580 ground trips were made to YUL by departing passengers, 20 260 ground trips were made from YUL by arriving passengers and 7 791 ground trips were made to YUL by passenger greeters. Further, 14 135, 12 683 and 14 986 airport ended trips were made to YMX by departing, arriving passengers and passenger greeters respectively.

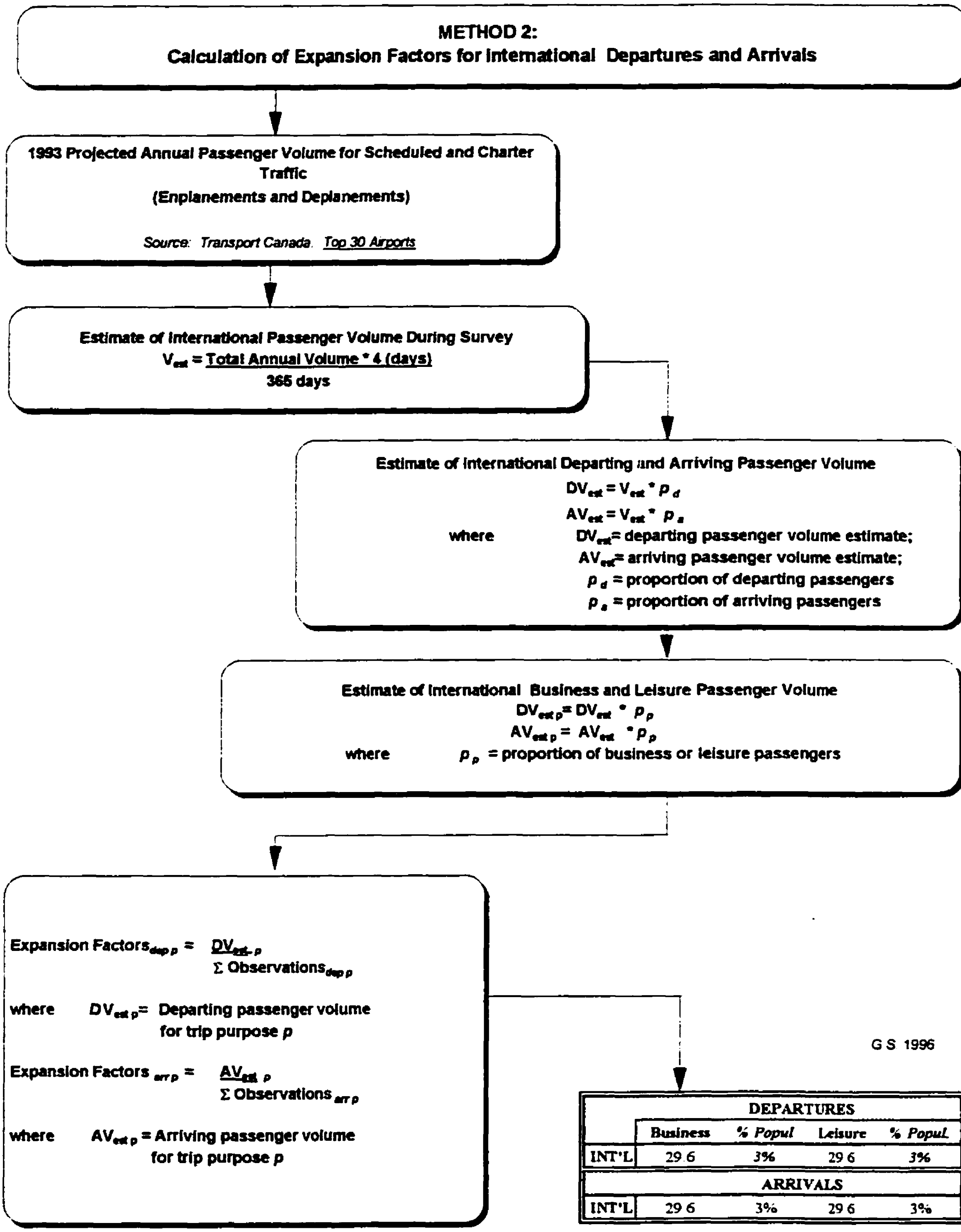



| | DEPARTURES | | | |
|---|---|---|---|---|
| | Business | % Popul | Leisure | % Popul. |
| DOM | 25.9 | 4% | 35.3 | 3% |
| TRANS | 15.2 | 7% | 29.9 | 3% |
| | ARRIVALS | | | |
| DOM | 23.9 | 4% | 16.8 | 6% |
| TRANS | 11.2 | 9% | 12.2 | 8% |

**Figure 2.8: Method 1 - Expansion Factors for YUL Departure and Arrival Passengers**

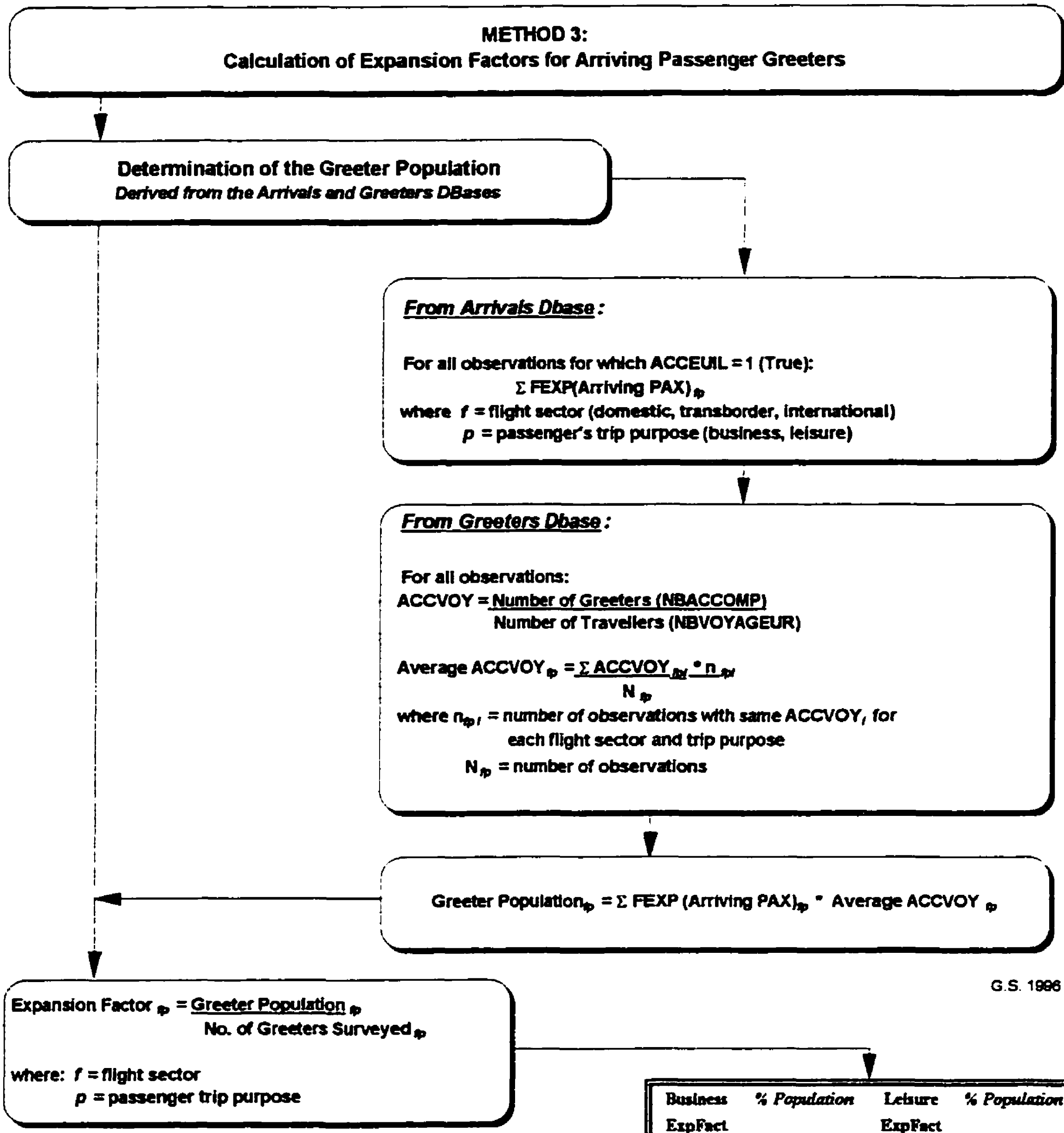
**Table 2.5: Expanded survey data - Number of Trips Represented by ADM Survey Data**

| AIRPORT | FLIGHT SECTOR | DEPARTURES | | ARRIVALS | | GREETERS | |
|---|---|---|---|---|---|---|---|
| | | Business | Leisure | Business | Leisure | Business | Leisure |
| *YUL* | *Domestic* | 12 470 | 3 880 | 8 960 | 3 020 | 2 958 | 1 098 |
| | *Transborder* | 5 650 | 6 580 | 4 260 | 4 020 | 1 229 | 2 506 |
| *YMX* | *International* | 4 267 | 9 868 | 3 912 | 8 771 | 3 824 | 1 162 |
| *Subtotal* | | 22 387 | 20 328 | 17 132 | 15 811 | 8 010 | 14 766 |
| *Total* | | 42 715 | | 32 943 | | 22 776 | |




| | DEPARTURES | | | |
|---|---|---|---|---|
| | Business | % Popul | Leisure | % Popul |
| INT'L | 29.6 | 3% | 29 6 | 3% |
| | ARRIVALS | | | |
| INT'L | 29 6 | 3% | 29 6 | 3% |

Figure 2.9: Method 2 - Expansion Factors for YMX Departure and Arrival Passengers




| | Business ExpFact | *% Population* | Leisure ExpFact | *% Population* |
|---|---|---|---|---|
| Domestic | 19.3 | *5%* | 10.0 | *10%* |
| Transborder | 15.2 | *7%* | 23.0 | *4%* |
| International | 78.2 | *1%* | 74.3 | *1%* |

**Figure 2.10: Method 3 - Expansion Factors for Passenger Greeters**

## 2.7 ENRICHMENT OF TRIP INFORMATION

The derivation of new variables that reflect an individual's tripmaking behaviour adds a new dimension to the analysis of airport access trips. An object-entity such as an airport status is derived by analyzing the trip chain links with the airport as a trip-end. For ADM data, a residential status distinguishes nonresidents from residents in the passenger population, thus facilitating the analysis of the differences in ground access travel behaviour for these groups. In addition, a secondary status which considers both residential status and trip purpose allows a more detailed analysis. For MUCTC-MTQ data, a derived airport status categorizes tripmakers as being worker, passenger, accompanier/greeter or other, facilitating the compilation and subsequent extraction of a specific class of trips.

### 2.7.1 Derivation of Variables for ADM Databases

Two object-entities were derived for the DEPARTURES and ARRIVALS databases: residential status (RESSTAT) and passenger status (AIRSTAT). Each passenger was attributed a residential status based on their declared residence. An individual was considered a resident of the GMA if his residence was located in one of the 65 municipal sectors defined earlier (Figure 1.7). If the residence was located out of the region, or if the residence was unknown, then the individual was considered a nonresident. No residential status was derived for greeters since no information was collected on their residence.

A passenger status was derived using the newly created residential status and the passenger's air trip purpose (Figure 2.11). This allowed the passenger-objects to be categorized as one of the following: resident-business passenger, resident-leisure passenger, nonresident-business and nonresident leisure passenger. The derived passenger status also allowed the analysis of the typical ground access behaviour for each passenger category.

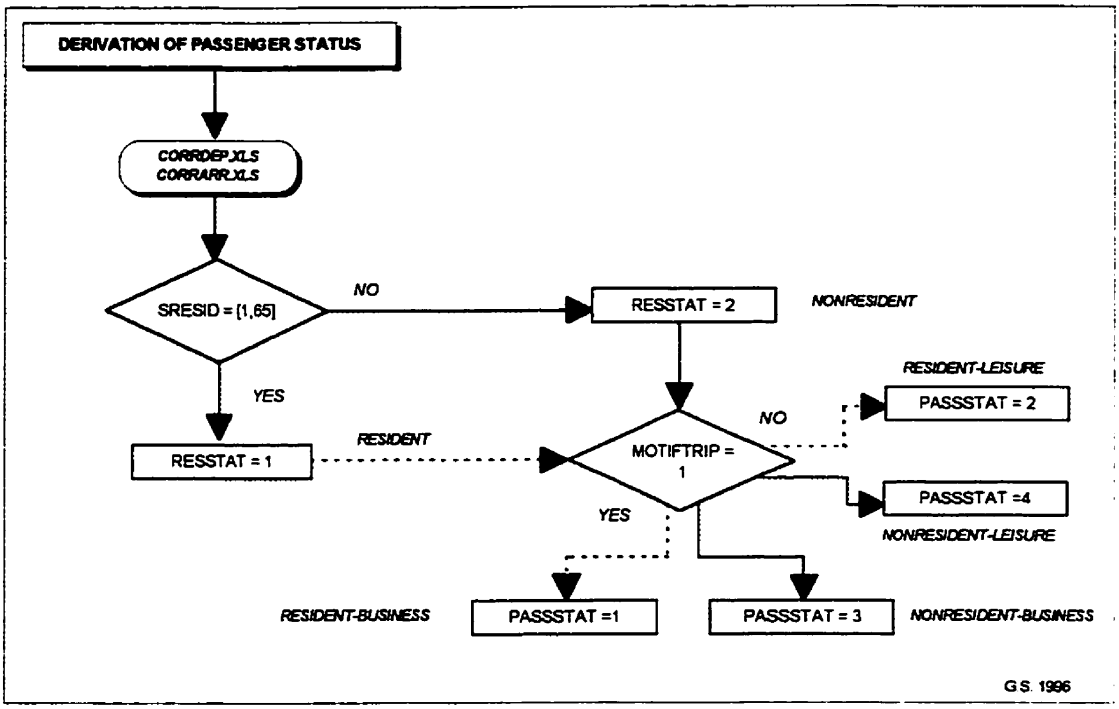



**Figure 2.11: Derivation of Passenger Status for ADM Passenger Databases**

## 2.7.2 Derivation of Variables for MUCTC-MTQ Data Sample

Each individual in the MUCTC-MTQ O-D database possesses a status that describes the individual's principal activity on a typical weekday (worker, student or other) (CHAPLEAU, 1993). To analyze ground access trips, an airport status (AIRSTAT) was attributed to each tripmaker. This status was derived using the origin or destination of each trip in the trip chain link, and the trip purpose(s).

Forty six different types of trip chain links were identified based on the number of declared airport trips for each person, the origin or destination and the associated trip purpose for each trip in the chain. Each digit in the variable TYPEDEPL represents one trip made for the given trip purpose. For example, a trip chain link type of '13' means that two airport ended trips were made: one work-trip to the airport, and one return-trip to this or her home. The program algorithms used to determine the different trip chain types as well as the definition of the 46 different trip chain types can be found in the Appendix.

The diagram in Figure 2.12 illustrates how the airport status of tripmakers was derived. An airport employee was defined as a tripmaker that travelled to either airport for a work purpose. A passenger was defined as a tripmaker whose first or last trip within the GMA regions either originated or terminated at the airport for either recreational or other trip purposes. Tripmakers who travelled out of the region from the airport using an indeterminate road for work purposes were classified as passengers; however it is possible that some of these tripmakers are airline employees such as flight attendants or pilots. Passengers were further classified into categories of arriving, departing or returning.

The status of accompanier is a broad classification for tripmakers that travel to the airport with either a passenger or a worker from the same household. Further analysis of the relationships between airport tripmakers within a household was required to distinguish accompaniers from greeters, and passenger accompaniers and greeters from other possible types of accompaniers. A passenger accompanier was defined as a tripmaker that travelled to the airport with a departing air passenger, a passenger; a passenger greeter either returned with or without an arriving air passenger (from the same household); and finally, a worker accompanier either dropped off or picked up an airport employee from the airport. A person was attributed the status of 'other' if their tripmaking behaviour did not comply with the above categorization of airport tripmakers.

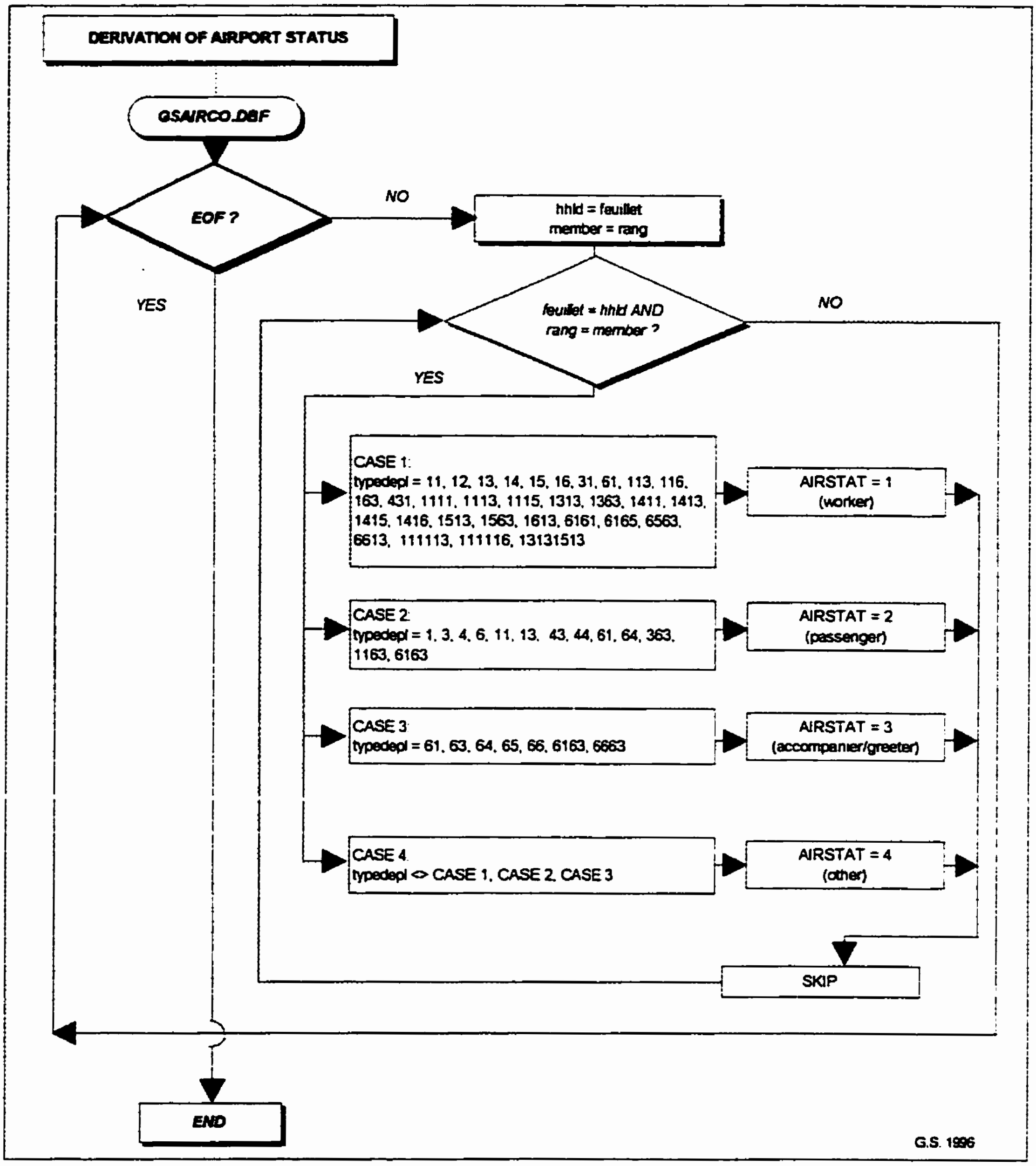



**Figure 2.12: Derivation of Airport Status for MUCTC-MTQ Observations**

## 2.8 EXTRACTION OF ACCESS TRIPS FOR FURTHER ANALYSIS

### 2.8.1 Airport Trips from the ADM O-D Survey

The trips that were extracted from the ADM databases are those that originated or terminated within the GMA region since these were trips with coordinate pairs - which are required for simulation with MAD(Strat)[2]. This represented 81% of departing passenger trips, 82% of arriving passenger trips and 72% of greeter trips as shown in Table 2.6.

**Table 2.6: Number of Airport-Ended Ground Trips Represented by ADM Data**

| Airport | Flight Sector | DEPARTURES | | ARRIVALS | | GREETERS | |
|---|---|---|---|---|---|---|---|
| | | Trips within GMA | Trips out of GMA | Trips within GMA | Trips out of GMA | Trips within GMA | Trips out of GMA |
| *YUL* | *Domestic* | 14 604 | 1 746 | 10 651 | 1 329 | 2 982 | 1 073 |
| | *Transborder* | 10 924 | 1 306 | 7 356 | 924 | 2 885 | 850 |
| *YMX* | *International* | 9 146 | 4 989 | 9 028 | 3 655 | 10 607 | 4 379 |
| *Total* | | 34 674 | 8 041 | 27 035 | 5 908 | 16 474 | 6 302 |

### 2.8.2 Airport Trips from MUCTC-MTQ O-D Survey

The MUCTC-MTQ data subsample of 16 438 surveyed persons from 14 197 different households within the GMA produced 32 366 airport-ended trips on the average weekday in 1993, of which 61% were produced by airport employees, 12% by passengers, 26% by accompaniers and 1% by others (Table 2.7). Since accompanier trips made up the largest proportion of airport trips next to airport employees, they were extracted for further analysis. Examination of these categories of accompaniers showed that passenger greeter trips - with and without passengers, made up the greatest proportion of accompanier trips (90%). Therefore, passenger greeter trips were extracted and analyzed independently of the ADM access trips. The MUCTC greeter trips could not be directly related to ADM passenger greeter trips due to the differences discussed above, however general comparisons were still be made.

**Table 2.7: Number of Airport-Ended Trips Represented by MUCTC-MTQ Data (24-hour trips)**

| Airport | WORKERS No. Trips | PASSENGERS No. Trips | ACCOMPANIERS No. Trips | OTHER No. Trips |
|---|---|---|---|---|
| *YUL* | 14 631 | 2 987 | 5 052 | 271 |
| *YMX* | 5 213 | 813 | 3 355 | 44 |
| **Total** | 19 844 | 3 800 | 8 407 | 315 |

**Table 2.8: Type of Accompanier Trips to the Airports (MUCTC-MTQ Data)**

| Type of Accompanier | YUL | | YMX | | TOTAL | |
|---|---|---|---|---|---|---|
| | 24-hour Trips | % Trips | 24-hour Trips | % Trips | 24-hour Trips | % Trips |
| *Passenger Accompanier* | 455 | 5% | 84 | 1% | 539 | 6% |
| *Passenger Greeter* | 266 | 3% | 133 | 2% | 399 | 5% |
| *Worker Accompanier* | 286 | 3% | 0 | 0% | 286 | 3% |
| *Passenger Greeter, w/o Passenger* | 4 045 | 48% | 3 138 | 37% | 7 184 | 85% |
| *Total* | 5 051 | 60% | 3355 | 40% | 8 407 | 100% |

## 2.9 STATISTICAL SIGNIFICANCE OF DATA SAMPLES

The statistical error of each extracted data sample was verified to ascertain that a level of statistical significance is maintained. This was determined by verifying if the associated error fell within the acceptable limits. For this study, a 5% margin of error at the 95% confidence interval was considered acceptable.

The number of records remaining in each extracted data sample, and the associated precision - or relative error associated with each sample are given in Tables 2.9 and 2.10. The relative error associated with each of these samples was calculated using the equation below. A proportion of 50% (LEVIN, R., 1978) was used as a conservative estimate of the real occurrence of passengers and greeters in the population since the real proportion was not known.

$$r = \sqrt{\frac{Z_{(1-(\alpha/2))}{}^2 * (1-p)}{np}}$$

where $r$ = relative error, or precision of the sample;

$Z_{(1-(\alpha/2))}$ = $Z$ - statistic for the normal distribution corresponding to the 1-$\alpha$ confidence level;

$\alpha$ = fraction of area under the normal curve representing events not within the confidence level;

$p$ = the proportion of data in the population;

$n$ = sample size

Table 2.9: ADM Survey Sample Sizes and Error (DESSAU, 1993)

| Airport Tripmaker | CORRECTED SAMPLE Observations | PRECISION r (%) | EXTRACTED SAMPLE Observations | PRECISION r (%) |
|---|---|---|---|---|
| ***Arriving Passengers*** | 1 696 | 4.76% | 1 354 | 5.32% |
| ***Departing Passengers*** | 1 655 | 4.82% | 1 428 | 5.19% |
| ***Passenger Greeters*** | 440 | 9.34% | 3 24 | 10.89% |

Table 2.10: Statistical error of MUCTC-MTQ Data Samples

| Airport Tripmaker | CORRECTED SAMPLE Observations | PRECISION r (%) |
|---|---|---|
| ***Workers*** | 1081 | 5.96% |
| ***Passengers*** | 214 | 13.40% |
| ***Accompaniers*** | 432 | 9.43% |
| ***Other*** | 20 | 43.83% |
| ***Total*** | 1747 | 4.68% |

The ADM passenger samples have relative errors of 5.96% at the 95% confidence limit which is reasonably acceptable. Further segmentation of the sample will increase the associated error as shown in Figure 2.13. If a lower confidence limit is acceptable, then the sample error will decrease, therefore the segmented samples may still be statistical representative, however, not at the same confidence limit as the whole sample.

The ADM greeter sample on the other hand, has a relative error of 10.89%. A sample of 1537 surveyed greeters would have been required to obtain a 5% margin of error at the 95% confidence limit.

The error associated with the entire MUCTC-MTQ data sample falls within the 5% margin of error at the 95% confidence level. However, the derived sample of passengers, accompaniers and greeters have errors that exceed those of the ADM data.

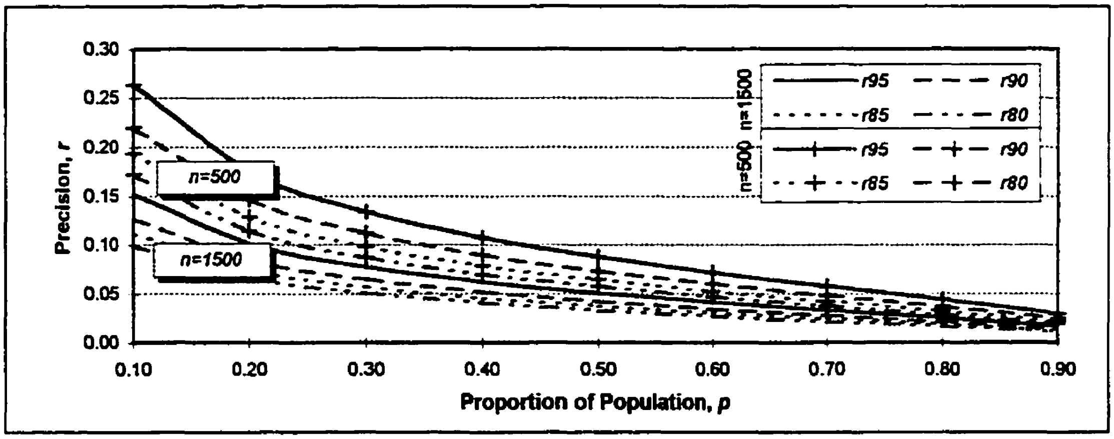



**Figure 2.13: Relative Error of Data Samples** (Adopted from MEYER AND MILLER (1984))

## 2.10 Chapter Summary

The proposed methodology for the analysis of ground access trips to Montreal's International Airports using the totally disaggregate approach embodied in the MADITUC-MAD(Strat)$^2$ system was presented in this chapter.

The methodology consists of four major parts: 1) the examination of the survey methodology used to collect the data, 2) the examination of the data samples, 3) the characterization of ground access trips, and 4) the simulation of ground access trips using the MAD(Strat)$^2$ system.

The examination of the ADM O-D survey methodology included a comparison with the MUCTC O-D survey data on two levels: survey methodology and data structure. This was done since the MUCTC O-D survey data was instrumental to the development of the totally disaggregate approach, and to identify the strong points of each data collection effort and the resulting data. In addition, analysis of the data structure of the data samples revealed the processing procedures that each data set was required to undergo.

The examination and processing of data followed a standard procedure. First, each data sample was examined for inconsistencies that may have still existed. Two major inconsistencies for the ADM databases were discovered: one involved the difference between the calculated time of arrival at the airport and the time interviewed, and the second involved missing x-y coordinate pairs of trip origins or destinations which are essential for simulating with the MAD(Strat)$^2$ system. In the first instance, 3% of the records in the Departures database and 5% of the records from the Greeters database were eliminated. In the second instance, 25% of Departures, 38% of Arrivals and 42% of Greeters records were recuperated by attributing coordinates depending on the spatial information available. In the worst case, the coordinates of the municipal sector were attributed to a trip origin or destination.

Only one inconsistency was found with the MUCTC-MTQ extracted sample. A declared mode was missing for 2% of the records which were corrected by attributing an indeterminate mode to each of these records.

Next, expansion factors were calculated for each of the three databases based on estimated population of passengers and greeters during the survey period and passenger air trip purpose using three different methods. Method 1 was used to calculate expansion factors for domestic and transborder passengers using the 'calibration interview' volume counts as the population for the survey period. Method 2 was used for international passengers using an estimate of international passenger population obtained from the annual number of passengers handled at Mirabel Airport. Method 3 was used for passenger greeters, using an estimate of the greeter population derived from both the arrivals and greeters database. These expansion factors are only estimates and should be treated as such. Therefore the subsequent analyses reflect the travel behaviour of passengers and greeters during the survey period.

New variables were then derived to add a new dimension to the analysis of airport trips. For passengers in the ADM databases, a residential status and a passenger status were derived based on the passenger's declared residence and air trip purpose. For the MUCTC-MTQ data sample, an airport status which identified the equivalent airport tripmaker category, was derived from the trip origin or destination of each trip in the person's trip chain link, the type of trip chain link and the declared trip purpose.

Finally, trips were extracted from each of the three ADM databases as well as from the MUCTC-MTQ data sample. The criteria used for the ADM databases was that each trip have coordinates for both the trip origin and trip destination, which means that only trips within the GMA were extracted for further analysis and simulation with MAD(Strat)$^2$. For the MUCTC-MTQ data sample, only potential passenger greeter trips were extracted since they represented the greatest percentage of trips surveyed by the MUCTC-MTQ O-D survey. The analysis of MUCTC-MTQ trips is supplementary to the analysis of ground access trips.

The chapter concluded with an examination of the statistical significance of the extracted sample. The error associated with the ADM passenger data samples fell within the acceptable margin of error (5%) at the 95% confidence interval. The error associated with the ADM greeter sample however doubled (10.89%) the tolerable margin of error at the 95% confidence interval. Similarly, the error associated with the MUCTC-MTQ accompanier sample (9.43%) falls within the same range as the ADM greeter sample.

# CHAPTER THREE

# ANALYSIS OF SURVEY DATA

This chapter examines and interprets the results of the analysis of airport ground access trips for passengers and passenger greeters using the DEPARTURES, ARRIVALS and GREETERS database files from the ADM survey database. In particular, the profile of passengers and greeters and the characteristics of passenger and greeter airport access (and egress) trips are presented in this chapter.

## 3.1 PROFILE OF PASSENGERS

This section examines the residential status of departing and arriving passengers. The residential status of passengers enables the residents to be distinguished from the nonresidents and thus a sociodemographical profile can be sketched for the typical air passenger.

Analysis of the residential status of passengers, as shown in Table 3.1, reveals that Greater Montreal (GMA) residents represent 49% of the total passenger population. Among the departing passenger population GMA residents were predominant (53%), while nonresidents were predominant among arriving passengers (55%). The residence of a small percentage (3%) of the departing population was unknown and were considered as nonresidents for the rest of the analysis.

**Table 3.1: Residential Status of Surveyed Passengers** (ADM Data)

| Residential Status | DEPARTURES | | ARRIVALS | | TOTAL | |
|---|---|---|---|---|---|---|
| | No. Trips | % Trips | No. Trips | % Trips | No. Trips | % Trips |
| *Resident* | 18 474 | 53% | 12 056 | 45% | 30530 | 49% |
| *Nonresident* | 15 045 | 43% | 14 979 | 55% | 30024 | 49% |
| *Unknown* | 1154 | 3% | 0 | 0% | 1154 | 2% |
| Total | 34 674 | 100% | 27 035 | 100% | 61708 | 100% |

The number of airport access trips to and from each airport produced by each type of passenger is shown in the following table (Table 3.2). Most of GMA resident passengers who depart from or arrive at Dorval Airport (YUL) were business passengers (30%), while most resident passengers departing from or arriving at Mirabel Airport (YMX) were leisure travellers (38%). Similarly, most of nonresident passengers using YUL were business passengers (34%), while nonresident passengers using YMX were leisure travellers (26%).

**Table 3.2: Residential Status and Trip Purpose of Passengers (ADM Data)**

| Passenger-Type | YUL | | YMX | |
|---|---|---|---|---|
| | No. Trips | % Trips | No. Trips | % Trips |
| *Resident - Business (RB)* | 13 081 | 30% | 3730 | 20% |
| *Resident - Leisure (RL)* | 6 705 | 15% | 6 993 | 38% |
| *Nonresident - Business (NRB)* | 14 768 | 34% | 2 635 | 14% |
| *Nonresident - Leisure (NRL)* | 8 980 | 21% | 4 795 | 26% |
| Total | 43 534 | 100% | 18 175 | 100% |

### 3.1.1 Resident Passengers

The greatest proportion of departing and arriving passengers reside in the MUC-Centre (28%), MUC-West (19%), and the Immediate South Shore (11%), as shown in Figure 3.1. The MUC-Centre generates the greatest proportion of both resident-business (RB) and resident-leisure (RL) travellers for both departing and arriving passengers. The MUC-West and Immediate South

Shore municipalities generate more RB than RL passengers for both departing and arriving passengers.

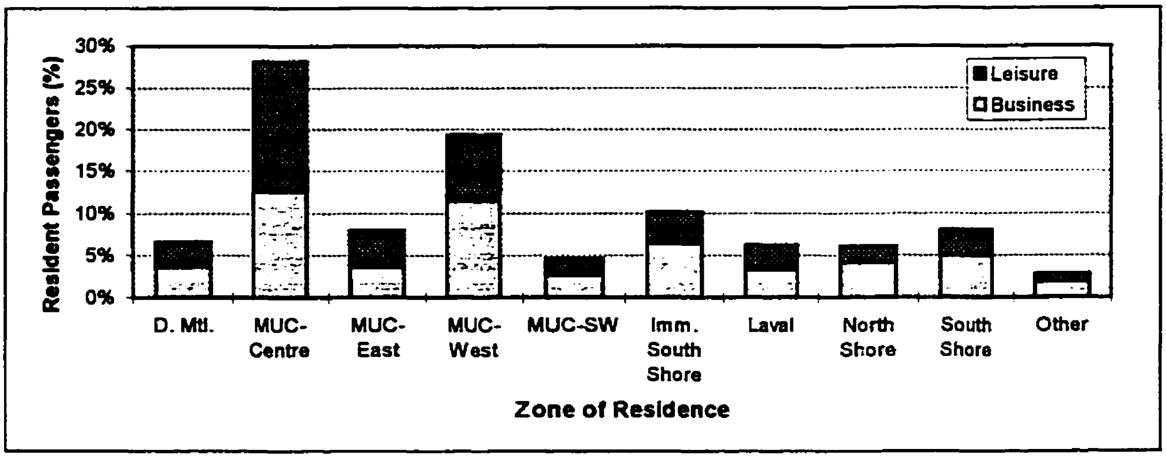



**Figure 3.1: Residence of GMA Resident Passengers**

The sociodemographic data of the three zones presented in Table 3.3, shows that high average household income households do not necessarily generate the greatest amount of resident air passengers. MUC-Centre resident passengers have a lower average household income ($39,599/hhld) compared to the MUC-West and Immediate South Shore resident passengers.

**Table 3.3: Sociodemographic Characteristics of Top Three Resident Trip Generating Zones**

| Zone | Persons/hhld[1] | HHLD Income[1] | No.Cars/hhld[2] | Average Age[2] | % Female[2] | Res Pax[3] |
|---|---|---|---|---|---|---|
| *MUC-Centre* | 2.19 | $ 39,599 | 0.79 | 37.5 | 0.53 | 8752 |
| *MUC-West* | 2.72 | $ 53,948 | 1.31 | 35.3 | 0.51 | 6041 |
| *Imm. S-Shore* | 2.68 | $ 48,348 | 1.32 | 33.9 | 0.52 | 3169 |

[1] Statistics Canada (1991)

[2] MADEOD (MUCTC-MTQ 1993 O-D Survey)

[3] ADM O-D Survey (1993)

Other household characteristics of the MUC-Centre include a small household size (2.19 persons/hhld) and a low number of automobiles per household in contrast to the other two zones. Personal characteristics of MUC-Centre resident passengers include a high average age (37.5

yrs) and a greater proportion of female residents among the population (53%) although all three zones exhibit high proportions of females. Therefore contrary to the hypothesis made in Chapter 1, zones with high average household income do not generate the greatest number of air trips.

### 3.1.2 Nonresident Passengers

Among the nonresident passengers, Figure 3.2 shows that the majority of nonresident-business (NRB) passengers reside in Canadian provinces other than Quebec (22%). Quebec residents from regions other than the Greater Montreal Area travelled more for business than for leisure purposes. The majority of nonresident-leisure (NRL) passengers reside in continents other than North America (19%). The United States is the residence of the greatest overall proportion of these passengers (31%).

Business passengers predominated among the arriving nonresident population from Canada (21%) and the United States (17%), while leisure travellers predominated among the nonresident population from other world countries (19%).

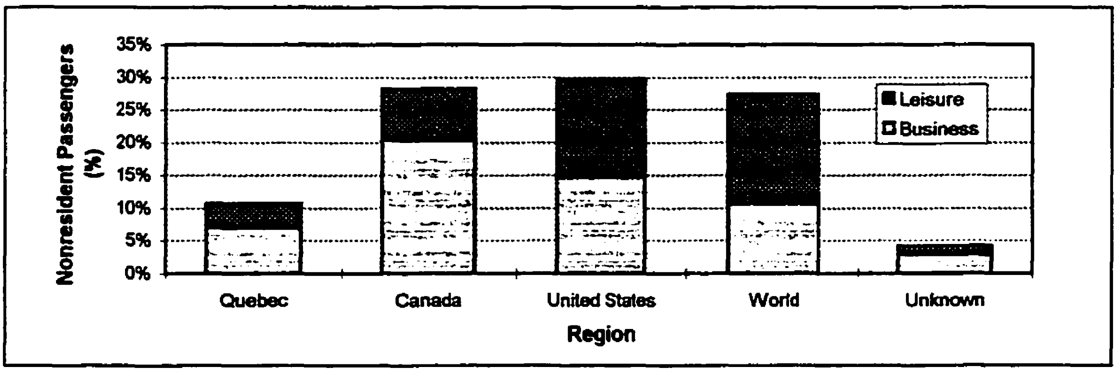



Figure 3.2: Residence and Trip Purpose of Nonresident Passengers (ADM Data)

## 3.2 PASSENGER AIRPORT ACCESS TRIPS

Passenger airport access trips are characterized in terms of origin and destination, distribution of the time of departure, modal choice, curbside activity and vehicle occupancy. Furthermore, a brief analysis for departing passengers on the time difference between time of arrival at the airport by ground access mode and the time of the passenger's flight was conducted to investigate the possible relationship between preflight waiting time at the airport and ground access conditions.

### 3.2.1 Last Trip Origin of Departing Passengers

Passenger access trip origins are shown to be centralized. Downtown Montreal and the MUC-Centre together produced the greatest amount of airport generated traffic for both airports. The distribution of departing passenger access trip origins is shown in Figure 3.3.

#### 3.2.1.1 Resident Departing Passengers

The three zones from which the greatest number of resident passenger trips departing Montreal via Dorval-YUL originate are the MUC-Centre (12%), the MUC-West (12%), and the Immediate South Shore (5%). The top three zones from which resident passengers departing Montreal from Mirabel-YMX originate are the MUC-Centre (22%), Downtown Montreal (9%) and the MUC-West (8%).

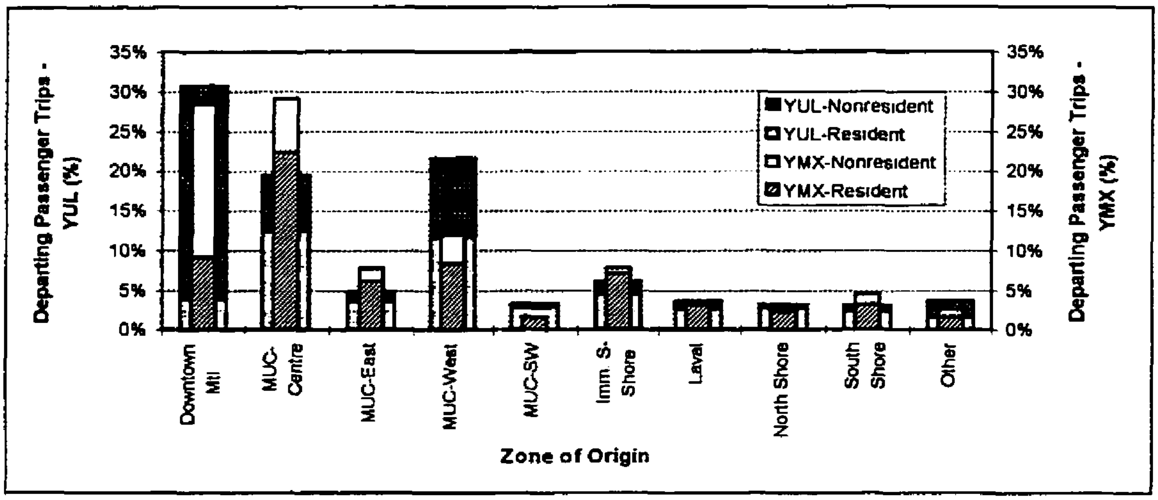



**Figure 3.3: Last Trip Origin of Departing Passengers**

Using the spatial information provided, it is possible to determine the type of activity centre that either produced airport-ended trips, as presented in Table 3.4. Resident passengers predominantly originated from their residence; 85% of RB and 94% of RL departing passengers departed for the airport from their residence. For nonresident passengers, 50% of NRB passengers departed from hotels while 54% of NRL passengers departed from other types of trip generators than hotels.

**Table 3.4: Trip Generators of Departing Passenger Airport Trips (ADM Data)**

| Category of Tripmaker | RESIDENCE | | HOTELS/MOTELS | | OTHER LOCATION | |
|---|---|---|---|---|---|---|
| | Passenger Trips | Percent Trips | Passenger Trips | Percent Trips | Passenger Trips | Percent Trips |
| *Resident-Business (RB)* | 8417 | 85% | 71 | 1% | 1423 | 14% |
| *Resident-Leisure(RB)* | 8037 | 94% | 35 | 0% | 438 | 5% |
| *Nonresident-Business (NRB)* | 232 | 2% | 4660 | 50% | 4381 | 47% |
| *Nonresident-Leisure (NRL)* | 285 | 4% | 2903 | 42% | 3790 | 54% |

#### 3.2.1.2 Nonresident Departing Passengers

The top three zones from which nonresident passengers leaving Montreal from Dorval-YUL originated in decreasing order were Downtown Montreal (24%), MUC-West (9%) and MUC-Centre (6%). Similarly, nonresident passengers leaving Montreal from Mirabel-YMX also predominantly originated from Downtown Montreal (20%). However, the second most popular zone of origin for nonresident passengers is the MUC-Centre (7%) followed by the MUC-West (4%). Few nonresident passengers originated from other areas of the Greater Montreal Area.

### 3.2.2 First Destination of Arriving Passengers

The distribution of first destinations of passengers arriving in Montreal from YUL and YMX is shown in Figure 3.4. Again, the centralization of nonresidents in the central area of the Montreal region is observed.

#### 3.2.2.1 Resident Arriving Passengers

For resident passengers returning to Montreal via YUL, the first destination zone was the MUC-West (9%), while for those resident passengers returning via YMX, it was the MUC-Centre (19%). Examination of the type of generator that attracted arriving resident passenger trips revealed that resident passengers returned predominantly to their residence than to any other point (Table 3.5); 91% of RB and 96% of RL passengers return to their residence.

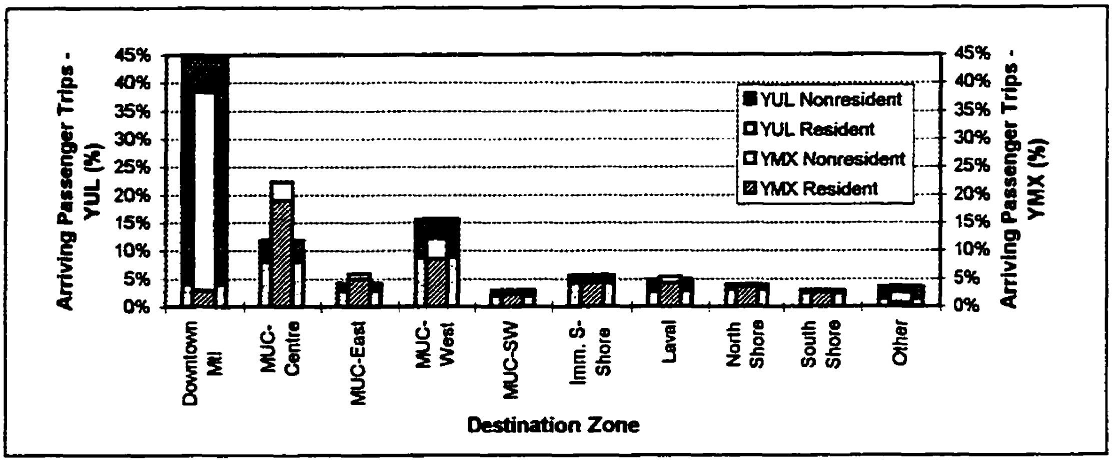



**Figure 3.4: First Destination of Arriving Passengers**

**Table 3.5: Trip Generators of Arriving Passenger Airport Trips (ADM Data)**

| Category of Tripmaker | RESIDENCE | | HOTELS/MOTELS | | OTHER LOCATION | |
|---|---|---|---|---|---|---|
| | Passenger Trips | Percent Trips | Passenger Trips | Percent Trips | Passenger Trips | Percent Trips |
| *Resident-Business (RB)* | 6 210 | 91% | 11 | 0% | 625 | 9% |
| *Resident-Leisure(RB)* | 4 980 | 96% | 0 | 0% | 230 | 4% |
| *Nonresident-Business (NRB)* | 125 | 2% | 2 876 | 35% | 5 180 | 63% |
| *Nonresident-Leisure (NRL)* | 66 | 1% | 2 270 | 33% | 4462 | 66% |

### 3.2.2.2 Nonresident Arriving Passengers

The first destination of the majority of nonresident passengers arriving in Montreal, is Downtown Montreal; 40% of nonresident passengers of YUL-arriving passengers, and 35% of YMX-arriving nonresident passengers travel to the same area. Most arriving nonresident passengers do not travel first to hotels compared to *departing* nonresident passengers; only 35% of NRB and 33% of NRL travel to hotels whereas over 60% of nonresident passengers said that they will travel to some other location first.

### 3.2.3 Temporal Distribution of Passenger Airport Trips

The temporal distribution of the time departing passengers leave for the airport is shown in Figure 3.5. Forty percent (9860 trips) of departing passenger traffic bound for Dorval Airport occurred during the regular traffic, morning peak period from 6:00a.m. to 8.59a.m.. The peak hour for YUL-bound trips was 6:00 a.m. with a volume of 4371 trips and 4:00 p.m. for YMX-bound trips, with a volume of 1954 trips.

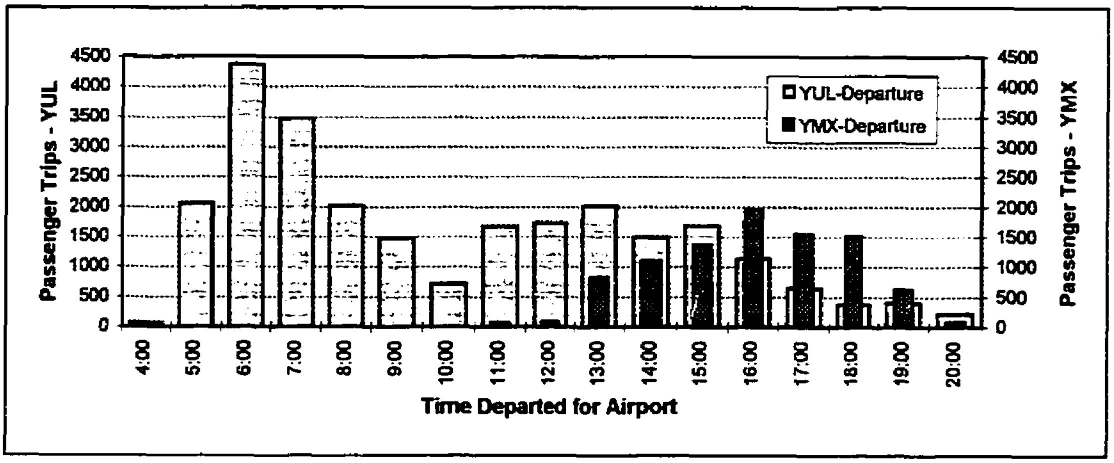



**Figure 3.5: Temporal Distribution of Departing Passenger Ground Trips to Airport**

The temporal distribution of arriving passenger egress trips from YUL and YMX is shown in Figure 3.6. The peak departure hour from YUL was 5:00 p.m., and 4:00p.m. at YMX. These peak periods correspond to the peak arrival flight activity at each airport (refer to Figure 1.3). Since no time variable other than the time surveyed was available for arriving passengers who are leaving the airport by ground access mode, it was this variable that was used to estimate the time of departure of arriving passengers from the airport terminal.

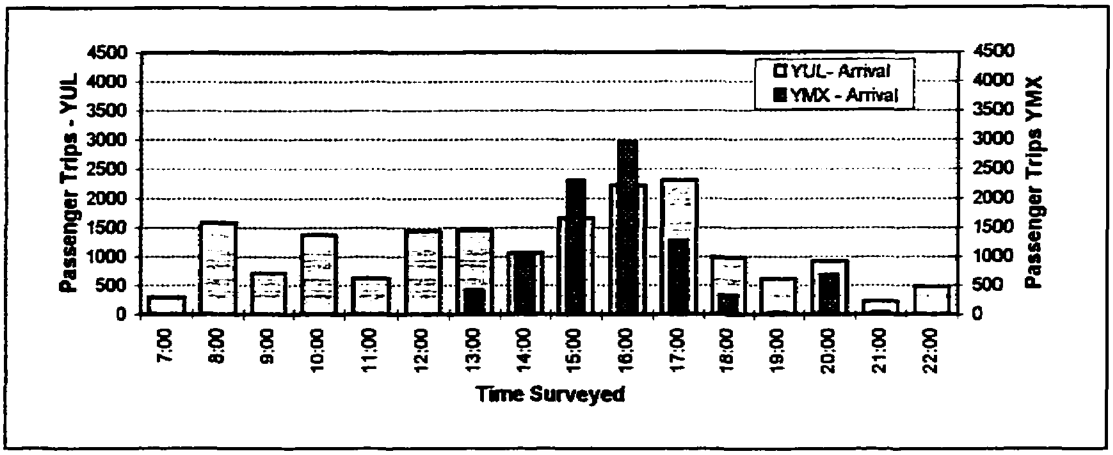



**Figure 3.6: Temporal Distribution of Arriving Passenger Ground Trips from Airport**

When the temporal distribution, air trip purpose and passenger type for departing and arriving air passengers are examined the following is revealed. (See figures in the Appendix):

- RB, RL and NRL passengers departing from YUL, travel to the airport during the morning peak period, while NRB passengers conduct their trips predominantly during the afternoon peak period.
- NRB passengers arriving at YUL begin their ground access trips at a consistent rate throughout the day. Resident passengers, however, both business and leisure arrive predominantly during the afternoon peak.
- Both business and leisure passengers generally travel during the same time period, whether from YUL or YMX.
- Business passengers predominate at YUL, while leisure passengers predominate at YMX.

### 3.2.4 Modal Choice

Private vehicle modes were most often used by passengers to access and egress both Dorval-YUL and Mirabel-YMX Airports. The top three modes used to access Dorval were: 1) automobile (49%); 2) taxi (32%), and 3) rental car (10%). While the modal split for the automobile is higher for YMX (66%), there was a tendency for passengers travelling to YMX to choose public modes such as the autocar shuttle service (11%) over the taxi (8%) or rental car (6%) modes. The cost of these modes, which are dependent on distance travelled, is an important factor in the choice of the airport access mode. Table 3.6 shows that departing and arriving passengers generally exhibit similar access modal choice, with minor exceptions, such as the preference for private vehicle modes exhibited more frequently by arriving passengers travelling from YMX than departing passengers travelling to YMX.

The following two graphs show the differences in the airport access modal choice for RB, RL, NRB and NRL departing (Figure 3.7) and arriving (Figure 3.8) passengers. For departing passengers the following trends were revealed: first, resident passengers predominantly used the automobile to travel to either YUL or YMX (74%). Second, more business than leisure passengers in both resident and nonresident categories used high-cost modes such as the taxi; 29% of RB and 40% of NRB passengers use the taxi to access YUL and 5% of RB and 20% of NRB passengers use the taxi to access YMX. Third, the autocar shuttle service to YMX was used more often by all passenger types, than taxi or rental car modes.

For arriving passengers, up to 98% of trips made by resident passengers originating from YUL used private modes (automobile, rental car, taxi, limousine) to egress the airport. Similarly, up to 94% of resident passengers originating from YMX used private modes as well. Nonresident passengers, on the other hand, exhibited a more varied modal distribution with 11% of trips from

YUL and 24% of trips from YMX made using public modes (chartered bus, autocar, transit, hotel shuttle).

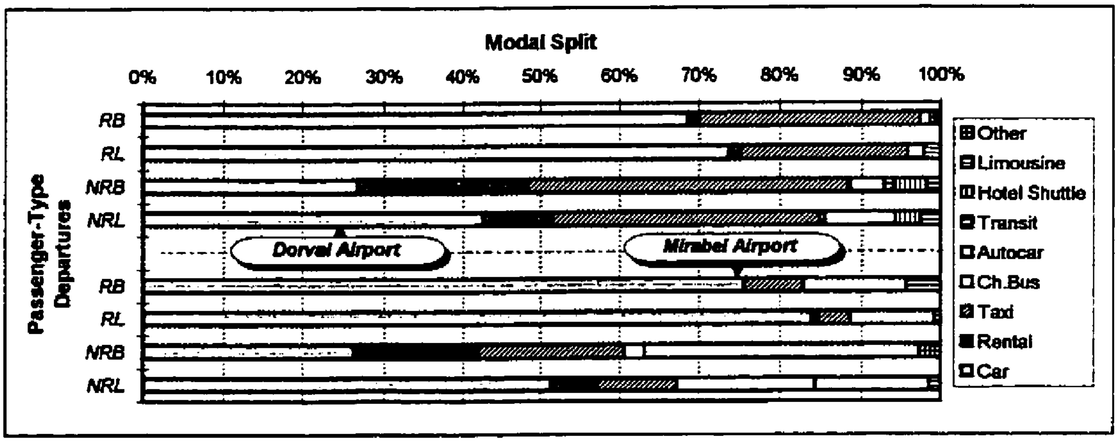



**Figure 3.7: Modal Choice of Departing Passengers to Access Dorval and Mirabel Airport**

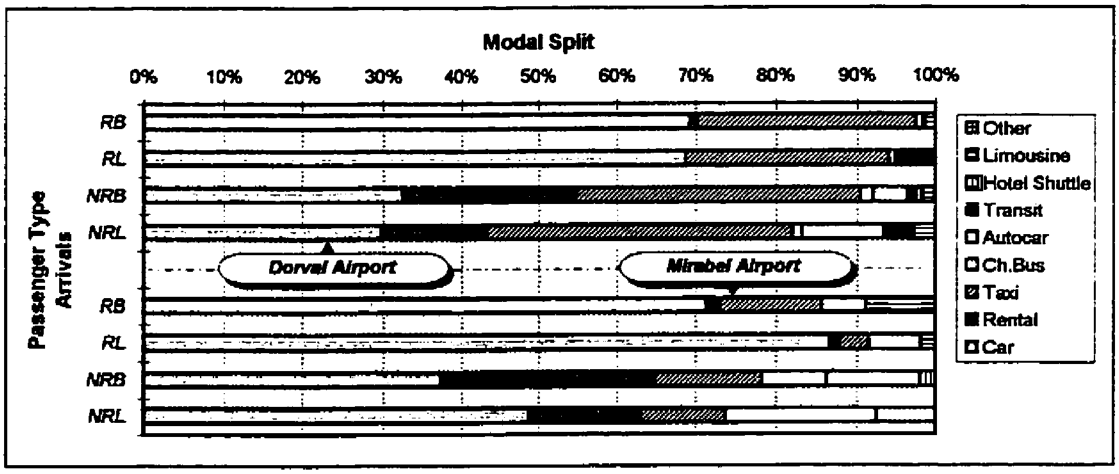



**Figure 3.8: Modal Choice of Arriving Passengers to Leave Dorval and Mirabel Airports**

Examination of the usage of the private automobile per zone revealed that the percentage of automobile trips increased with distance from the airport as well as with the level of household car ownership. For zones with a high level of car ownership, the percentage of departing and arriving passenger automobile trips were higher than for zones with less cars available per household (Figure 3.9). This would explain the high modal split of car trips to YMX from Laval, and the North and South Shores where car ownership levels are higher. Another factor which affected the rate of car trips per zone is the availability or lack of public modes in the zone. For example, there were less automobile trips originating from zones where public modes were available, such as the central area of Montreal and in the vicinity of YUL (i.e. hotel shuttles). In the suburbs, where public modes are lacking, there was no option other than to use the automobile.

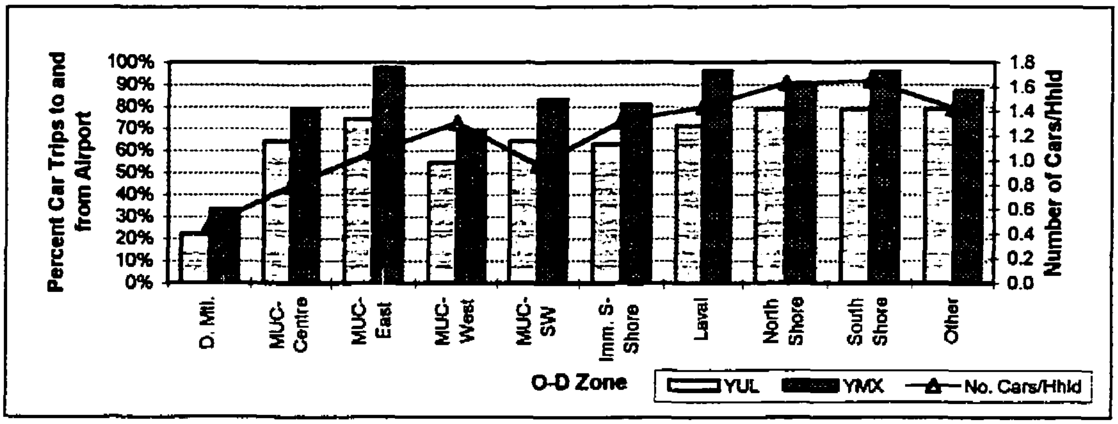



**Figure 3.9: Percent Car Trips and Car Ownership per Origin-Destination Zone**

### 3.2.5 Curbside Activity of Departing Passengers

The analysis of curbside activity examined how passengers accessed the terminal and transferred from ground mode to air mode. In this case, the ground mode in question is the automobile. Departing passengers using the automobile to travel to the airports were categorized as being either *auto-passenger* or *auto-driver* using the variable RECONDUIT in the DEPARTURES database. The drop-off type for each auto-passenger and the parking lot used by auto-drivers, are also examined in this section.

Of the 13,077 departing passenger car trips to Dorval-YUL, 64%, or 8410 trips, were auto-passengers and 36%, or 4667 trips, were auto-drivers (Table 3.6). For car trips to Mirabel-YMX, the proportion of auto-passengers increases to 92%, or 3345 trips, and the number of auto-drivers decreases to 8% (296 trips).

**Table 3.6: Car Trips to Dorval and Mirabel Airports**

| *Type of Passenger* | YUL | | YMX | |
|---|---|---|---|---|
| | Number Car Trips | Percent Car Trips | Number Car Trips | Percent Car Trips |
| *Auto-Passengers* | 8410 | 64% | 3345 | 92% |
| *Auto-Drivers* | 4667 | 36% | 296 | 8% |
| Total | 13 077 | 100% | 3641 | 100% |

Figure 3.10 shows that 50% (3611 trips) of all resident air passengers and 15% (476 trips) of all nonresident passengers leaving Montreal via YUL drove to the airport. It was also observed that more business than leisure passengers drove to the airport, regardless of residential status.

Departing passengers (both resident and nonresident) leaving Montreal via YMX and travelling by car are predominantly auto-passengers as opposed to auto-drivers. This is due to the fact that the duration of an international trip is usually longer than a domestic or transborder trip passengers tend not to leave their vehicles in the airport parking lot for the duration of their trip.

The majority of persons that accompanied air passengers to either airport, dropped them off at the curb and then left the airport grounds. Table 3.7 shows that at YUL 94% of air passengers were dropped off at the departures curb and of these, 6% of the persons that drove the air passengers went to park the vehicle and then joined the passenger in the terminal. Only 6% of auto-passengers remained in the vehicle with the accompanier until the vehicle was parked. However, at YMX, a lower percentage (55%) of passengers were dropped off at the curb; the remaining 45% of international passengers stayed in the vehicle until it was parked, and then walked to the terminal together with the person accompanying them.

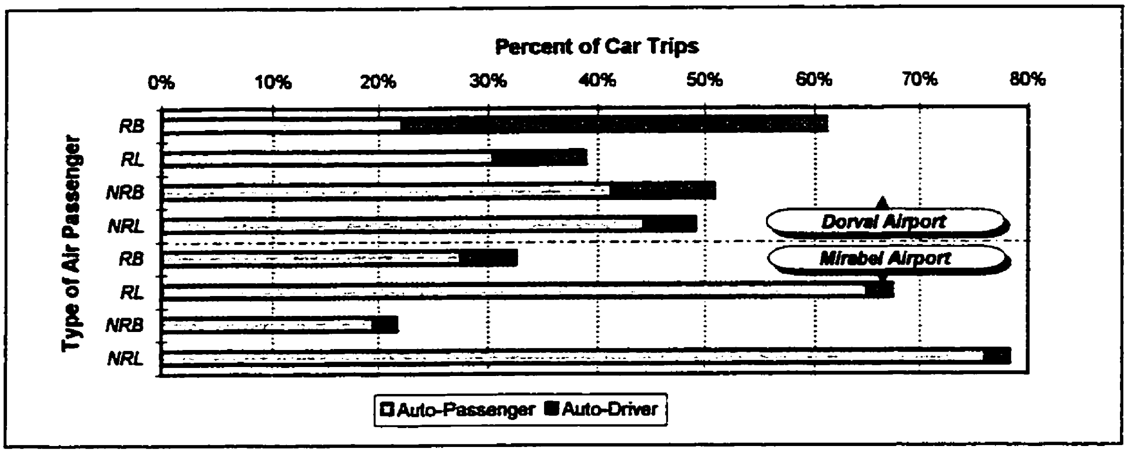



**Figure 3.10: Departing Air Passenger Type and Automobile Ground Trips to the Airport**

**Table 3.7: Curbside Activity of Departing Passengers at Dorval and Mirabel Airports**

| Type of Activity | YUL | | | | YMX | |
|---|---|---|---|---|---|---|
| | Domestic | | Transborder | | International | |
| | Number of Trips | Percent Trips | Number of Trips | Percent Trips | Number of Trips | Percent Trips |
| *Passenger Dropped off at Terminal Curb - Accompanier Leaves Airport Grounds* | 3461 | 88% | 3981 | 89% | 2575 | 44% |
| *Passenger Dropped off at Terminal Curb - Accompanier Parks Car* | 235 | 6% | 272 | 6% | 622 | 11% |
| *Vehicle Parked - Passenger and Accompanier walk to Terminal* | 219 | 6% | 242 | 5% | 2605 | 45% |
| Total | 3915 | 100% | 4495 | 100% | 5802 | 100% |

### 3.2.5.1 Parking

Of the 4667 auto-driver trips to YUL, 45% used the multilevel parking lot adjacent to the terminal, while 43% used the exterior parking lot at the airport. Examination of the trip purpose revealed most business passengers (50%) used the multilevel parking and most leisure passengers used either the exterior parking lot at the airport (47%), or some other parking lot (22%).

**Table 3.8: Parking Lot Used by Air Passenger Auto-Drivers at Dorval Airport**

| Trip Purpose | MULTILEVEL PARKING | | EXTERIOR PARKING | | OTHER | | TOTAL |
|---|---|---|---|---|---|---|---|
| | Number Trips | Percent Trips | Number Trips | Percent Trips | Number Trips | Percent Trips | |
| *Business* | 1859 | 50% | 1537 | 41% | 336 | 9% | 3732 |
| *Leisure* | 291 | 31% | 438 | 47% | 206 | 22% | 935 |
| Total | 2150 | 46% | 1975 | 42% | 542 | 12% | 4667 |

The average time that auto-drivers left their vehicles parked at YUL is 1.48 days for business passengers and 2.61 days for leisure passengers (Table 3.9). Overall, air passenger auto-drivers parked for longer periods in the exterior parking lot than in the multilevel parking lot. Leisure passengers showed a greater parking duration than business passengers, which further confirms that leisure air trips are longer than business air trips.

The shorter parking duration observed for the multilevel parking lot implies that passengers prefer to leave their vehicle in a less expensive parking lot if their trip is for an average of 2 or more days. However the marginal difference observed in choice of lots by leisure passengers, who are assumed to be more cost-sensitive than business passengers, leads to no definite conclusion.

**Table 3.9: Average Parking Time for Air Passenger Auto-Drivers at Dorval Airport.**

| Trip Purpose | EXTERIOR PARKING | MULTILEVEL PARKING | TOTAL |
|---|---|---|---|
| | Average Parking Time (days) | Average Parking Time (days) | Average Parking Time (days) |
| *Business* | 1.73 | 1.54 | 1.48 |
| *Leisure* | 2.96 | 2.99 | 2.61 |
| Total | 2.00 | 1.74 | 1.71 |

Parking lot usage by air passenger auto-drivers at YMX is presented in Table 3.10. The multilevel parking lot is most frequently selected for both business and leisure passengers (79%). The parking duration for air passenger auto-drivers is shown in Table 3.11. Once again, the average duration is longer for leisure passengers than business passengers (3.00 days versus 1.78 days). In addition, the average duration for international passengers is longer than domestic and transborder passengers. However, due to the small number of passengers that drive themselves to Mirabel, the values presented in Table 3.11 should be interpreted with caution.

**Table 3.10: Parking Lot Use of Air Passenger Auto-Drivers at Mirabel Airport**

| Trip Purpose | MULTILEVEL PARKING | | EXTERIOR PARKING | | OTHER | | TOTAL |
|---|---|---|---|---|---|---|---|
| | Number Trips | Percent Trips | Number Trips | Percent Trips | Number Trips | Percent Trips | |
| *Business* | 237 | 89% | 30 | 11% | 0 | 0% | 267 |
| *Leisure* | 89 | 60% | 0 | 0% | 59 | 40% | 148 |
| *Total* | 326 | 79% | 30 | 7% | 59 | 14% | 415 |

**Table 3:11: Average Parking Time of Air Passenger Auto-Drivers at Mirabel Airport**

| Trip Purpose | EXTERIOR PARKING | MULTILEVEL PARKING | TOTAL |
|---|---|---|---|
| | Average Parking Time (days) | Average Parking Time (days) | Average Parking Time (days) |
| *Business* | 14.0 | 5.02 | 1.78 |
| *Leisure* | 0 | 10.39 | 3.00 |
| Total | 14.0 | 6.11 | 2.04 |

### 3.2.6 Vehicle Occupancy

The vehicle occupancy of private vehicles, calculated using the variables NBVOYAGEUR and NBACCOMP from the DEPARTURES database, is given in Table 3.12 for each flight sector and type of passenger. International passengers - including transborder passengers - exhibited a consistently higher vehicle occupancy than for domestic passengers. Also, business passengers had a lower vehicle occupancy than leisure passengers both for residents and nonresidents.

$$veh.occ. = \frac{\sum_{i=1}^{n} (nbvoyageur + nbaccomp)_i * f\exp_i}{\sum_{i=1}^{n} f\exp_i} \qquad i = 1, 2, 3, \ldots, n$$

where: $nbvoyageur_i$ = number of air passengers aboard respondent $i$ 's ground access vehicle;

$nbaccomp_i$ = number of accompaniers aboard respondent $i$ 's ground access vehicle;

$fexp_i$ = expansion factor for respondent $i$

**Table 3.12: Vehicle Occupancy of Departing Passenger Private Vehicles**

| Passenger-Type | DOMESTIC | TRANSBORDER | INTERNATIONAL | TOTAL |
|---|---|---|---|---|
| *Resident-Business (RB)* | 1.58 | 1.89 | 2.66 | 1.89 |
| *Resident-Leisure (RL)* | 2.30 | 2.70 | 2.80 | 3.02 |
| *Nonresident-Business (NRB)* | 2.17 | 2.70 | 2.80 | 2.39 |
| *Nonresident-Leisure (NRL)* | 2.35 | 2.98 | 3.33 | 2.98 |
| **Total** | 1.90 | 2.68 | 3.14 | 2.53 |

It was also possible to analyze the composition of the persons aboard a ground access mode using the two variables NBVOYAGEUR and NBACCOMP. In particular, an estimate of the size of the party travelling together by air, as well as the number of accompaniers per passenger were examined.

Analysis of the number of passengers travelling together revealed that domestic air passengers travelled in smaller groups than transborder and international passengers. Table 3.13 shows that 70% of passengers travelling to Canadian destinations travel alone, whereas the number of single travellers decreases to 58% for passengers travelling to the United States, and 52% for international destination-bound passengers. The percentage of passengers travelling in groups of 3 or more was 10% for domestic passengers, 15% for transborder passengers and 26% for international passengers.

**Table 3.13: Number of Air Passengers Travelling Together** (All modes)

| Group Size | DOMESTIC | | TRANSBORDER | | INTERNATIONAL | |
|---|---|---|---|---|---|---|
| | Number of Passengers | Percent | Number of Passengers | Percent | Number of Passengers | Percent |
| 1 | 10 260 | 70% | 6 383 | 58% | 4 766 | 52% |
| 2 | 2 943 | 20% | 2 942 | 27% | 1 983 | 22% |
| >=3 | 1 401 | 10 % | 1599 | 15% | 2398 | 26% |
| Total | 14 604 | 100% | 10 924 | 100% | 9 146 | 100% |

The average traveller group size also varied with trip purpose and residential status, as shown in Table 3.14. In general, business passengers travelled in smaller groups than leisure passengers and residents travelled in smaller groups than nonresidents. The average number of resident-business (RB) passengers travelled in groups of 1.59, resident-leisure (RL) passengers travelled in groups of 2.10, and nonresident-business (NRB) passengers travelled in groups of 2.25.

**Table 3.14: Average Number of Passengers Travelling Together and Type of Passenger**

| Type of Passenger | DOMESTIC | TRANSBORDER | INTERNATIONAL | TOTAL |
|---|---|---|---|---|
| *Resident-Business (RB)* | 1.24 | 1.34 | 2.81 | 1.59 |
| *Resident-Leisure (RL)* | 2.08 | 1.89 | 2.26 | 2.10 |
| *Nonresident-Business (NRB)* | 1.63 | 1.73 | 6.53 | 2.25 |
| *Nonresident-Leisure (NRL)* | 1.86 | 2.25 | 8.30 | 3.97 |
| Total | 1.56 | 1.86 | 4.28 | 2.37 |

Similar trends were observed for persons accompanying passengers to the airport in the same vehicle. The average number of accompaniers in the same vehicle per type of passenger is found in Table 3.15. The values in Table 3.15 are for the private automobile only. From this table it is evident that the average number of people in the same vehicle accompanying the passenger to the airport increased for destinations other than domestic. When the destinations were examined by type of passenger, it was observed that for domestic destinations, fewer persons accompanied business passengers to the airport compared to leisure passengers, however for international and transborder destinations, the average number of business passenger accompaniers increased by approximately 100% to 200% of the number of domestic passenger accompaniers for resident passengers, and by 20 to 80% for nonresident passengers. Also, resident passengers generally have less accompaniers per passenger than nonresidents.

**Table 3.15: Number of People Accompanying Passenger in Same Vehicle to the Airport**

| Type of Passenger | DOMESTIC[1] | TRANSBORDER[1] | INTERNATIONAL[1] |
|---|---|---|---|
| *Resident-Business (RB)* | 0.36 | 0.63 | 1.28 |
| *Resident-Leisure (RL)* | 0.70 | 1.18 | 1.68 |
| *Nonresident-Business (NRB)* | 0.88 | 1.11 | 1.40 |
| *Nonresident-Leisure(NRL)* | 0.94 | 1.20 | 1.72 |
| Total | 0.58 | 1.03 | 1.57 |

[1] Mode = Automobile

The total number of accompanier trips to the airport, generated by each departing passenger, for all modes, is given in Table 3.16. Again, it is observed that passengers travelling to international destinations, both transborder and international, generate more accompanier trips than those travelling to Canadian destinations. This is true for both residents and nonresidents.

**Table 3.16: Total Number of Accompaniers per Passenger - All Modes**

| Type of Passenger | DOMESTIC | TRANSBORDER | INTERNATIONAL | TOTAL |
|---|---|---|---|---|
| *Resident-Business (RB)* | 0.39 | 0.64 | 1.24 | 1.23 |
| *Resident-Leisure (RL)* | 0.63 | 1.14 | 1.62 | 1.23 |
| *Nonresident-Business (NRB)* | 0.59 | 0.60 | 1.66 | 0.72 |
| *Nonresident-Leisure(NRL)* | 0.65 | 0.81 | 1.49 | 0.98 |
| Total | 0.52 | 0.80 | 1.51 | 0.87 |

### 3.2.7 Time Before Flight Departure

Airline companies and airport authorities suggest that passengers arrive 60 minutes before scheduled flights at Dorval Airport and 90 minutes before scheduled flights at Mirabel Airport for check-in, security screening and customs procedures (ADM, 1993B). The amount of time that a passenger actually spends waiting at the airport prior to the flight could be attributed to familiarity with the access network. It is assumed that nonresident passengers arrive at the airport earlier than residents, since they are unfamiliar with the access road network and consequently with how much time is required to travel to the airport or with the traffic patterns. Also, business passengers are assumed to arrive closer to the time of their flight since they place a high value on their time and are not willing to spend it waiting at the airport. The time spent at the airport prior to a departing flight may also depend on the passenger's perception of the time required for airline and airport passenger processing procedures prior to the flight.

Using the departure time (HDEPART) and travel time (TPPARCOURS) for the ground trip to the airport, it was possible to estimate how early departing passengers arrive at the airport prior to their flight, and to observe the differences between the passenger categories.

The flight guide published by ADM for the period from April 1, 1993 to July 1, 1993 was used to obtain the flight departure times. A secondary validation was carried out to extract records for which departure times were available for the given flight numbers. The number of trips for which this analysis could be conducted represented 88% of the total trips made by departing passengers (Table 3.17).

Table 3.17: Number of Trips With Available Flight Numbers and Departure Times

| Flight Sector | DEPARTURES | |
|---|---|---|
| | Trips with Flight Numbers and Departure Times | Total Ground Trips Originating in GMA |
| *Domestic* | 14 022 | 14 604 |
| *Transborder* | 9 821 | 10 924 |
| *International* | 6 654 | 9 146 |
| Total | 30 497 | 34 674 |

The results of the analysis of the average time difference before departure flights for each flight sector and type of tripmaker is given in Table 3.18. Domestic passengers tended to arrive the closest to their flight, with an average of 72 min prior to the time of flight departure, since customs clearance is not required. For transborder and international flights where prior flight customs clearance is required, the average time difference between the time of arrival and time of flight was 84 min for transborder passengers and 166 min for international passengers. Table 3.18 also shows that nonresident passengers arrived at Dorval Airport earlier than residents. However at Mirabel Airport, business passengers arrived earlier than leisure passengers regardless of the residential status of passengers.

Table 3.18: Average Time at Airport Before Departing Flight

| Passenger-Type | YUL | | YMX |
|---|---|---|---|
| | Domestic | Transborder | International |
| | Average Time (min) | Average Time (min) | Average Time (min) |
| *Resident-Business (RB)* | 64 | 76 | 157 |
| *Resident-Leisure (RL)* | 77 | 76 | 172 |
| *Nonresident-Business (NRB)* | 79 | 90 | 152 |
| *Nonresident-Leisure(NRL)* | 75 | 91 | 177 |
| Total | 72 | 84 | 166 |

All passenger types arrived at Mirabel Airport almost twice as early than they did at Dorval Airport. However when the time prior to flight was plotted against the Euclidean distance to the airport (Figure 3.11) no correlation existed, as observed by the dispersion of the points; a value of 0.4556 was obtained for the coefficient of correlation $R^2$. For a given distance to the airport (x=15km), the time before flight ranges from 10 to 300 minutes.

Analysis of the average distance and time difference prior to the airport for each zone of origin shows that passengers at each airport generally arrived at the same time prior to their flight departure regardless of the zone of origin or distance to the airport (Table 3.19).

Therefore, the time that passengers arrive at the airport prior to the flight departure is dependent on other factors than distance to the airport: namely the sector of the flight departure, residential status of passengers for Dorval Airport, and trip purpose for Mirabel Airport.

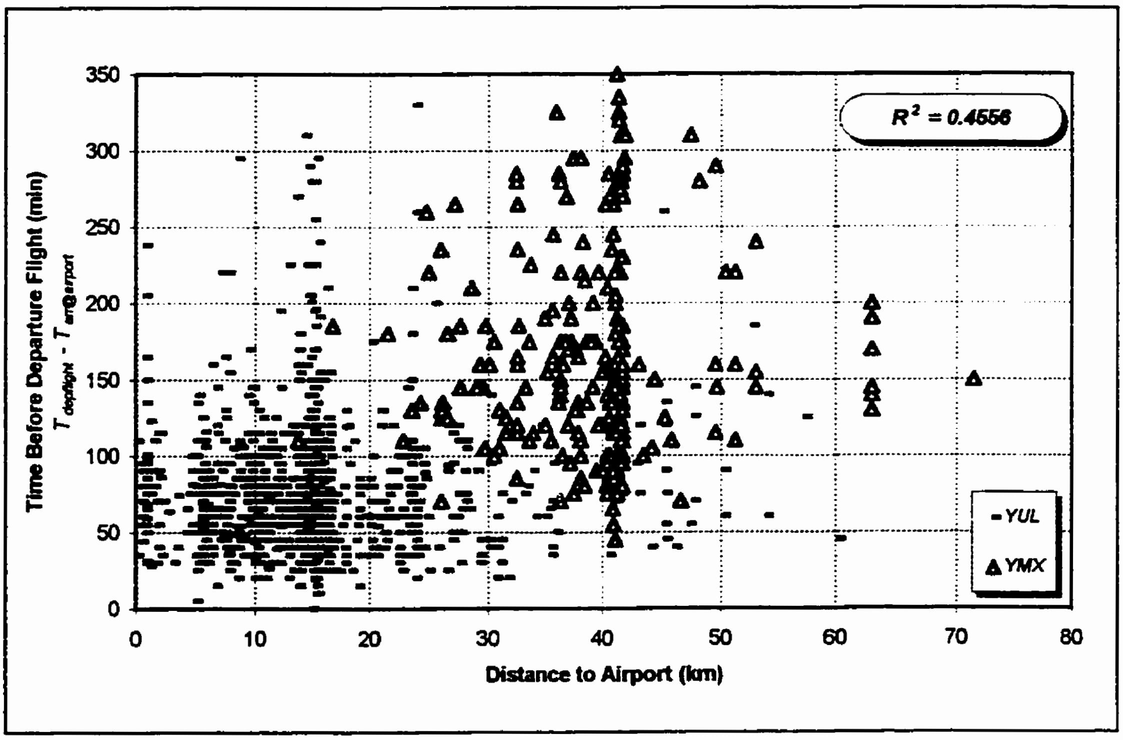



**Figure 3.11: Time Difference Before Flight vs. Distance to Airport**

Table 3.19: Average Time at Airport Before Departing Flight and Distance to Airport

| Zone of Origin | YUL | | YMX | |
|---|---|---|---|---|
| | Average Time Before Flight Δt (min) | Average Distance (Euclidean) d (km) | Average Time Before Flight Δt (min) | Average Distance (Euclidean) d (km) |
| *Downtown Montreal* | 86 | 14.93 | 170 | 41.44 |
| *MUC-Centre* | 76 | 11.50 | 169 | 37.59 |
| *MUC-East* | 67 | 21.23 | 179 | 38.82 |
| *MUC-West* | 68 | 5.91 | 153 | 29.70 |
| *MUC-SW* | 77 | 12.50 | 118 | 43.62 |
| *Immediate South Shore* | 84 | 23.80 | 186 | 49.33 |
| *Laval* | 71 | 16.09 | 160 | 26.13 |
| *North Shore* | 77 | 27.95 | 151 | 24.24 |
| *South Shore* | 77 | 29.57 | 154 | 56.42 |
| *Other* | 78 | 36.59 | 156 | 38.95 |
| Total | 77 | 14.75 | 167 | 38.95 |

## 3.3 PROFILE OF PASSENGER GREETERS

The residence of the passenger greeter was not captured by the ADM O-D survey data. However the residence of the passenger(s) being greeted is known for each greeter trip. By comparing the passenger's residence with the greeter's trip origin, it was possible to infer a relationship between the greeter and the passenger. In particular, Table 3.20 shows that only 20% of all greeter trips to both airports were to greet at least one member of the same household; the other 80% were to pick up other passengers. In fact, the percentage of same household member greeters may actually be higher, however there is no way to determine this without knowing the greeter's residence.

**Table 3.20: Relationships Between Greeter and Passenger**

| Number of Passengers | Relationship | YUL | | YMX | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Number Trips | Percent Trips | Number Trips | Percent Trips | Number Trips | Percent Trips |
| 1 | *F(Family)* | 366 | 6% | 1528 | 14% | 1894 | 12% |
| | *O(Other)* | 3737 | 64% | 3799 | 36% | 7536 | 46% |
| 2 | *F+F* | 37 | 1% | 416 | 4% | 454 | 3% |
| | *F+O* | 94 | 2% | 333 | 3% | 427 | 3% |
| | *O+O* | 1266 | 22% | 3183 | 30% | 4450 | 27% |
| >=3 | *F+F+F* | 0 | 0.0% | 87 | 1% | 87 | 1% |
| | *F+O+O* | 0 | 0.0% | 167 | 2% | 167 | 1% |
| | *O+O+O* | 366 | 6% | 1094 | 10% | 1460 | 9% |
| Total | | 5867 | 100% | 10607 | 100% | 16474 | 100% |

Examination of the residential status of the arriving passengers with greeters (Table 3.21) revealed that 41% of all greeters trips were to greet at least one GMA resident arriving passenger; 59% of greeter trips were to greet nonresident passengers.

**Table 3.21: Residential Status of Greeted Passengers**

| Number of Passengers | Residential Status | YUL | | YMX | | TOTAL | |
|---|---|---|---|---|---|---|---|
| | | Number Trips | Percent Trips | Number Trips | Percent Trips | Number Trips | Percent Trips |
| 1 | *R (Resident)* | 788 | 13% | 2890 | 27% | 3678 | 22% |
| | *NR (Nonresident)* | 3315 | 56% | 2437 | 23% | 5752 | 35% |
| 2 | *R+R* | 309 | 5% | 1843 | 17% | 2152 | 13% |
| | *NR+R* | 21 | 0% | 167 | 2% | 187 | 1% |
| | *NR+NR* | 1068 | 18% | 1923 | 18% | 2991 | 18% |
| >=3 | *R+R+R* | 58 | 1% | 587 | 6% | 645 | 4% |
| | *NR+NR+R* | 37 | 1% | 0 | 0.0% | 37 | 0% |
| | *NR+NR+NR* | 271 | 5% | 760 | 7% | 1031 | 6% |
| Total | | 5867 | 100% | 10607 | 100% | 16474 | 100% |

Leisure passengers were more likely to have greeters than business passengers. Analysis of the arriving passengers using the ARRIVALS database showed that 54% of arriving leisure passengers had at least one person meeting them at the airport. The proportion of passengers with greeters was higher for transborder and international passengers. Table 3.22 shows that 32% of arriving domestic, 36% of transborder, and 63% of international passengers had someone meeting them at the airport.

**Table 3.22: Percent of Arrivals Passengers With Greeters**

| Trip Purpose | DOMESTIC | | TRANSBORDER | | INTERNATIONAL | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | PAX trips | Percent Total Trips | PAX trips | Percent Total Trips | PAX trips | Percent Total Trips | PAX trips | Percent Total Trips |
| *Business* | 2510 | 31% | 1187 | 31% | 1569 | 50% | 5266 | 35% |
| *Leisure* | 924 | 35% | 1488 | 42% | 4085 | 70% | 6498 | 54% |
| Total | 3434 | 32% | 2676 | 36% | 5654 | 63% | 11763 | 44% |

The number of greeters per arriving passenger was determined from the GREETERS database. Transborder and international passengers had a greater number of greeters per passenger than domestic passengers. Table 3.23 shows that the average domestic, transborder and international passengers have 0.80, 1.06 and 1.61 greeters meet them at the airport.

**Table 3.23: Average Number of Passenger Greeters Per Arriving Passenger**

| Trip Purpose | DOMESTIC | TRANSBORDER | INTERNATIONAL | TOTAL |
|---|---|---|---|---|
| *Business* | 0.87 | 0.78 | 1.86 | 1.33 |
| *Leisure* | 0.67 | 1.18 | 1.54 | 1.41 |
| Total | 0.80 | 1.06 | 1.61 | 1.39 |

## 3.4 PASSENGER GREETER TRIPS

### 3.4.1 Origin and Destination of Greeter Trips

A dispersion of trip origins for greeter trips to both airports is observed in Figure 3.12. The greatest proportion of greeter trips to Dorval -YUL originated from the MUC-Centre and the MUC-West, both with 21% of greeter trips, followed by Downtown Montreal, with 13% of greeter trips. From Dorval-YUL, the majority of greeters returned to these same zones, however this time, Downtown Montreal was the top attractor of greeter trips (23%). Referring back to Figure 3.4, Downtown Montreal also attracted the greatest number of nonresident arriving passengers from Dorval Airport, whereas two zones attracted the most number of resident arriving passenger first destination trips from Dorval Airport: the MUC-West and the MUC-Centre.

For passenger greeter trips to and from Mirabel Airport, the MUC-Centre and -West were the highest producing and attracting zones for greeter trips. These two zones also attracted the greatest number of resident arriving passengers from Mirabel-YMX (Refer to Figure 3.6).

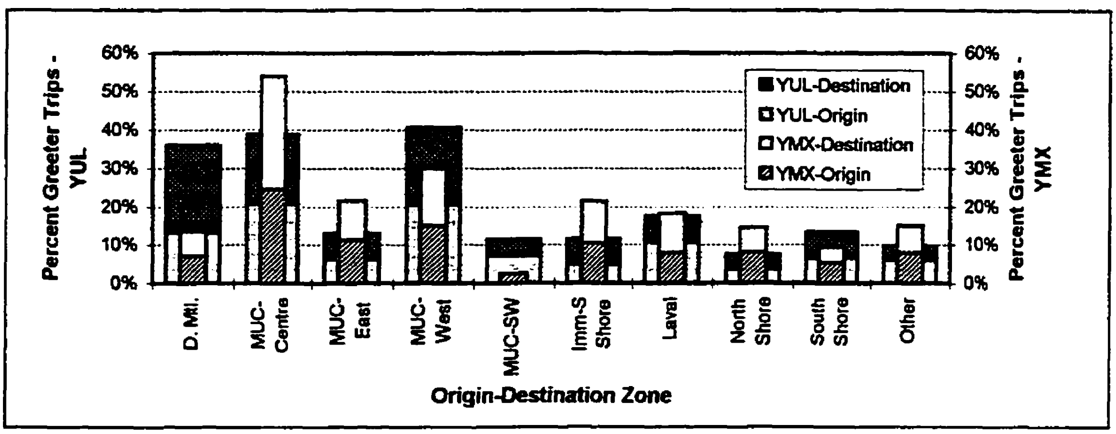



**Figure 3.12: Origin and Destination of Passenger Greeter Trips**

When the greeter's destination was compared to his origin and with the passenger's residence, it was also possible to derive a destination. Analysis of greeter destinations revealed that 49% of greeters return to their point of origin, 22% travel to some other point, and 14% travel to one of the passengers' residence (Table 3.24). From the derived relationships between the greeter and the arriving passenger(s), it is observed that 15% of greeters return to their residence with at least one other household member.

**Table 3.24: Greeter Trips Destinations**

| Destination: | YUL | | YMX | | TOTAL | |
|---|---|---|---|---|---|---|
| | Number Trips | Percent Trips | Number Trips | Percent Trips | Number Trips | Percent Trips |
| *Greeter's Origin* | 2914 | 50% | 5121 | 48% | 8035 | 49% |
| *Greeter's Residence* | 420 | 7% | 2032 | 19% | 2451 | 15% |
| *Passenger's Residence* | 309 | 5% | 2021 | 19% | 2330 | 14% |
| *Other* | 2223 | 38% | 1434 | 14% | 3657 | 22% |
| Total | 5867 | 100% | 10607 | 100% | 16474 | 100% |

## 3.4.2 Temporal Distribution of Greeter Trips

The peak hour for greeter airport access trips to Dorval Airport occurred at 7:00 a.m., with a volume of 1108 trips. For Mirabel Airport, the peak hour was 3:00 p.m., with a volume of 2531 trips. The time of departure from the airports was estimated using the time surveyed. The peak hour for Dorval Airport greeter return trips was 12:00 p.m. (875 trips); for Mirabel Airport, it was 4:00 p.m. (2778 trips). The peak hour for return greeter trips from Mirabel corresponded with the peak hour for arriving passenger trips from that airport. There is no correspondence of peak hours between arriving passengers and returning greeters originating from Dorval Airport.

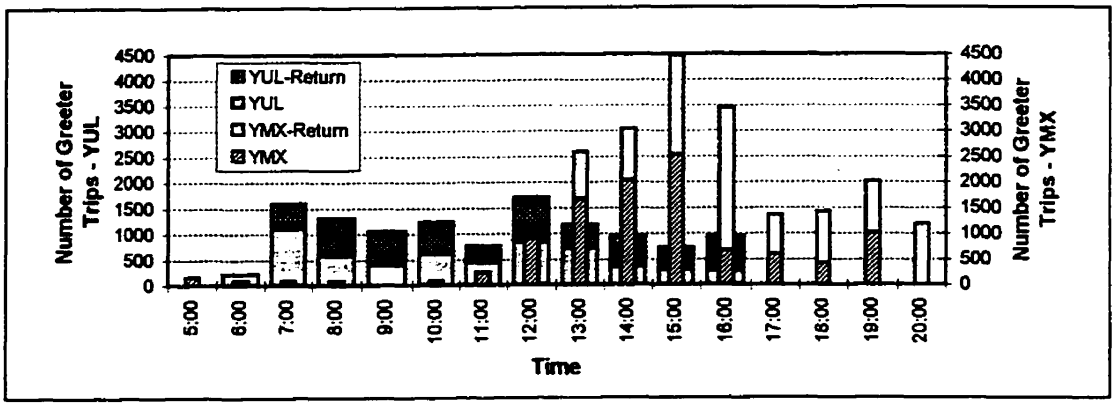



**Figure 3.13: Temporal Distribution of Greeter Trips to Dorval and Mirabel Airports**

### 3.4.3 Duration of Activity

The average duration for the activity of 'greeting' a passenger at the airport was estimated using the time departed for the airport and the time surveyed; it was assumed that the greeter departed from the airport at the time of the survey, or a short time thereafter. Since travel time is included in this value, the activity duration was expected to vary between airports as well as between trip origins. Also, additional time is required to wait for arriving passengers to complete the customs procedures associated with international flights; therefore the greeter activity duration was expected to be greater for Mirabel Airport for this reason as well. The average amount of time passenger greeters spend getting to the airport to greet or pick-up an arriving passenger is 58 min for Dorval Airport and 97 min for Mirabel Airport (Table 3.25).

**Table 3.25: Duration of Greeter Activity**

| Airport | Average Duration of Greeter Activity (min) |
|---|---|
| *Dorval Airport* | 58 |
| *Mirabel Airport* | 97 |
| Total | 84 |

### 3.4.4 Mode Used By Greeters

Passenger greeters use the automobile more than any other mode; 89% of greeter trips to Dorval Airport and 96% of greeter trips to Mirabel Airport are made by car. Since the origin of the greeter sample has been shown to be dispersed throughout the region and especially originating in areas with no or insufficient public modes available, this might explain why the automobile is so highly used for the trip.

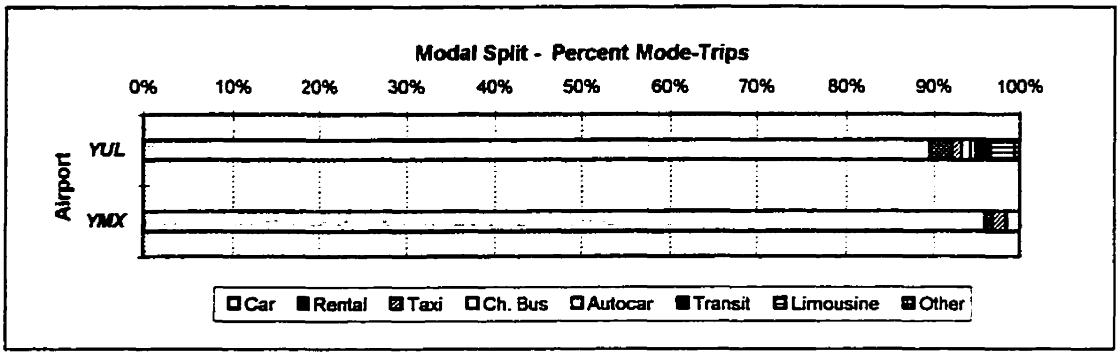



**Figure 3.14: Modes Used by Passenger Greeters to Access the Airport**

## 3.5 GREETER TRIPS FROM THE MUCTC-MTQ DATA

Despite the differences in data structure and data collection methodology between the airport user O-D survey and the regional O-D survey, a similar characterization of passenger greeter trips was observed in the two surveys. Nevertheless, a summary sociodemographic profile of the typical passenger greeter was achieved with the MUCTC-MTQ data.

The profile of passenger greeters and greeter airport access trips using the MUCTC-MTQ data is found in the Appendix, however the key points from the analysis are summarized below:

- The average age of a passenger greeter was 37.5 years. The average male greeter was a 40.5 year-old worker, while the average female greeter was 37.5 years old and is other than a worker or a student. Passenger greeters reside predominantly in the MUC-Centre (26%) and the MUC-West (24%).

- The average number of greeters per household was found to be 1.65 per passenger. The average number of Dorval Airport-bound greeters per household was 1.29 per passenger, while the average number of Mirabel-bound greeters was 2.12 per passenger per household.

- The origin and destination of Dorval Airport-bound greeter trips was the MUC-West; the origin and destination of Mirabel Airport-bound greeter trips was the MUC-Centre.

- 66.7% of greeters returned to their residence after greeting someone at the airport; 71.4% for Dorval greeters and 60.7% for Mirabel greeters.

- The automobile is the preferred mode for greeters; 95% of all greeter trips use the automobile to access the airport.

- The peak hour of greeter trips was determined as being 5:00p.m. for Dorval Airport and 4:00 p.m. for Mirabel Airport; the peak hour for the 'return' trip was 7:00 p.m., for both airports.

- The duration of the greeter activity was determined to be 84.4 minutes overall; 113 min at Dorval Airport and 149 min at Mirabel airport.

## 3.6 Chapter Summary

This chapter presented an analysis of ground access trips made by passengers and passenger greeters using the ADM O-D databases: DEPARTURES, ARRIVALS and GREETERS. A summary of the profile of the typical passenger and greeter were also presented. Analysis of Montreal's International Airport passengers revealed:

- 49% of all passengers, both departing and arriving, were GMA residents versus nonresidents. GMA residents represented 53% of departing passengers, while 55% of arriving passengers were nonresidents.

- Business travel predominates at Dorval Airport and leisure travel predominates at Mirabel Airport, regardless of the residential status of the passengers. The breakdown for resident and nonresident passengers is 30% RB and 34% NRB for Dorval Airport; 38% RL and 26% NRL for Mirabel Airport.

- The majority of business and leisure resident passengers reside in the MUC-Centre. This zone group is characterized by relatively high household income ($39,599/hhld), an older population (average age=37.5 years).

- The majority of nonresident passengers reside within the United States (30%). However, the majority of NRB passengers (20%) reside in provinces other than Quebec, while NRL passengers (17%) reside predominantly in other parts of the world.

Analysis of passenger ground access trips revealed:

- Departing passengers generated 25 527 daily trips to Dorval Airport and 9 146 daily trips to Mirabel Airport; arriving passengers generated 18 007 trips from Dorval Airport and 9 029 trips from Mirabel Airport daily during the survey period.

- Resident passenger airport access trips originated and terminated in the MUC-Centre, while nonresident passenger access trips originated and terminated in Downtown Montreal for both Dorval and Mirabel Airports.

- Resident passenger trips originated from and terminated at the passenger's residence. NRB passenger trips originated from either a hotel or a motel, while NRL passenger trips originated from some other location. However, nonresident arriving passengers made their first destination within the GMA some point or trip generator other than a hotel.

- The peak hour of **departing** passenger trips to Dorval Airport occurred at 6:00 a.m. during which there was a volume of 4371 trips. Forty percent (9860 trips) of departing passenger traffic bound for Dorval Airport occurred during the regular morning traffic peak period from 6:00 a.m. to 8:59 a.m.. The peak hour for **arriving** passenger trips from Dorval Airport occurred at 5:00 p.m. with a volume of 2250 trips.

- The peak hour of **departing** passenger trips to Mirabel Airport occurred at 4:00 p.m. with a volume of 1954 trips. The peak hour for **arriving** passenger trips from Mirabel Airport occurred at 4:00 p.m. with a volume of 3000 trips.

- The automobile (49.3%), taxi (31.9%) and rental car (10.2%) were the top three modes used to access Dorval Airport, while the automobile (66.0%), autocar (11.2%) and taxi (8.5%) were the top three modes used by all passengers to access to and from Mirabel Airport.

- Modal choice varied with residential status, trip purpose and airport. Private modes were generally preferred over public modes to access either airport, however, there was a tendency to use public modes to travel to Mirabel Airport. Moreover, nonresident passengers were more likely to use public modes than resident passengers. In addition, business passengers were more likely to select higher-cost modes, such as the taxi to travel to the airport than leisure passengers.

- The majority of passengers who used the automobile to travel to the airport were auto-passengers especially in the case of Mirabel Airport where 92% of passengers were driven compared to 8% who drove themselves to the airport.

- Most passengers driven to Dorval Airport were dropped off at the curb (≈88% passenger-trips); this value dropped to 44% for passengers driven to Mirabel Airport.

- The average number of departing passengers travelling together varies with flight sector and trip purpose. Domestic business passengers travelled in the smallest groups (1.43 passengers) while international leisure passengers travelled in the largest groups (4.27 passengers). Furthermore, resident passengers travelled in smaller numbers than nonresidents (1.83 resident passengers vs. 2.99 nonresident passengers).

- The average number of accompaniers in the same access vehicle (car) as the passenger also varied with flight sector, residential status and trip purpose. Domestic passengers had the smallest number of accompaniers per passenger with 0.58 accompaniers/passenger; international passengers had the highest number of accompaniers with 1.57 accompaniers/passenger.

- The vehicle occupancy rate for airport-bound passenger vehicles varied from 1.90 persons/vehicle for domestic passengers to 3.14 persons/vehicle for international passengers. The vehicle occupancy rate for nonresident passengers was greater than the rate for resident passengers (2.72 persons/vehicle vs. 2.44 persons/vehicle). Vehicle occupancy also varied with trip purpose, although not consistently.

- The amount of time spent by a passenger at the airport prior to a flight varied with flight sector. Domestic and transborder passengers spent 72.3 min and 84.4 min respectively at Dorval Airport, whereas international passengers spent 166.5 min at Mirabel prior to their flight. The difference between resident and nonresident passengers departing from Mirabel was less than the difference between resident and nonresident passengers departing from Dorval. No relationship was found to exist between the distance to the airport and the amount of time spent at the airport prior to the flight.

Analysis of the passenger greeter trips using the ADM data revealed the following:

- Only 18% of greeters met at least one family member at either Dorval or Mirabel Airport. The remaining 82% greeted other passengers.

- 41% of greeted passengers were resident passengers, while 59% were nonresidents.

- The average number of greeters per passenger ranged from 0.80 for domestic passengers to 1.81 for international passengers. Business passengers had fewer greeters per passenger (1.33) than leisure passengers (1.41).

- The majority of greeter trips to Dorval Airport originated from the MUC-West and terminated in Downtown Montreal. However, the majority of greeter trips to Mirabel Airport originated from and terminated in the MUC-Centre.

- Symmetry existed in greeter trips; 49% of greeters returned to their origin. 15% returned to their residence (greeter and passenger), 14% returned to the passenger's residence and 22% travelled to some other trip destination.

- The peak hour for greeter trips **to** Dorval occurred at 7:00 a.m. with a volume of 1108 trips. The peak hour for greeter 'return' trips **from** Dorval Airport was 12:00 p.m. with a volume of 875 trips. The peak hours of travel for greeter trips **to** Mirabel Airport was 3:00 p.m. (2531 trips) and **from** Mirabel Airport is 4:00 p.m. (2778 trips).

- The average duration of the greeter activity was determined as being 58 min for Dorval Airport and 97 minutes for Mirabel Airport.

- The mode preferred by the greeter was the automobile; 89% of trips to Dorval Airport and 96% of trips to Mirabel Airport were made by car.

# CHAPTER FOUR

# SIMULATION AND ANALYSIS WITH MAD(Strat)$^2$

Travel distance and time are indicators that are often used to measure accessibility of an airport. The information from the ADM O-D Survey characterizes the airport access trip in terms of trip origin and destination, mode used, time of trip and trip purpose, however the exact route taken to travel to or from the airport was not declared and therefore is not known. Despite this lack of specific information, a route can be estimated and attributed to each record using a modelling system such as MAD(Strat)$^2$. Subsequently, the estimated travel distance and time are determined from the simulated path.

This chapter focuses on the presentation of the results from simulation of the airport access trips to and from Montreal's International Airports using the totally disaggregate MAD(Strat)$^2$ system. An introduction to MAD(Strat)$^2$ begins this chapter, and is followed by a description of the simulation scenario. The simulation results are used to determine a measure of accessibility of Dorval and Mirabel International Airports.

## 4.1 An Overview of MAD(Strat)$^2$

Originally developed to analyze the multifaceted demand of the transportation of goods using the totally disaggregate approach exclusive to Professor Chapleau and his research team, the *Groupe* MADITUC, MAD(Strat)$^2$ can also be used to analyze person-trips on a road network. For this study specifically, MAD(Strat)$^2$ was used to assign a path to each airport tripmaker and subsequently, to determine the network distance and travel time.

In order to simulate with MAD(Strat)$^2$, two elements are required: a) a complete spatial referencing information system for analysis and planning purposes (R.I.S.A.P.P), and b) a trip file derived from an O-D trip database, with spatially referenced points of origin and destination. A brief description of these elements follows.

- REFERENCE INFORMATION SYSTEM FOR TRANSPORTATION ANALYSIS AND PLANNING

A complete spatial referencing information system requires eight different components (CHAPLEAU, 1993B):

- a geographical coordinate system to reference all entities with a relative location. (The UTM system is frequently used).
- a littoral representation of the study region including geographical boundaries, bodies of water, etc.;
- street plans, including the location of traffic lanes as well as a few summary characteristics;
- an onscreen map generated by the synthetic conversion of the street network in a corresponding territory;
- additional cartographic attributes such as an alphanumeric referencing of traffic lanes, and a colour-coding system for different categories of streets;
- codification of designated areas that are frequent trip-ends for transportation system users and considered major trip generators or attractors;

- a definition of the territorial divisions/ traffic analysis zones as defined by the analyst's needs. These can be socioeconomic, demographic, geopolitical, etc.;

- analytical transportation networks to which are applied transit or road network trip assignment models.

The reference information system used for the analysis of airport access trips was the Greater Montreal Area R.I.S.A.P.P. previously created by the *Groupe MADITUC* for MTQ's analysis of trucking within the GMA.

- TRIP FILE

The trip file, DEPLAC.DTA, therefore contains for each recorded trip: the points of origin and destination represented by coordinate pairs; the transfer points, where available, also represented by coordinate pairs; the corresponding expansion factor; the record I.D. number and an optional index number to allow the grouping of data according to the needs of the analyst.

### 4.1.1 Trip Simulation With MAD(Strat)$^2$

As discussed in Chapter One, the MADITUC-MAD(Strat)$^2$ approach uses a system of data operators or modules as opposed to the more traditional, *O-D trip matrix - simulation - network flows* aggregate planning sequence. The simulation of a trip on the road network using MADITUC-MAD(Strat)$^2$ involves the operation of three consecutive modules described below. They are: ACCESS, PATH CALCULATION and NETWORK LOADING (CHAPLEAU, 1993B; BERGERON, D, CHAPLEAU, R., 1996).

- <u>ACCESS</u>

Using the points of origin and destination, the MAD(Strat)$^2$ ACCESS module determines the nearest access nodes to the analytical transportation network for each trip in the trip file. This module provides the origin and destination access nodes, the distance to the access origin and destination nodes from the points of origin and destination, and the access times. (Output file: ITINP.DTA)

- <u>PATH CALCULATION</u>

Once the network access and egress nodes have been determined, the path calculation module in MAD(Strat)$^2$ calculates the minimal general cost path between these two nodes, in terms of time, distance, and level of comfort as perceived by the tripmaker. The links used for each trip are determined along with their corresponding distance and time (Output files: ITIN.DTA and ITINTD.DTA).

The simulation yields an itinerary for each tripmaker which consists of entry and exits nodes to and from the network, the transfer points (if applicable) and the path taken represented by a series of route sections (links).

- <u>NETWORK LOADING</u>

The calculated paths are then loaded onto the network to estimate the principal impacts of the travel demand on various components of the network (nodes, routes or links, specific points, or districts). Either the entire trip or any selected portion of it can be loaded onto the network, depending on the needs of the analyst. The output file VOLUME.DTA from the network loading module is used to establish the load profile showing the volume of trips on each link of the network. The resulting load profile can be visualized through MADCADD, an AutoCAD environment adapted for the purposes of transportation analysis.

### 4.1.2 Possible Simulation Scenarios

There are two possible network conditions under which the minimal cost path can be determined: 1) either while the network is under peak period conditions, or 2) while it is under free flow conditions.

In the first scenario, the path is calculated using the equilibrium trip assignment method, and follows Wardrop's first criterion, which is:

> *"The journey time in all routes actually used are equal, and less than those which would be experienced by a single vehicle on any unused route."* [1]

The system is calibrated to represent the morning peak period. The relation between travel time and the network link volume is determined using the delay curve established by the Bureau of Public Roads (BPR):

$$t = t_0[1 + \alpha(\frac{Q}{C})^{\beta}]$$

where $t_0$ = the travel time under free flow conditions, and $\alpha$ = 0.15 and $\beta$ = 4 (BERGERON, D., CHAPLEAU, R., 1996).

In the second scenario, the path is calculated using an all-or-nothing type of trip assignment which determines the shortest path between the origin and destination nodes. All the flow is then assigned to this path with no flow assignment to any other route. Link capacities are not taken into account since link costs (travel time) are assumed to be constant and flow independent (POTTS, R.B., OLIVER, R.M., 1972).

### 4.1.3 Interactive Graphic Representation with MADCADD

The data stored in the trip file as well as the results from the MADITUC-MAD(Strat)[2] simulations can be viewed in MADCADD. The multilayered platform available in an AutoCAD environment is a definite asset to transportation analysis and thus permits the examination of more complex issues (CHAPLEAU, 1993B).

The functions available with this tool allow for (CHAPLEAU, 1993B):

- the digitizing and coding of transportation networks as well as of territorial borders and centroids;
- the interactive validation of origin-destination survey data spatial references, namely the points of origin and destination, the connectivity of declared trip itineraries, etc.;
- the comparison of declared and simulated travel behaviour for the calibration of models (disaggregate);
- the visual representation of various types of analyses including load profiles.

The four figures in Figure 5.1 created with MADCADD, illustrate the desire lines for both airports compiled for each of the 65 municipal sectors. From these figures, it is apparent that Downtown Montreal is the greatest generator of passenger and greeter airport trips for both Dorval and Mirabel Airports.

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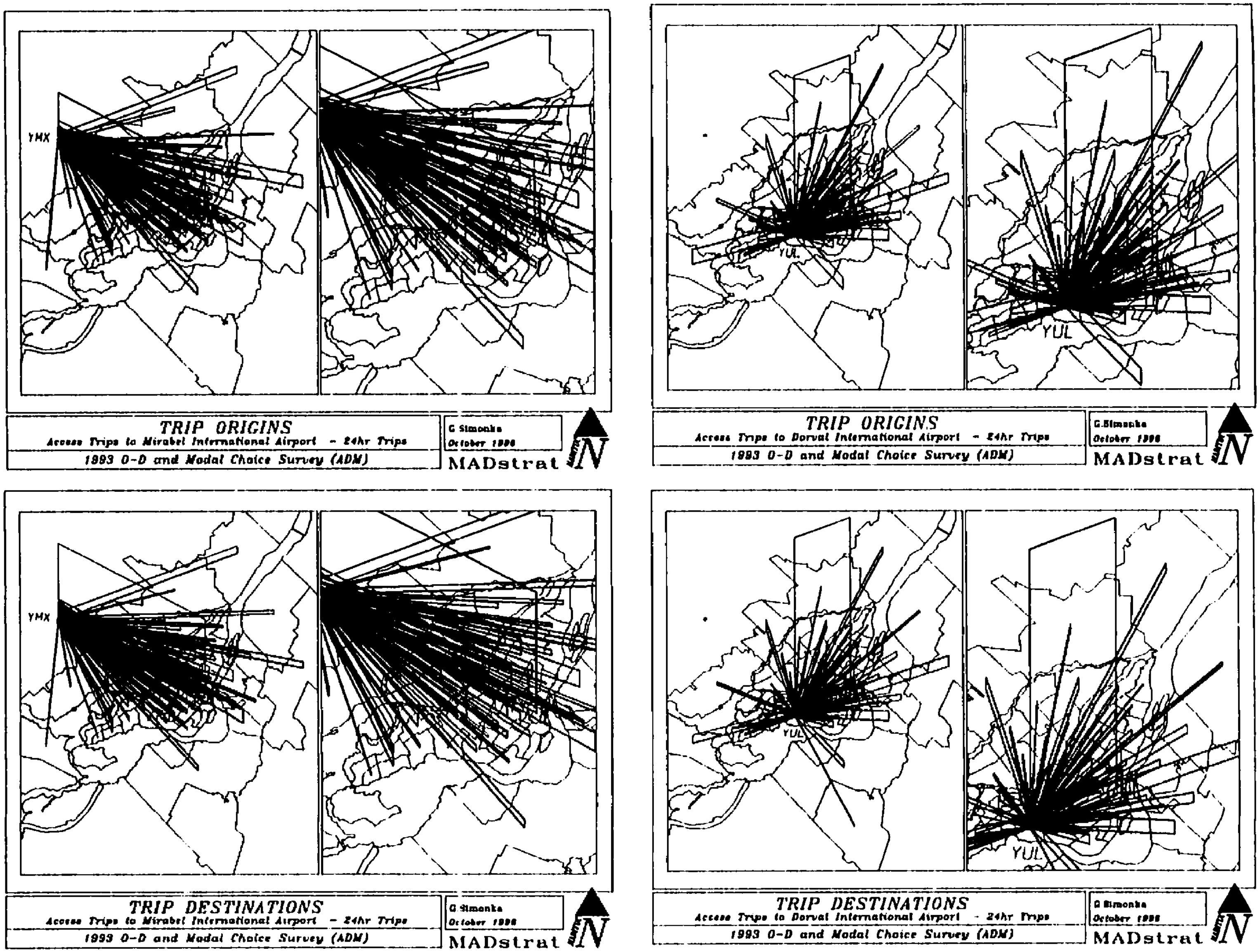
[1] Wardrop, J.G. in Potts, R. B., Oliver, R. M. (1972).

Figure 4.1: Desire Lines for Dorval and Mirabel Airports



## 4.2 SIMULATION OF AIRPORT ACCESS TRIPS

Simulation of airport access trips was made for the ADM survey data only. Further, only the records for which there are x-y coordinate pairs are included in the simulation trip file.

All trips made by private modes (car, rental car, taxi, limousine) by departing passengers, passenger greeters and arriving passengers are included. For the purposes of this simulation exercise, the hotel shuttle and chartered bus modes are treated as private modes, since they are assumed to travel from their point of origin to their destination without a predefined route. Trips made by the autocar shuttle mode are also treated as a "private mode". However, these autocar trips were expanded into three or four smaller trips as shown in Figure 4.2, depending on the declared origin or destination, to compensate for the stops made by the shuttle.

Preparation for simulation also included the recoding of Dorval Airport. The access roads to Dorval Airport, Roméo-Vachon Boulevard and Albert-de-Niverville, were not coded for the analytical network used in MAD(Strat)$^2$. This means that the system might select entry and exit (access) nodes that are closest to the airport, but from which it is physically impossible to access, or egress from, the airport as shown in Figure 4.3 (a). Figure 4.3 (b) shows the existing physical network in the vicinity of Dorval Airport.

To ensure that access to the airport was made at the same point for all trips, the airport was recoded, for the purpose of this study only, as being situated at the junction of westbound Highway 520 (Côte-de-Liesse Boulevard) and Cardinal Avenue, forcing all trips to this point. The remaining distance was calculated as the Euclidean distance to the airport from this new point.

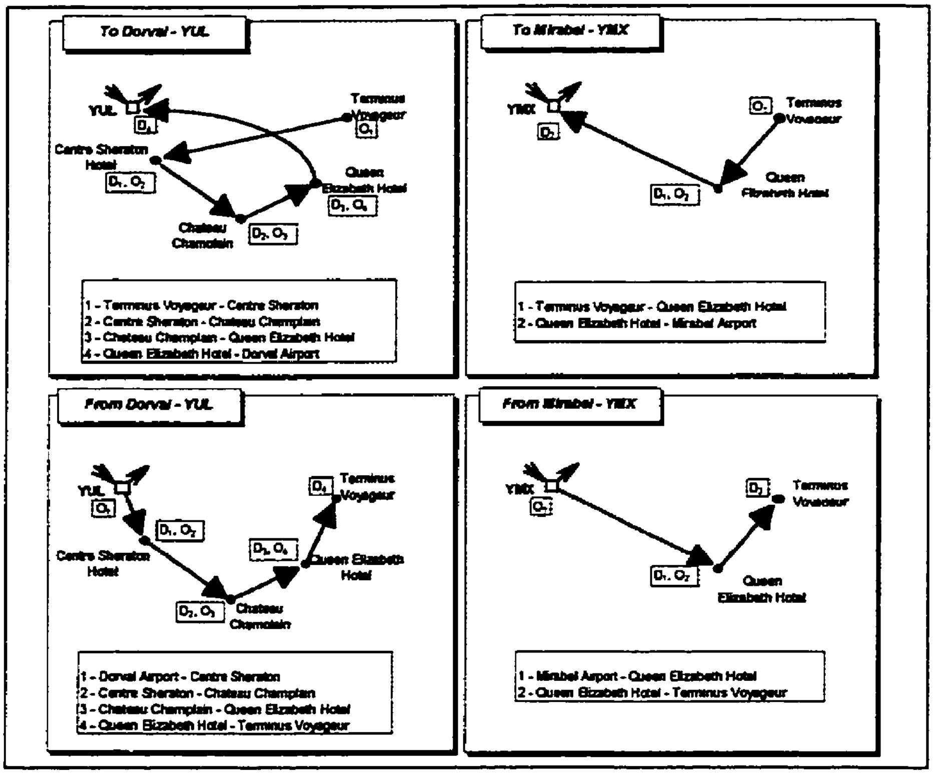



**Figure 4.2: Expansion of Autocar Trips for Simulation Purposes**

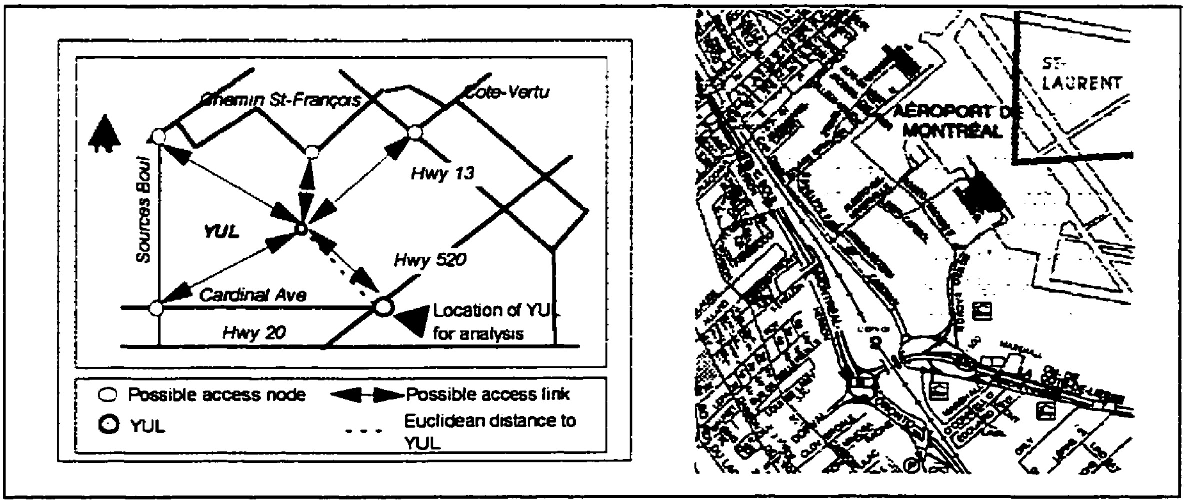



**Figure 4.3: Access Roads to Dorval Airport (a) Analytical Network, (b) Real Network** (PERLY 1996)

### 4.2.1 Accuracy of Simulated Travel Time

The simulated travel time for the airport access trip was compared to declared travel time values to determine the degree of accuracy of airport access trip simulation with MAD(Strat)$^2$. This was performed only on departing passenger and greeter access trips since declared travel times were available for these two types of tripmakers only. Since free flow conditions were assumed on the road network, and each individual was assigned the shortest path from their origin to the airport, lower simulated travel time values were expected.

The closer the mean difference between the simulated and declared travel times was to zero, the more accurate the estimation of the travel time was using MAD(Strat)$^2$. The average difference between simulated and declared travel times, for all departing passenger and greeter trips to both Dorval and Mirabel Airports originating from each zone can be seen in the graphs in Figures 4.4 and 4.5.

The mean time difference for Dorval Airport was found to be 0.77 min which indicates that the simulated travel times were relatively equal to the declared travel times. However, the standard deviation for all trips to Dorval Airport was calculated as being 12.84 min, ranging from 8.98 min to 30.35 min per zone of origin. The 95% confidence interval of the mean of differences was [0.05 min, 1.48 min]. Only 4% of all Dorval-bound trips had time differences that fell within this interval. The majority of simulated Dorval Airport trips, 58%, had greater simulated travel times than declared times.

The average differences between simulated and declared travel times to Mirabel Airport for each zone of origin indicated that the travel times were consistently underestimated with the exception of trips from the MUC-SW and the North Shore. The average time difference for Mirabel Airport trips was -9.55 min. The standard deviation of the time difference for all trips to Mirabel Airport was 17.51 min, ranging from 9.51 min to 32.53 min per zone. Approximately 10% of Mirabel-bound trips had time differences within the 95% confidence interval of [-11.20 min, -7.90 min]. The travel time was underestimated for 69% of all Mirabel trips.

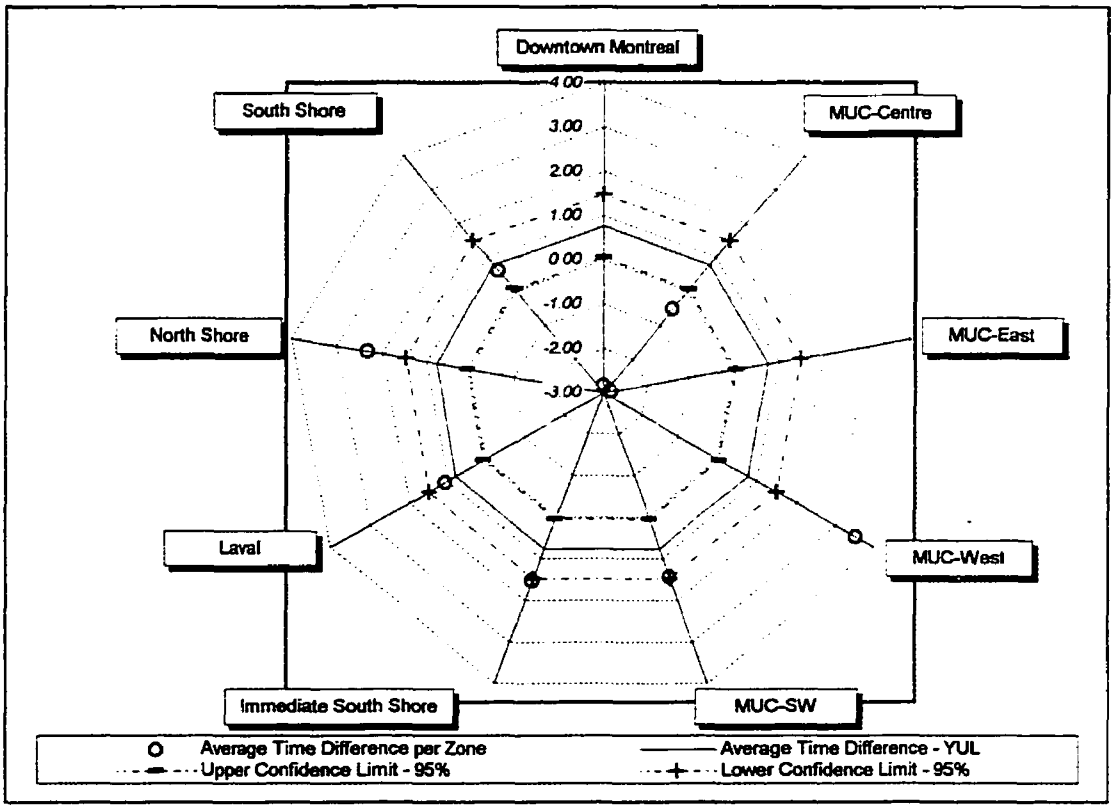



**Figure 4.4: Difference Between Simulated and Declared Travel Times for Dorval Airport Trips**

Therefore, this experimentation with MAD(Strat)$^2$ using the spatial referencing system developed for MTQ's urban goods movement analysis was not successful for the analysis of airport ground access trips. An incompletely coded network, particularly in the vicinity of Dorval Airport, can cause the selection of a longer path due to the lack of direct access to certain roads.

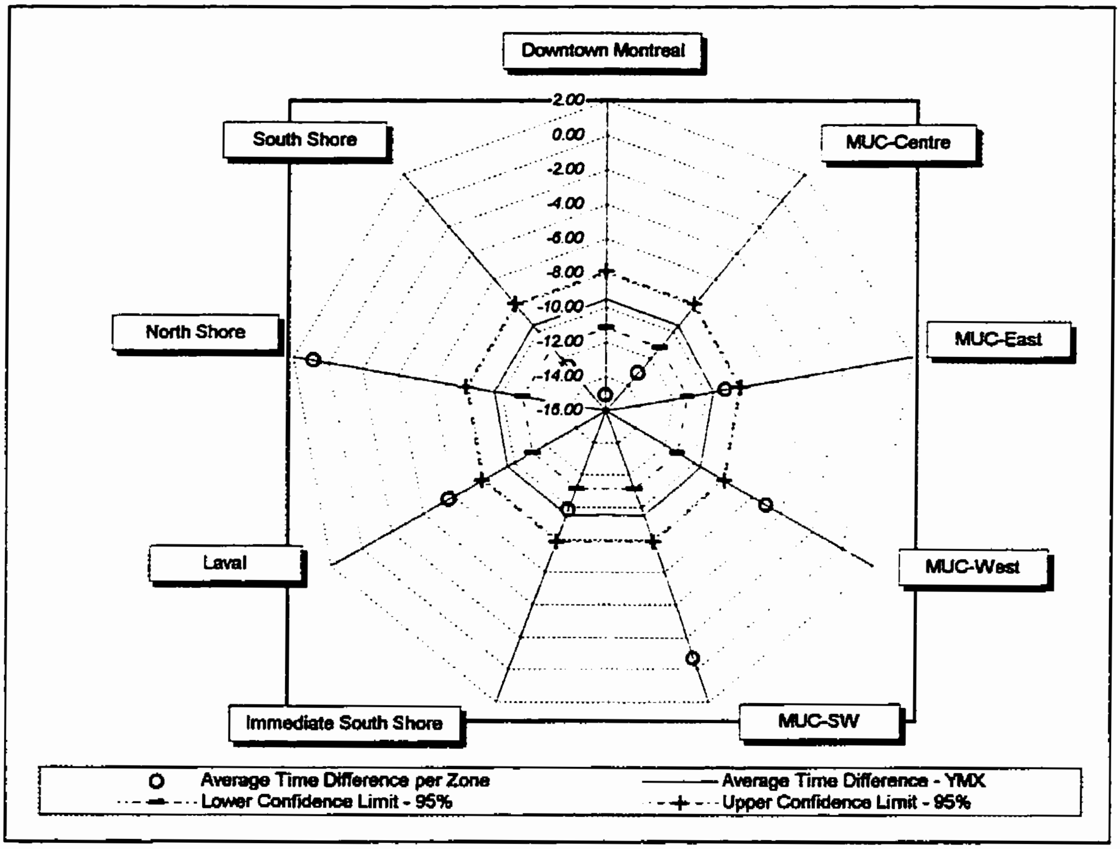



**Figure 4.5: Difference Between Simulated and Declared Travel Times for Mirabel Airport**

### 4.2.2 Simulated Paths

The simulated paths determined by MAD(Strat)$^2$ are shown in Figure 4.6. The shortest path to Mirabel Airport predominantly included Highway 15 for all MUC, Laval and South Shore trips. On the other hand, the shortest path to Dorval Airport predominantly included Highway 20, particularly for trips originating from or terminating Downtown Montreal. Highways 40 and 520 were included in the shortest path for tripmakers originating or terminating in the MUC-East or Centre. West Island (MUC-West) tripmakers accessed Dorval Airport using Highway 20 and Cardinal Avenue in Dorval.

The accessibility of both airports based on these simulated paths is discussed in the following section.

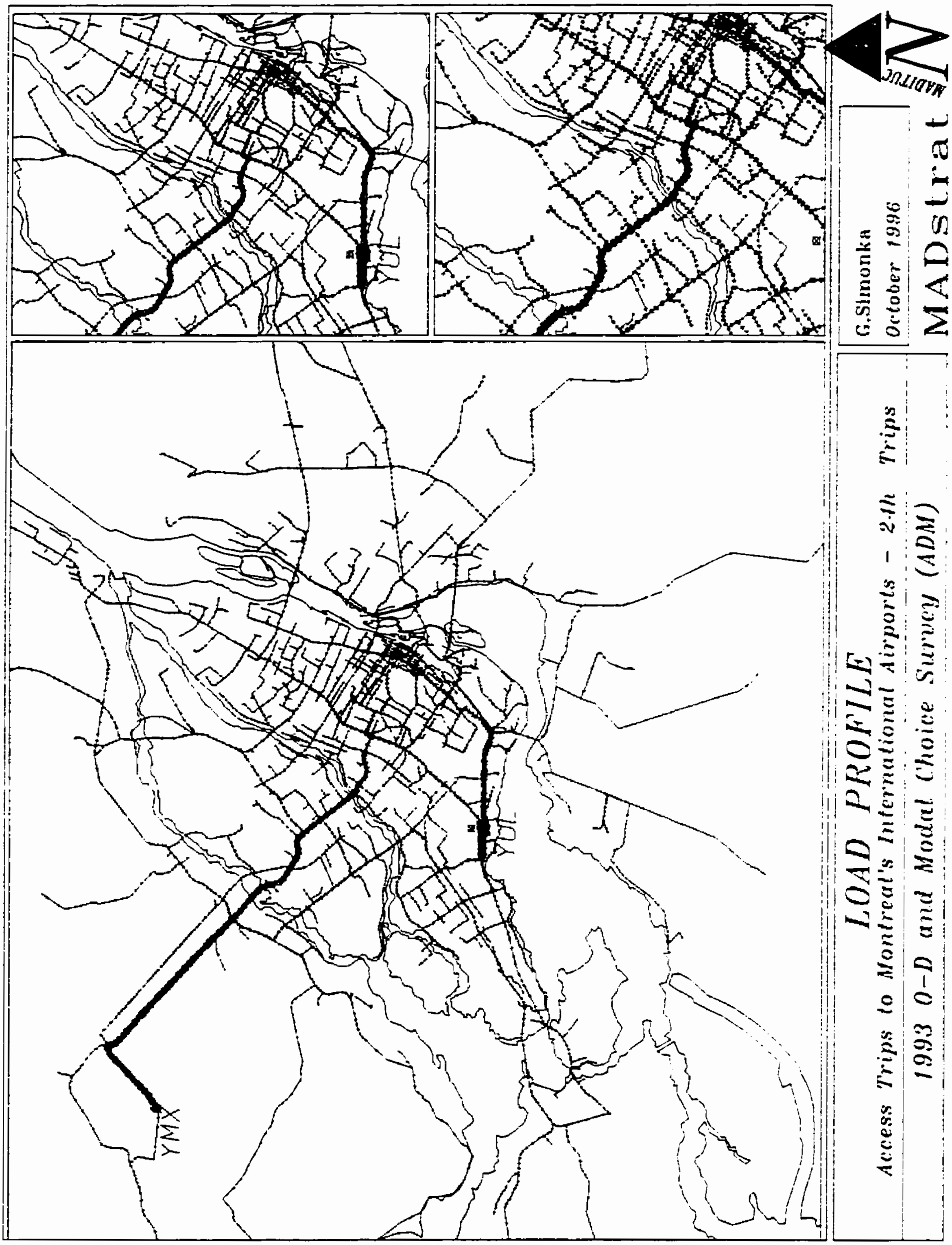



Figure 4.6: Simulated Shortest Paths to Dorval and Mirabel Airports

## 4.3 ACCESSIBILITY OF DORVAL AND MIRABEL AIRPORTS

PENDAKUR (1974) proposed a method of comparing major Canadian national airports to identify those which greatly needed government funds to improve ground access to airports. His method took the three following factors into account: 1) travel time increases with distance; 2) travel time depends on the time of day the trip occurs, and 3) the impact of airport access time depends on the volume of passengers experiencing a given set of access conditions. Therefore, PENDAKUR developed a measure which considered these factors. This accessibility indicator was calculated using the following expression:

$$\frac{AnnualPassenger-min}{mile} = \left(\frac{t_p}{d} * P_p\right) + \left(\frac{t_{op}}{d} * P_{op}\right)$$

where: $t_p$ = travel time during peak period (min);

$t_{op}$ = travel time during off-peak period (min);

$d$ = average distance to airport (miles);

$P_p$ = number of passengers during peak hour;

$P_{op}$ = number of passengers during off-peak period.

The time and distance are standardized by dividing the travel time by the travel distance. The resulting number yields the number of minutes spent per unit distance to the airport. The number of minutes expended by all passengers is determined by calculating the standardized time-distance measure for both peak and off-peak hours. When added together the two components yield the total annual number of passenger-minutes per unit distance (mile).

While intended as a broader scale measure of ground access conditions, this measure was adapted to account for the variation in travel time, distance and volume of airport tripmakers during the time of the survey for each origin-destination zone using the following expression. Since the airport access trips were simulated under free-flow conditions, no distinction was made between peak and off-peak periods. The resulting value yields the impact of ground access travel time for a given zone, in terms of person-minutes per km.

$$Index_j = \frac{\left(\sum_{i=1}^{n} w_i\right)_j * \bar{t}_j}{\bar{d}_j} \qquad j = 1, 2, \ldots, m$$

$$\text{where: } \bar{t}_j = \left(\frac{\sum_{i=1}^{n} w_i * t_i}{\sum_{i=1}^{n} w_i}\right)_j \text{ and } \bar{d}_j = \left(\frac{\sum_{i=1}^{n} w_i * d_i}{\sum_{i=1}^{n} w_i}\right)_j$$

where: $Index_j$ = person-minutes/km for zone $j$

$w_i$ = expansion factor for tripmaker $i$;

$\bar{d}_j$ = average travel distance for zone $j$ (km);

$\bar{t}_i$ = travel time for tripmaker (km ).

The average speed experienced by airport tripmakers during their trip between the airport and their zone of origin or destination, can also be used as a measure of ground accessibility to each airport. The average ground access speed was calculated using the expression:

$$\bar{v}_j = \frac{\bar{d}_j}{\bar{t}_j} \qquad j = 1, 2, \ldots, m$$

$$\text{where: } \bar{t}_j = \left( \frac{\sum_{i=1}^{n} w_i * t_i}{\sum_{i=1}^{n} w_i} \right)_j \quad \text{and} \quad \bar{d}_j = \left( \frac{\sum_{i=1}^{n} w_i * d_i}{\sum_{i=1}^{n} w_i} \right)_j$$

where:

$\bar{v}_j$ = average speed for zone $j$ (km/h)

$\bar{d}_i$ = average travel distance on the network for zone $j$ (km);

$\bar{t}_i$ = average travel time for zone $j$ (h);

$w_i$ = expansion factor for tripmaker $i$.

A high accessibility index value identifies that the access travel time has a great impact on the airport tripmakers travelling to or from a particular zone. A high value for the average zonal access speed on the other hand, indicates a good level of access

The impact of ground access travel time was found to be greater on Dorval Airport tripmakers (52 983 person-min/km) than for Mirabel Airport tripmakers (28 724 person-min/km). The average access speed to Dorval Airport for all zones was also found to be lower (63 km/h) than the average speed to Mirabel Airport (82 km/h), as shown in Table 4.1. A large volume of tripmakers is generated by Dorval Airport which explains the greater impact. The low access speed is explained by the category of roads connecting the airport to the rest of the highway network: high-speed highways (100 km/h) provide access to Mirabel Airport, and lower-speed highways and local roads (50-70 km/h) provide access to Dorval Airport.

Table 4.1: Average Distance, Time, Volume, Speed and Accessibility Index for All Airport Trips

| Zone | YUL | | | | | YMX | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average Distance (km) | Average Time (min) | Volume (trips) | Average Speed (km/h) | Index (pers-min/km) | Average Distance (km) | Average Time (min) | Volume (trips) | Average Speed (km/h) | Index (pers-min/km) |
| *Downtown Montreal* | 22.44 | 19.66 | 17 992 | 68 | 15 761 | 47.97 | 34.33 | 7 476 | 84 | 5 350 |
| *MUC-Centre* | 19.92 | 19.32 | 9 397 | 62 | 9 113 | 45.19 | 30.93 | 10 388 | 88 | 7 110 |
| *MUC-East* | 28.60 | 26.92 | 2 754 | 64 | 2 592 | 48.25 | 33.14 | 3 532 | 87 | 2 426 |
| *MUC-West* | 11.31 | 14.08 | 10 736 | 48 | 13 353 | 45.92 | 32.38 | 5 377 | 85 | 3 791 |
| *MUC-SW* | 19.74 | 19.18 | 2 048 | 62 | 1 990 | 53.42 | 37.70 | 612 | 85 | 432 |
| *Immediate South Shore* | 33.52 | 30.66 | 3 250 | 66 | 2973 | 59.59 | 44.38 | 3 366 | 81 | 2 507 |
| *Laval* | 26.28 | 25.61 | 2 856 | 62 | 2 784 | 35.31 | 24.76 | 2 733 | 86 | 1 916 |
| *North Shore* | 39.60 | 35.58 | 1 979 | 67 | 1 778 | 37.98 | 28.10 | 2 127 | 81 | 1 574 |
| *South Shore* | 43.36 | 39.96 | 2 102 | 65 | 1 938 | 74.12 | 55.30 | 1 680 | 80 | 1 254 |
| *Other* | 53.60 | 55.65 | 2 154 | 58 | 2 236 | 71.76 | 70.51 | 2 067 | 61 | 2 031 |
| TOTAL | 23.53 | 22.56 | 55 268 | 63 | 52 983 | 49.01 | 35.77 | 39 360 | 82 | 28 724 |

While the accessibility index indicated the impact of access travel time on the tripmakers of a particular zone, it did not always indicate the zones for which access conditions (time, distance, speed) were adverse; Downtown Montreal tripmakers had an index value of 15 761 person-min/km and an average access speed of 68 km/h. On the other hand, the index value for MUC-West tripmakers was calculated as being 13 353 person-min/km and the average speed was calculated as being 48 km/h. Therefore the adapted accessibility index does not appear to be a satisfactory, independent measure of accessibility to the airports.

Analysis of the average access speed to Dorval Airport for each zone revealed that MUC-West tripmakers experienced the lowest access speed and that tripmakers from Downtown Montreal and South Shore - including the Immediate South Shore municipalities experienced the fastest access speeds, primarily because of the category of road sections included in the tripmakers' path to Dorval Airport. However, the high speeds for Downtown Montreal and the South Shore might be optimistic since the paths to the airport were simulated under free-flow conditions. A simulation should be conducted under a congested network to determine what the average access speed would be under peak ground traffic conditions.

Analysis of the average access speed to Mirabel Airport from each zone revealed that tripmakers from the South Shore and the Immediate South Shore experienced lower access speeds than Montreal Island tripmakers, as expected, due to the bridge that South Shore tripmakers must traverse to travel to and from the airport.

Therefore, despite the potential over-optimistic access speeds calculated for airport tripmakers, average zonal speed was a better indicator of ground accessibility than the proposed accessibility index adapted from PENDAKUR's analysis of access conditions to Canadian national airports.

## 4.4 CHAPTER SUMMARY

Therefore, within the scope of this research analysis Mirabel Airport was found to be more accessible in terms of average speed than Dorval Airport despite its distance to the central area of Montreal. Furthermore, analysis of the average access speed based on the simulated paths revealed that tripmakers originating or terminating in Downtown Montreal or the South Shore, including the Immediate South Shore, have a reasonably good level of access to Dorval Airport. On the other hand, tripmakers from the MUC-West have a low level of ground access to Dorval Airport, due to the type of roads available and the lack of access roads from the analytical network. Analysis of paths simulated under peak traffic conditions should reveal whether these zones maintain their level of ground accessibility to Dorval Airport.

While the accessibility index identified the impact of the access travel time on the tripmakers originating or terminating from a given zone, it did not always identify a zone for which the access conditions (travel time, distance and speed) were adverse, as was the case for Downtown-Montreal tripmakers. For this reason, the average zonal access speed to each airport was a more suitable, independent measure of the level of ground access since the average speed better reflected the travel time and distance experienced by airport tripmakers to and from each zone

In conclusion, future analysis of airport access should include the effect of peak traffic conditions on access time and speed, particularly with the scheduled increase in traffic at Dorval Airport in the near future. Also, transportation and airport planners should further examine the possibility of improving access to Dorval Airport in the vicinity of the airport, since the MUC-West is one of the three important generators of airport traffic.

# CONCLUSION

The analysis methodology proposed in this research analysis established the groundwork for further analyses and eventually the modelling of airport ground access trips. The methodology consisted of the examination and correction of data samples, the calculation of expansion factors, the derivation of variables, the extraction of ground access trips for further analysis, the analysis of survey data and the simulation of the extracted trips using the MAD(Strat)$^2$ system.

The principal limitation of the ADM O-D survey is that the survey is valid only for the point-in-time the data collection took place. Knowledge of the real population of passengers and greeters would have improved the integrity of the calculated expansion factors. Also, a larger passenger greeter sample would have decreased the error associated with the sample.

Analysis of ground access using the ADM O-D survey revealed that passengers exhibited the typical behaviour described in the literature: nonresident passengers originated and terminated in Downtown Montreal, whereas resident trip origins and destinations exhibited a greater dispersion throughout the region. Also, typical ground access behaviour was observed in airport access modal choice: 94 % of residents used private modes such as the automobile, rental car or taxi to access both airports. Public mode use was more common among nonresidents than nonresidents, although the use of private modes was also prevalent among nonresidents (83%). Although private mode use was preferred among residents accessing Mirabel Airport, public mode use for nonresidents did increase, implying that cost is a factor in the selection of an access mode.

Analysis of profile of the passengers revealed that 49% of all passengers were Greater Montreal residents, the majority of which resided in the MUC-Centre. The United States was the greatest generator of nonresident passengers (30%). Nonresident business passengers however, were predominantly from other provinces than Quebec whereas nonresident leisure passengers resided elsewhere in the world. It was also revealed that business travel represented 64% of all passenger trips at Dorval Airport and leisure travel represented 65% of all passenger trips at Mirabel Airport, regardless of the residential status of the passengers.

The typical resident passenger originated or terminated his airport trip from his residence in the MUC-Centre, whereas the nonresident passenger began or ended his airport trip at either a hotel or some other location in Downtown Montreal, for both Dorval and Mirabel Airports.

Analysis of the passenger greeter trips revealed that only 18% of greeters met at least one family member at either airport. Forty-one percent (41%) of greeted passengers were resident passengers. Analysis also revealed that symmetry existed in a majority of greeter access trips; 49% of greeters returned to their origin, 15% returned to their residence, 14% return to the passenger's residence and 22% travel to some other location.

The average number of greeters per passenger ranged from 0.80 for domestic passengers to 1.81 for international passengers. It was observed that business passengers had fewer greeters per passenger (1.33) than leisure passengers (1.41).

This experimentation with MAD(Strat)$^2$, using the spatial referencing system developed for the Quebec Ministry of Transport's urban goods movement analysis within the Greater Montreal Area, was not successful for the analysis of access trips to Dorval and Mirabel Airports. The simulated travel times are a function of both the distance travelled and the speed of the links in the simulated path. An incompletely coded network, particularly in the vicinity of Dorval Airport, therefore affects the itineraries assigned to airport tripmakers and consequently the distance and time travelled to the airport.

The average travel time and distance to Dorval Airport were calculated as being 25.72 min and 34.32 km, based on the paths obtained from the simulation with $MAD(Strat)^2$. Similarly, the average travel time and distance to Mirabel Airport were calculated as being 35.76 min and 49.01 km. Despite its distance to the centre of Montreal, Mirabel Airport was found to be more accessible in terms of average speed than Dorval Airport, which is nestled in the western part of the GMA and is surrounded by lower speed roads, highways and traffic circles. The average access speed to Mirabel Airport was 82 km/h; the average access speed to Dorval Airport was 63 km/h.

Analysis of the average access speed of each zone based on the simulated paths revealed that tripmakers originating or terminating in Downtown Montreal, the North Shore, and the Immediate South Shore had relatively good access to Dorval Airport. The average zonal access speed was 68 km/h for Downtown Montreal tripmakers, 67 km/h for North Shore tripmakers and 66 km/h for Immediate South Shore tripmakers.

On the other hand, tripmakers from the MUC-West exhibited a low level of ground access to Dorval Airport; the average zonal access speed experienced by MUC-West tripmakers was 48 km/h. This is explained by the type of roads available for tripmakers from this zone as well as the lack of access roads in the analytical network causing longer, slower paths to be assigned to MUC-West tripmakers. Further analysis of paths simulated under peak traffic conditions should reveal whether these zones maintain their level of ground accessibility to Dorval Airport.

Comparison of the two proposed measures of ground accessibility revealed that the average zonal access speed was a more suitable independent indicator of the level of ground access since the average speed better reflected the travel time and distance experienced by airport tripmakers to and from each zone. The accessibility index identified the impact of the access travel time on the tripmakers originating or terminating from a given zone, however it did not always identify a zone for which the access conditions - travel time, distance and speed, were adverse, as was the case for Downtown Montreal tripmakers. For this reason the accessibility index could not be used as an independent measure of ground accessibility to Dorval and Mirabel Airports.

In conclusion, future analyses of airport access should include the effect of peak conditions on the access time and speed, particularly with the advent of an eventual increase in air traffic at Dorval Airport. This implies increasing the passenger sample size to be able to adequately analyze airport access trips during the (morning) peak period. Also transportation and airport planners should further examine the access to Dorval Airport particularly in the vicinity of the airport, since the MUC-West is one of the three important generators of airport traffic.

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# APPENDIX TO CHAPTER TWO

## Method 1: Sample Calculation of Expansion Factors for Dorval Airport Passengers

**DOMESTIC DEPARTURES**

| | Total 4 days | | | | | |
|---|---|---|---|---|---|---|
| | Total Surveyed Business | Total Population Business | Total Surveyed Leisure | Total Population Leisure | *Surveyed Total* | *Population Total* |
| *Total* | *482* | *12470* | *110* | *3880* | *592* | *16350* |
| % | 81% | 76% | 19% | 24% | | |

**TRANSBORDER DEPARTURES**

| | Total 4 days | | | | | |
|---|---|---|---|---|---|---|
| | Total Surveyed Business | Total Population Business | Total Surveyed Leisure | Total Population Leisure | *Surveyed Total* | *Population Total* |
| *Total* | *370* | *5650* | *219* | *6580* | *589* | *12230* |
| % | 63% | 46% | 37% | 54% | | |

**DOMESTIC ARRIVALS**

| | Total 4 days | | | | | |
|---|---|---|---|---|---|---|
| | Total Surveyed Business | Total Population Business | Total Surveyed Leisure | Total Population Leisure | *Surveyed Total* | *Population Total* |
| *Total* | *375* | *8960* | *180* | *3020* | *555* | *11980* |
| % | 68% | 75% | 32% | 25% | | |

**TRANSBORDER ARRIVALS**

| | Total 4 days | | | | | |
|---|---|---|---|---|---|---|
| | Total Surveyed Business | Total Population Business | Total Surveyed Pleasure | Total Population Pleasure | *Surveyed Total* | *Population Total* |
| *Total* | *381* | *4260* | *329* | *4020* | *710* | *8280* |
| % | 54% | 51% | 46% | 49% | | |

**EXPANSION FACTORS**

| DEPARTURES | BUSINESS | | LEISURE | |
|---|---|---|---|---|
| | Factor | *% Population* | Factor | *%Population* |
| Domestic | 25.9 | 4% | 35.3 | 3% |
| Transborder | 15.3 | 7% | 30.0 | 3% |
| **ARRIVALS** | **BUSINESS** | | **LEISURE** | |
| | Factor | *%Population* | Factor | *%Population* |
| Domestic | 23.9 | 4% | 16.8 | 6% |
| Transborder | 11.2 | 9% | 12.2 | 8% |

**EXPANDED DATA**

| DEPARTURES | BUSINESS | LEISURE |
|---|---|---|
| | Number of Trips | Number of Trips |
| Domestic | 12470 | 3880 |
| Transborder | 5650 | 6580 |
| **ARRIVALS** | **BUSINESS** | **LEISURE** |
| | Number of Trips | Number of Trips |
| Domestic | 8960 | 3020 |
| Transborder | 4260 | 4020 |

## METHOD 2: SAMPLE CALCULATION OF EXPANSION FACTORS FOR INTERNATIONAL PASSENGERS

### INTERNATIONAL DEPARTURES

| *Day of Survey* | **Business** | **Leisure** | ***Total Surveyed*** |
|---|---|---|---|
| *02-Jun* | 31 | 59 | ***90*** |
| *05-Jun* | 41 | 94 | ***135*** |
| *09-Jun* | 34 | 85 | ***119*** |
| *12-Jun* | 38 | 95 | ***133*** |
| ***Total Surveyed*** | ***144*** | ***333*** | ***477*** |
| ***Average Surveyed Per Day*** | ***36.40*** | ***85.79*** | ***121.96*** |
| ***%*** | ***30%*** | ***70%*** | |

### INTERNATIONAL ARRIVALS

| *Day of Survey* | **Business** | **Leisure** | ***Total Surveyed*** |
|---|---|---|---|
| *02-Jun* | 30 | 68 | ***98*** |
| *06-Jun* | 43 | 84 | ***127*** |
| *09-Jun* | 28 | 65 | ***93*** |
| *12-Jun* | 31 | 79 | ***110*** |
| ***Total Surveyed*** | ***132*** | ***296*** | ***428*** |
| ***Average Surveyed Per Day*** | ***34.05*** | ***74.82*** | ***108.60*** |
| ***%*** | ***31%*** | ***69%*** | |

| | | |
|---|---|---|
| Number of Enplanements and Deplanements for 1993: | 2 411 981 | |
| Average Daily Passenger Volume (E+D) | 6608 | E+D Pax/Day |
| Estimate of Volume of Passengers During Survey Period: | 26433 | E+D Pax |
| Proportion of Departing Passengers During Survey: | 53% | |
| Proportion of Arriving Passengers During Survey: | 47% | |
| Estimate of Departures Population Volume During Survey: | 13932 | Pax |
| Estimate of Arrivals Population Volume During Survey: | 12501 | Pax |
| Estimate of Departures-Business Population Volume During Survey: | 4232 | Pax |
| Estimate of Departures-Leisure Population Volume During Survey: | 9699 | Pax |
| Estimate of Arrivals-Business Population Volume During Survey: | 3858 | Pax |
| Estimate of Arrivals-Leisure Population Volume During Survey: | 8643 | Pax |

### EXPANSION FACTORS

| | **BUSINESS** | | **LEISURE** | |
|---|---|---|---|---|
| | Factor | *%Population* | Factor | *%Population* |
| **DEPARTURES** | 29.6 | *3%* | 29.6 | *3%* |
| **ARRIVALS** | 29.6 | *3%* | 29.6 | *3%* |

### EXPANDED DATA

| | **BUSINESS** | **LEISURE** |
|---|---|---|
| | Number of Trips | Number of Trips |
| **DEPARTURES** | 4267 | 9868 |
| **ARRIVALS** | 3912 | 8771 |

# METHOD 3: SAMPLE CALCULATION OF EXPANSION FACTORS FOR PASSENGER GREETERS

### ARRIVING PASSENGERS WITH GREETERS

| FLIGHT SECTOR | | TRIP PURPOSE | | Grand Total |
|---|---|---|---|---|
| | | Business | Leisure | |
| *Domestic* | Sum of FEXP | 2940 | 1142 | 4082 |
| | *No. of Observations* | *123* | *68* | *191* |
| *Transborder* | Sum of FEXP | 1322 | 1769 | 3091 |
| | *No. of Observations* | *118* | *145* | *263* |
| *International* | Sum of FEXP | 1865 | 5742 | 7318 |
| | *No. of Observations* | *63* | *194* | *257* |
| Total Sum of FEXP | | 6126 | 8654 | 14780 |
| Total Number of Observations | | *304* | *407* | *711* |

### AVERAGE NUMBER OF GREETERS PER ARRIVING PASSENGER

| FLIGHT SECTOR | | TRIP PURPOSE | | Grand Total |
|---|---|---|---|---|
| | | Business | Leisure | |
| *Domestic* | Avg. ACCVOY | 1.01 | 0.96 | 0.99 |
| | *Count of ACCVOY* | *91* | *53* | *144* |
| *Transborder* | Avg. ACCVOY | 0.93 | 1.42 | 1.21 |
| | *Count of ACCVOY* | *51* | *67* | *118* |
| *International* | Avg. ACCVOY | 2.05 | 1.94 | 1.97 |
| | *Count of ACCVOY* | *44* | *134* | *178* |
| Total Average of ACCVOY | | 1.24 | 1.60 | 1.45 |
| Total Count of ACCVOY | | *186* | *254* | *440* |

### ESTIMATE OF GREETER POPULATION DURING SURVEY PERIOD

| FLIGHT SECTOR | TRIP PURPOSE | | Grand Total |
|---|---|---|---|
| | Business | Leisure | |
| *Domestic* | 2983 | 1098 | 4061 |
| *Transborder* | 1229 | 2512 | 3740 |
| *International* | 3823 | 11139 | 14416 |
| **Total** | 7572 | 13846 | 21374 |

### EXPANSION FACTORS

| | BUSINESS | | LEISURE | |
|---|---|---|---|---|
| | Factor | %Population | Factor | %Population |
| *Domestic* | 32.5 | 3% | 20.7 | 5% |
| *Transborder* | 24.1 | 4% | 37.4 | 3% |
| *International* | 86.9 | 1% | 83.3 | 1% |

### EXPANDED DATA

| | BUSINESS | LEISURE | TOTAL |
|---|---|---|---|
| | Number of Trips | Number of Trips | Number of Trips |
| *Domestic* | 2958 | 1098 | 4055 |
| *Transborder* | 1229 | 2506 | 3735 |
| *International* | 3824 | 11162 | 14986 |
| **Total** | 8010 | 14766 | 22776 |

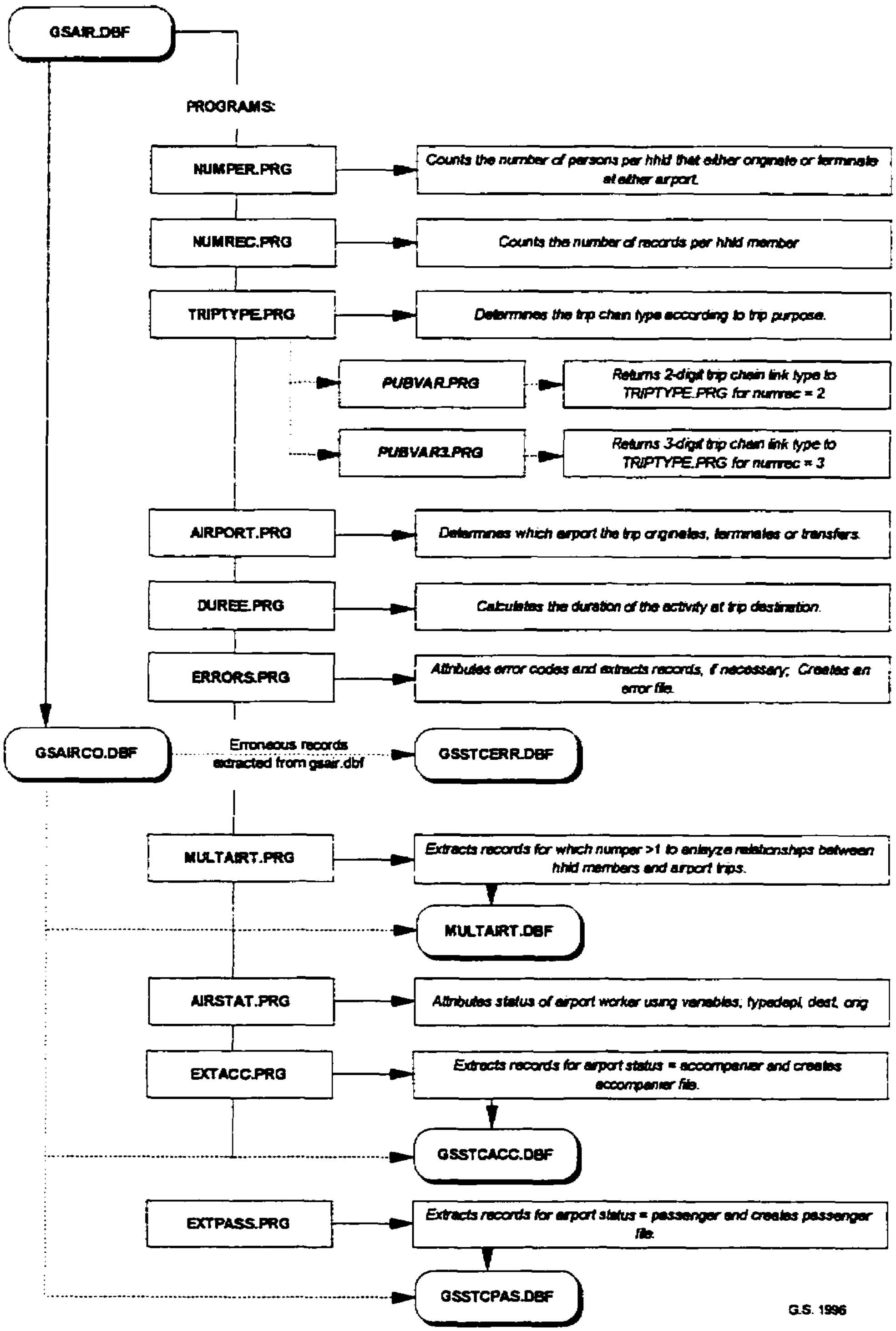


**Figure A2.1: Programs Used to Process MUCTC-MTQ O-D Survey Data Sample**

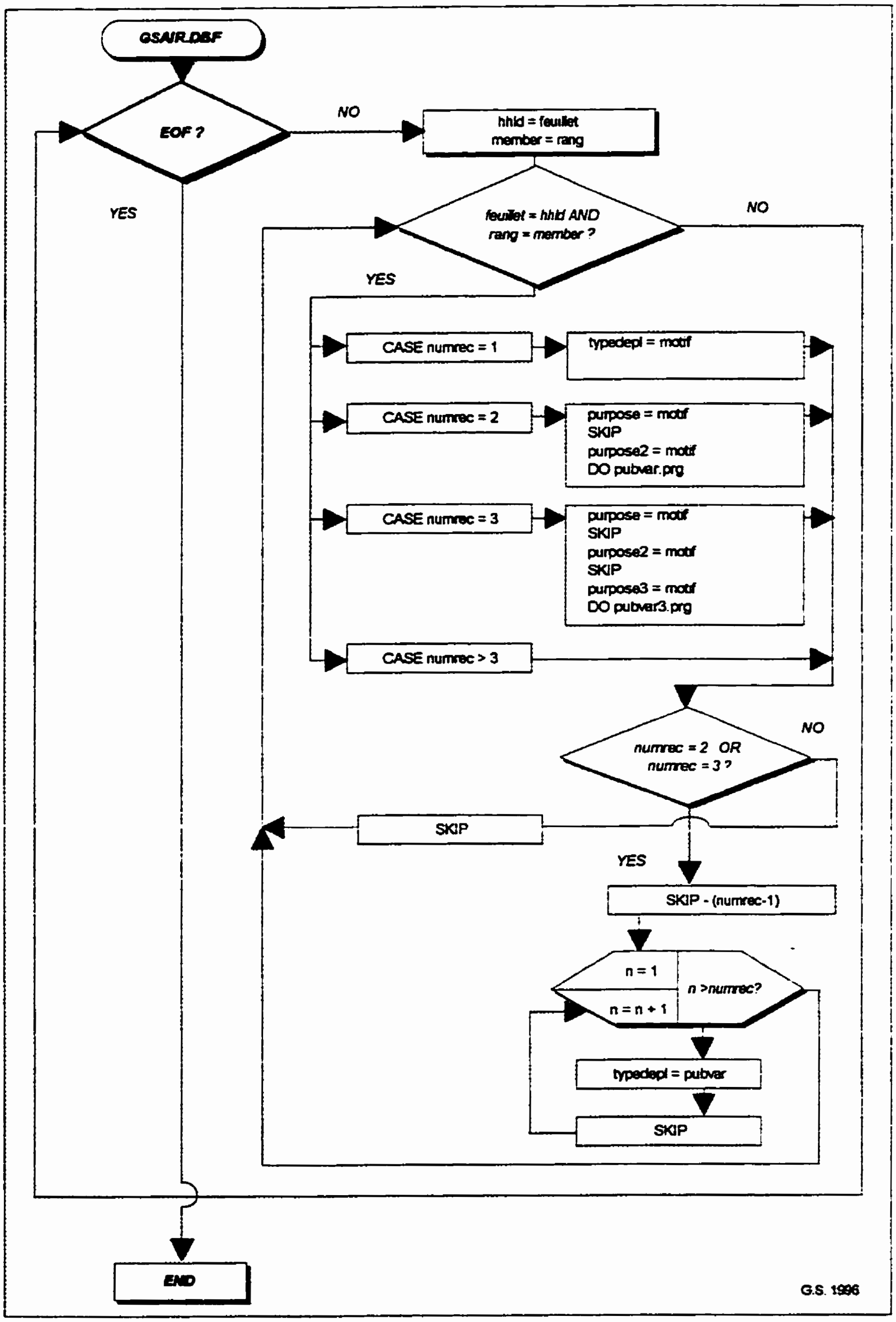


**Figure A2.2: Algorithm Used to Determine Trip Type for MUCTC-MTQ Data**

**Table A2.1: Definition of Trip Chain Types and Airport Status (MUCTC-MTQ Data)**

| Number of Trips per person (*numrec*) | Type of Trip Chain Link(s) (*typedepl*) | Description | AIRPORT STATUS | | | | Total |
|---|---|---|---|---|---|---|---|
| | | | Worker | Passenger | Accompanier or Greeter | Other | |
| 1 | 1 | Work (W) | 0.0% | 13.2% | 0.0% | 0.0% | 1.5% |
| | 3 | Return (R) | 0.0% | 25.3% | 0.0% | 0.0% | 3.0% |
| | 4 | Recreation (Re) | 0.0% | 3.2% | 0.0% | 0.0% | 0.4% |
| | 6 | Other (O) | 0.0% | 10.3% | 0.0% | 0.0% | 1.2% |
| 2 | 11 | W - W | 4.5% | 9.0% | 0.0% | 0.0% | 3.8% |
| | 12 | W - School | 0.7% | 0.0% | 0.0% | 0.0% | 0.4% |
| | 13 | W - R | 69.3% | 1.2% | 0.0% | 0.0% | 42.6% |
| | 14 | W - Re | 4.5% | 0.0% | 0.0% | 0.0% | 2.7% |
| | 15 | W - Shopping (Sh) | 1.9% | 0.0% | 0.0% | 0.0% | 1.2% |
| | 16 | W - O | 5.0% | 0.0% | 0.0% | 0.0% | 3.1% |
| | 31 | R - W | 0.6% | 0.0% | 0.0% | 0.0% | 0.3% |
| | 43 | Re - R | 0.0% | 4.7% | 0.0% | 13.9% | 0.7% |
| | 44 | Re - Re | 0.0% | 2.1% | 0.0% | 0.0% | 0.2% |
| | 46 | Re - O | 0.0% | 0.0% | 0.0% | 6.8% | 0.1% |
| | 53 | Sh - R | 0.0% | 0.0% | 0.0% | 6.9% | 0.1% |
| | 61 | O - W | 0.1% | 5.1% | 6.8% | 6.9% | 2.5% |
| | 63 | O - R | 0.0% | 11.7% | 64.4% | 35.0% | 18.5% |
| | 64 | O - Re | 0.0% | 0.6% | 5.9% | 19.1% | 1.8% |
| | 65 | O - Sh | 0.0% | 0.0% | 4.5% | 11.3% | 1.3% |
| | 66 | O - O | 0.0% | 0.0% | 16.2% | 0.0% | 4.2% |
| 3 | 113 | W - W - R | 0.5% | 0.0% | 0.0% | 0.0% | 0.3% |
| | 116 | W - W - O | 0.3% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 163 | W - O - R | 0.6% | 0.0% | 0.0% | 0.0% | 0.4% |
| | 363 | R - O - R | 0.0% | 2.0% | 0.0% | 0.0% | 0.2% |
| | 431 | Re - R - W | 0.3% | 0.0% | 0.0% | 0.0% | 0.2% |
| 4 | 1111 | W - W - W - W | 0.5% | 0.0% | 0.0% | 0.0% | 0.3% |
| | 1113 | W - W - W - R | 0.7% | 0.0% | 0.0% | 0.0% | 0.4% |
| | 1115 | W - W - W - Sh | 0.4% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 1163 | W - W - O - R | 0.0% | 6.9% | 0.0% | 0.0% | 0.8% |
| | 1313 | W - R - W - R | 2.1% | 0.0% | 0.0% | 0.0% | 1.3% |
| | 1363 | W - R - O - R | 0.4% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 1411 | W - Re - W - W | 0.4% | 0.0% | 0.0% | 0.0% | 0.3% |
| | 1413 | W - Re - W - R | 2.0% | 0.0% | 0.0% | 0.0% | 1.2% |
| | 1415 | W - Re - W - Sh | 0.5% | 0.0% | 0.0% | 0.0% | 0.3% |
| | 1416 | W - Re - W - O | 0.4% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 1513 | W - Sh - W - R | 0.7% | 0.0% | 0.0% | 0.0% | 0.4% |
| | 1563 | W - Sh - O - R | 0.3% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 1613 | W - O - W - R | 1.2% | 0.0% | 0.0% | 0.0% | 0.7% |
| | 6161 | O - W - O - W | 0.4% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 6163 | O - W - O - R | 0.0% | 4.7% | 1.6% | 0.0% | 1.0% |
| | 6165 | O - W - O - Sh | 0.2% | 0.0% | 0.0% | 0.0% | 0.1% |
| | 6563 | O - Sh - O - R | 0.3% | 0.0% | 0.0% | 0.0% | 0.2% |
| | 6663 | O - O - O - R | 0.0% | 0.0% | 0.6% | 0.0% | 0.1% |
| 6 | 111113 | W - W - W - W - W - R | 0.6% | 0.0% | 0.0% | 0.0% | 0.4% |
| | 111116 | W - W - W - W - W - O | 0.6% | 0.0% | 0.0% | 0.0% | 0.4% |
| 8 | 13131513 | W - R - W - R - W - Sh - W - R | 0.4% | 0.0% | 0.0% | 0.0% | 0.2% |
| Total | | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

# APPENDIX TO CHAPTER 3

**Table A3.1: Sociodemographic Characteristics of GMA Resident Passengers**

| Zone | Population[1] | Population Density[1] | HHLD[1] | Persons/ HHLD | HHLD Income[1] | No.Cars/ HHLD[2] | Average Age[2] | % F[2] | Res Pax[3] |
|---|---|---|---|---|---|---|---|---|---|
| *Downtown Mtl.* | 62070 | 6145.54 | 34 615 | 1.79 | $ 36,153 | 0.47 | 38.7 | 0.48 | 2052 |
| *MUC-Centre* | 732172 | 6212.75 | 333970 | 2.19 | $ 38,599 | 0.79 | 37.5 | 0.53 | 8752 |
| *MUC-East* | 389230 | 3696.74 | 167659 | 2.32 | $ 37,565 | 1.07 | 36.1 | 0.53 | 2474 |
| *MUC-West* | 314600 | 1471.81 | 115856 | 2.72 | $ 53,946 | 1.31 | 35.3 | 0.51 | 6041 |
| *MUC-SW* | 145258 | 5121.93 | 62695 | 2.32 | $ 39,897 | 0.96 | 37.4 | 0.52 | 1428 |
| *Imm. S-Shore* | 346530 | 1492.67 | 129072 | 2.66 | $ 48,348 | 1.32 | 33.9 | 0.52 | 3169 |
| *Laval* | 257316 | 1040.50 | 89965 | 2.86 | $ 50,196 | 1.44 | 34.4 | 0.51 | 1954 |
| *North Shore* | 358604 | 340.39 | 121876 | 2.94 | $ 47,777 | 1.63 | 30.9 | 0.50 | 1897 |
| *South Shore* | 331084 | 213.18 | 113021 | 2.93 | $ 52,069 | 1.65 | 32.0 | 0.50 | 1831 |
| *Other (Vaudreuil)* | 84503 | 99.16 | 30036 | 2.81 | $ 49,129 | 1.42 | 33.9 | 0.51 | 880 |

[1] Statistics Canada (1991)
[2] MADEOD (MUCTC-MTQ 1993 O-D Survey)
[3] ADM O-D Survey (1993)

**Table A3.2: Passenger Trips per Zone (ADM Data)**

| Zone | DEPARTING | | | | ARRIVING | | | |
|---|---|---|---|---|---|---|---|---|
| | RB | RL | NRB | NRL | RB | RL | NRB | NRL |
| *Downtown Mtl.* | 1099 | 730 | 5033 | 3567 | 603 | 390 | 5892 | 4595 |
| *MUC-Centre* | 2395 | 2847 | 1003 | 1395 | 1364 | 1809 | 340 | 634 |
| *MUC-East* | 602 | 916 | 316 | 125 | 537 | 429 | 172 | 142 |
| *MUC-West* | 2270 | 1482 | 1808 | 1065 | 879 | 1003 | 876 | 656 |
| *MUC-SW* | 497 | 391 | 119 | 0 | 360 | 218 | 96 | 58 |
| *Imm. S-Shore* | 1062 | 752 | 279 | 179 | 790 | 360 | 149 | 95 |
| *Laval* | 438 | 552 | 195 | 90 | 509 | 390 | 190 | 255 |
| *North Shore* | 643 | 278 | 72 | 60 | 602 | 302 | 91 | 75 |
| *South Shore* | 574 | 339 | 108 | 184 | 480 | 212 | 46 | 59 |
| *Other (Vaurdreuil)* | 331 | 225 | 340 | 285 | 224 | 96 | 330 | 230 |
| TOTAL | 9911 | 8512 | 9303 | 6950 | 6847 | 5210 | 8081 | 6798 |

## TEMPORAL DISTRIBUTION OF PASSENGER TRIPS (ADM DATA)

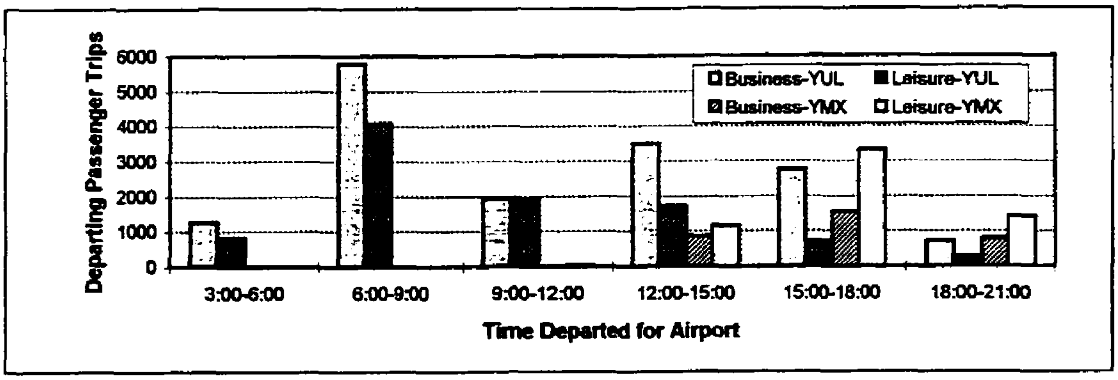


Figure A3.1: Temporal Distribution and Trip Purpose of Departing Passenger Access Trips

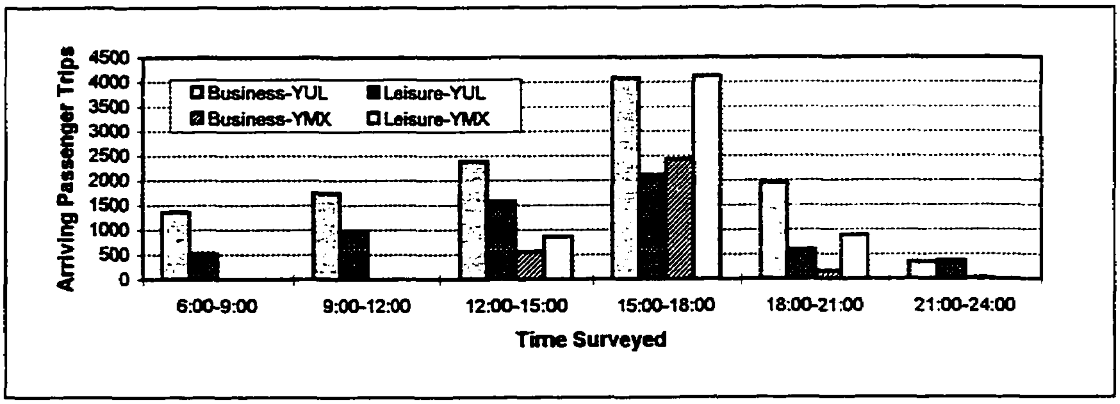


Figure A3.2: Temporal Distribution and Trip Purpose of Arriving Passenger Egress Trips

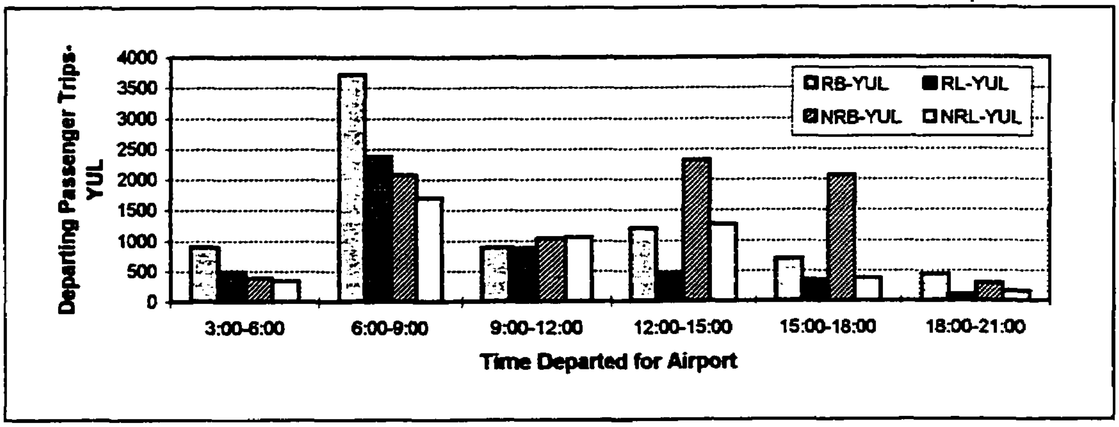


Figure A3.3: Temporal Distribution and Passenger Type of YUL Departing Passengers

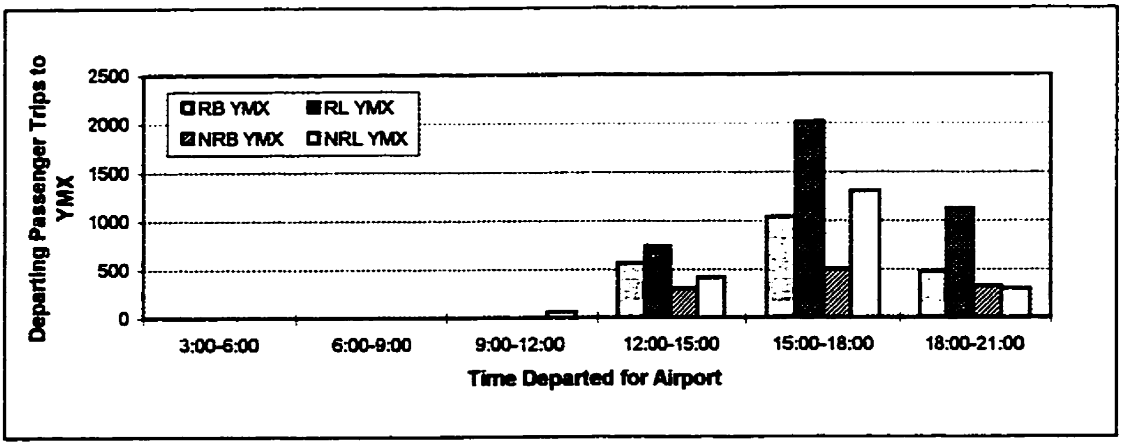


Figure A3.4: Temporal Distribution and Passenger Type of YMX Departing Passengers

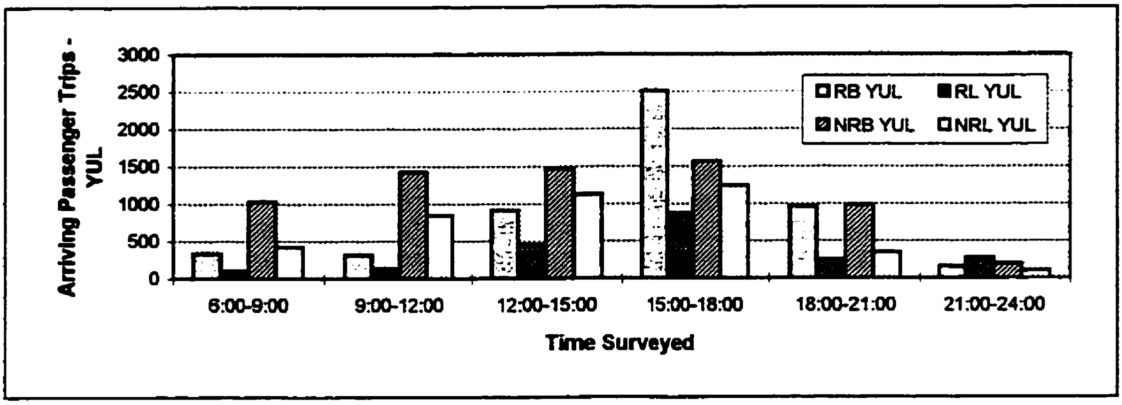


Figure A3.5: Temporal Distribution and Passenger Type of YUL Arriving Passengers

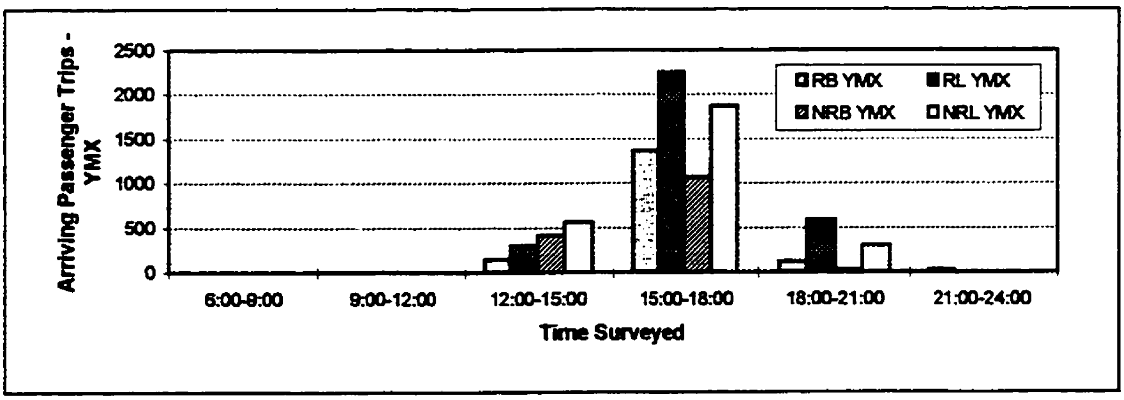


Figure A3.6: Temporal Distribution and Passenger Type of YMX Arriving Passengers

## MODAL SPLIT OF PASSENGER AIRPORT ACCESS TRIPS (ADM DATA)

**Table A3.3: Modes Used by Passengers to Access and Egress Dorval and Mirabel Airports**

| MODE | DEPARTURES | | ARRIVALS | | TOTAL | |
|---|---|---|---|---|---|---|
| | YUL | YMX | YUL | YMX | YUL | YMX |
| | % Trips | % Trips | % Trips | % Trips | % Trips | % Trips |
| *Car* | 51.2% | 67.6% | 46.6% | 64.3% | 49. 3% | 66.0% |
| *Rental Car* | 9.3% | 3.6% | 11.6% | 9.5% | 10.2% | 6.5% |
| *Taxi* | 31.3% | 7.8% | 32.7% | 9.2% | 31.9% | 8.5% |
| *Chartered Bus* | 0.2% | 4.2% | 0.9% | 6.9% | 0.5% | 5.5% |
| *Autocar* | 3.8% | 14.9% | 4.3% | 7.5% | 4.0% | 11.2% |
| *Transit* | 1.0% | 0.0% | 1.8% | 0.0% | 1.3% | 0.0% |
| *Hotel Shuttle* | 2.0 % | 0.0% | 0.4% | 0.3% | 1.4% | 0.2% |
| *Limousine* | 1.2% | 1.6% | 1.6% | 2.3% | 1.4% | 2.0% |
| *Other* | 0.1% | 0.3% | 0.1% | 0.0% | 0.1% | 0.2% |

**Table A3.4: Modes Used by Resident and Nonresident Passengers (Departure & Arrivals)**

| Mode | RESIDENTS | | | NONRESIDENTS | | |
|---|---|---|---|---|---|---|
| | YUL | YMX | Total | YUL | YMX | Total |
| | % Trips | % Trips | % Trips | % Trips | % Trips | % Trips |
| *Car* | 70.0% | 81.3% | 74.0% | 32.2% | 44.0% | 35.0% |
| *Rental Car* | 1.1% | 0.8% | 1.0% | 17.8% | 14.8% | 17.1% |
| *Taxi* | 25.5% | 5.8% | 18.6% | 37.1% | 12.4% | 31.3% |
| *Chartered Bus* | 0.0% | 0.0% | 0.0% | 0.9% | 13.6% | 3.9% |
| *Autocar* | 1.3% | 9.1% | 4.0% | 6.2% | 14.4% | 8.1% |
| *Transit* | 1.3% | 0.0% | 0.8% | 1.3% | 0.0% | 1.0% |
| *Hotel Shuttle* | 0.0% | 0.0% | 0.0% | 2.5% | 0.0% | 1.9% |
| *Limousine* | 0.6% | 3.0% | 1.5% | 2.0% | 0.4% | 1.6% |
| *Other* | 0.0% | 0.0% | 0.0% | 0.0% | 0.4% | 0.1% |

# TIME BEFORE FLIGHTS (ADM DATA)

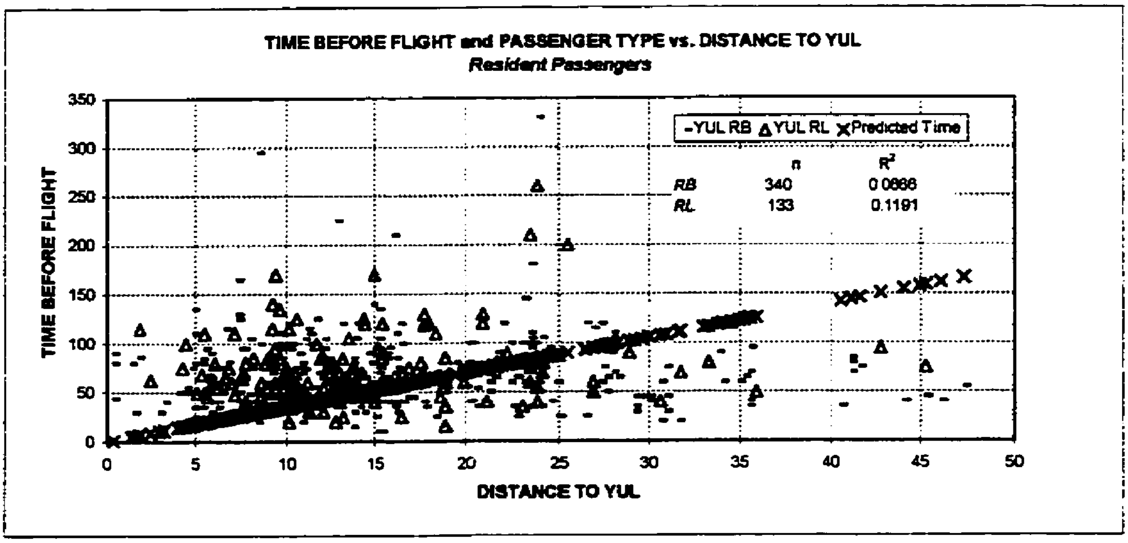


Figure A3.7: Time Before Flight vs. Distance to YUL (Resident Passengers)

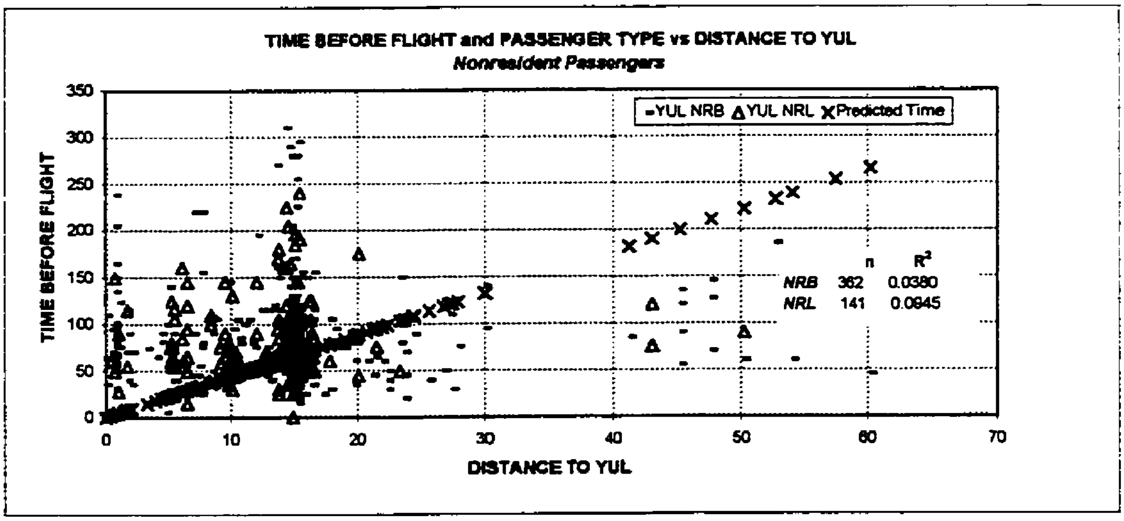


Figure A3.8: Time Before Flight vs. Distance to YUL (Nonresident Passengers)

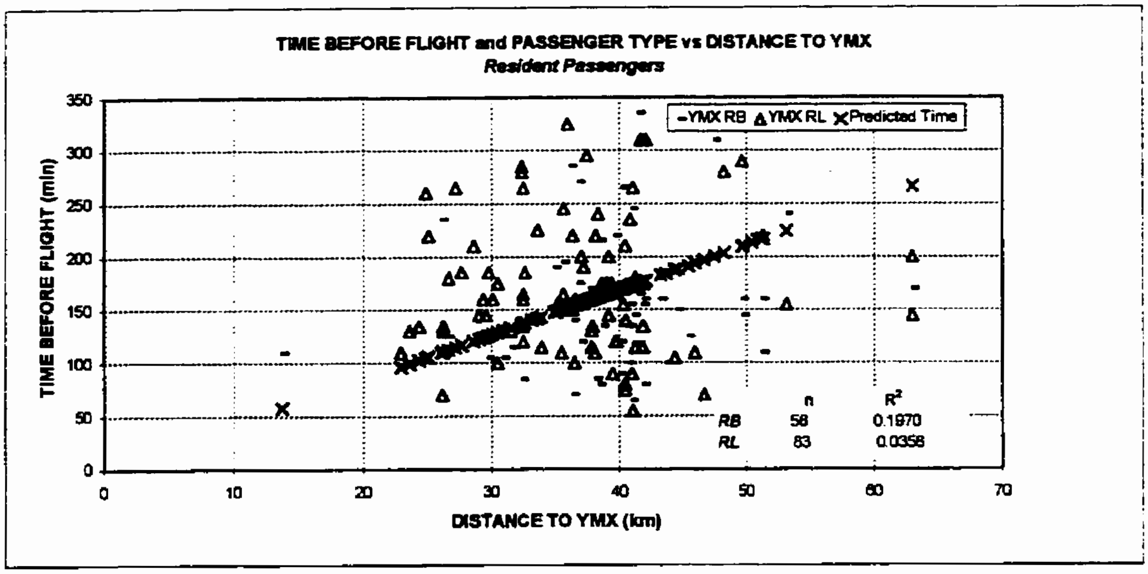


**Figure A3.9: Time Before Flight vs. Distance to YMX (Resident Passengers)**

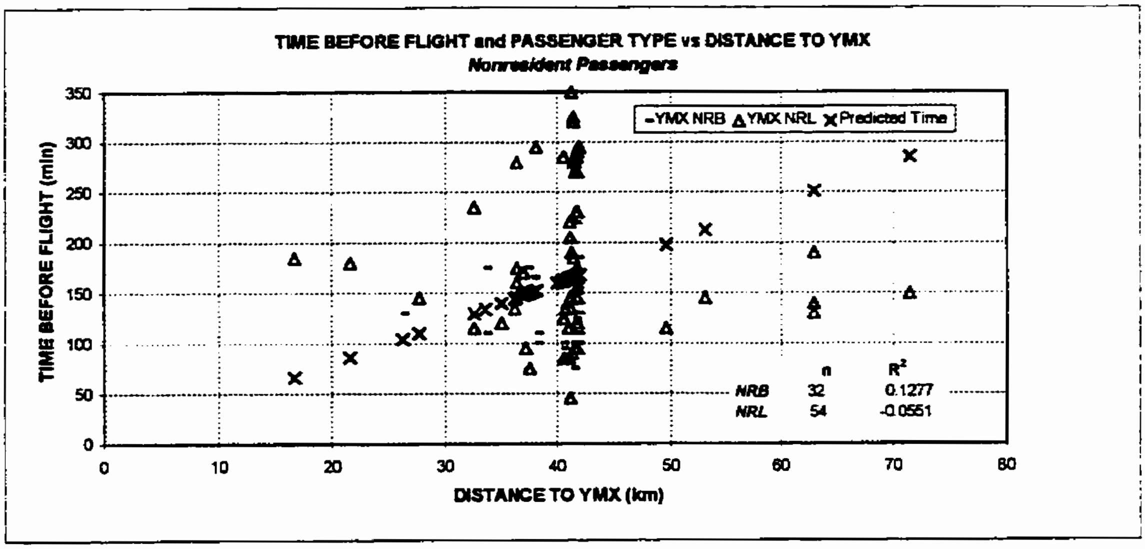


**Figure A3.10: Time Before Flight vs. Distance to YMX (Nonresident Passengers)**

## GREETER TRIPS FROM THE MUCTC-MTQ DATA

### Sociodemographic Profile of Greeters

According to the MUCTC-MTQ data, the majority of passenger greeters reside in the municipalities of the MUC-Centre, -West and -East (Figure A3.11). The average age of the male greeter is 40.5 years. The average female greeter is slightly younger at 37.5 years. Figure A3.12 shows that the males are the predominant gender among the greeter population. Analysis of the greeter status reveals that male greeters are workers while female greeters are either "other" than workers or students (Table A3.5).

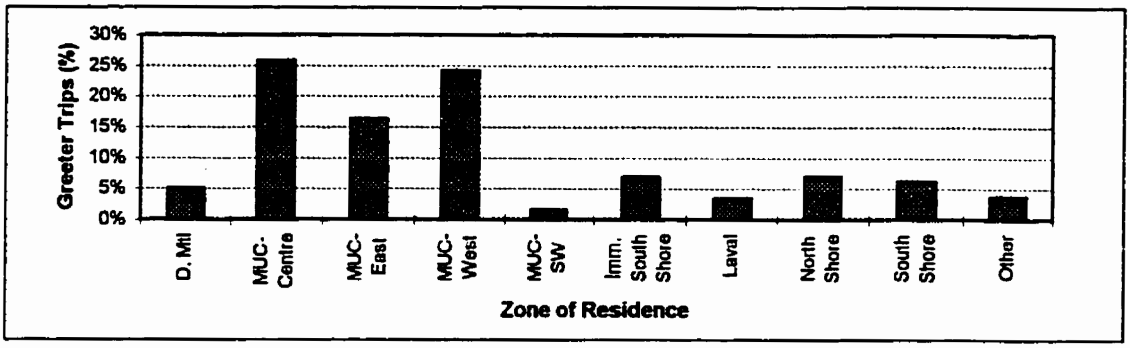


**Figure A3.11: Residence of GMA Passenger Greeters (MUCTC-MTQ Data)**

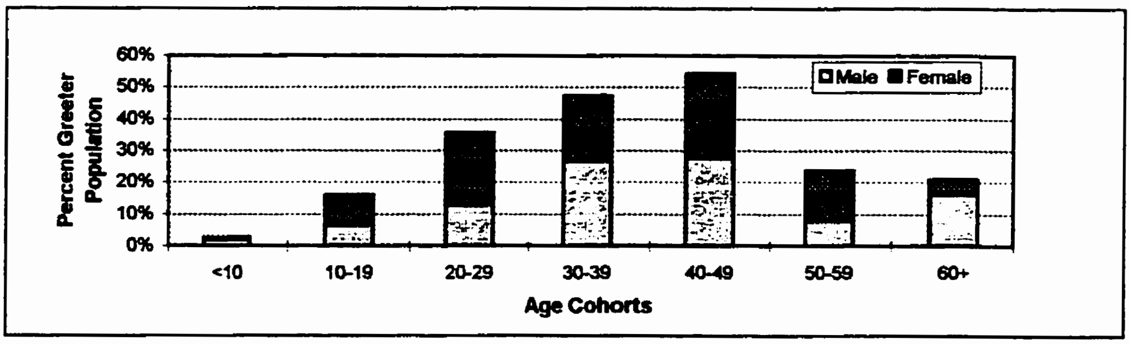


**Figure A3.12: Age and Gender of Passenger Greeters (MUCTC-MTQ Data)**

**Table A3.5: Status of Airport Greeters** (MUCTC-MTQ Data)

| Gender | WORKER | STUDENT | OTHER |
|---|---|---|---|
| *Male* | 50.7% | 7.8% | 41.5% |
| *Female* | 32.7% | 6.2% | 61.1% |
| TOTAL | 42.9% | 7.1% | 50.0% |

Analysis of the number of greeters per household in the MUCTC-MTQ survey data reveals that fewer greeters per household greet passengers at Dorval Airport than at Mirabel Airport. This is consistent with the ADM data, however the number of greeters per passenger obtained from the ADM data was not necessarily restricted to one household.

**Table A3.6: Number of Greeters per Household** (MUCTC- MTQ Data)

| Airport | AVERAGE NUMBER OF GREETERS PER HOUSEHOLD |
|---|---|
| *YUL* | 1.29 |
| *YMX* | 2.12 |
| TOTAL | 1.65 |

## Greeter Airport Trips

Analysis of the trip origins and destinations of greeter trips revealed that the MUC-West and the MUC-Centre generate the greatest proportion of Dorval Airport-based greeter trips (Figure A3.13). Similarly, these zones together with the MUC-East, also generate the greatest proportion of Mirabel Airport-based greeter trips. These zones were also shown to generate the greatest amount of greeter trips with the ADM data.

Analysis of greeters' trip chains reveals they are often symmetrical, that is, they depart from and return to their residence. Table A3.7, shows that 66.7% of all greeters return to their residence after greeting someone at the airport; the rest travel to a different destination point after leaving the airport for either work (6%), recreation (7%), shopping (4%) or some other trip purpose (16%).

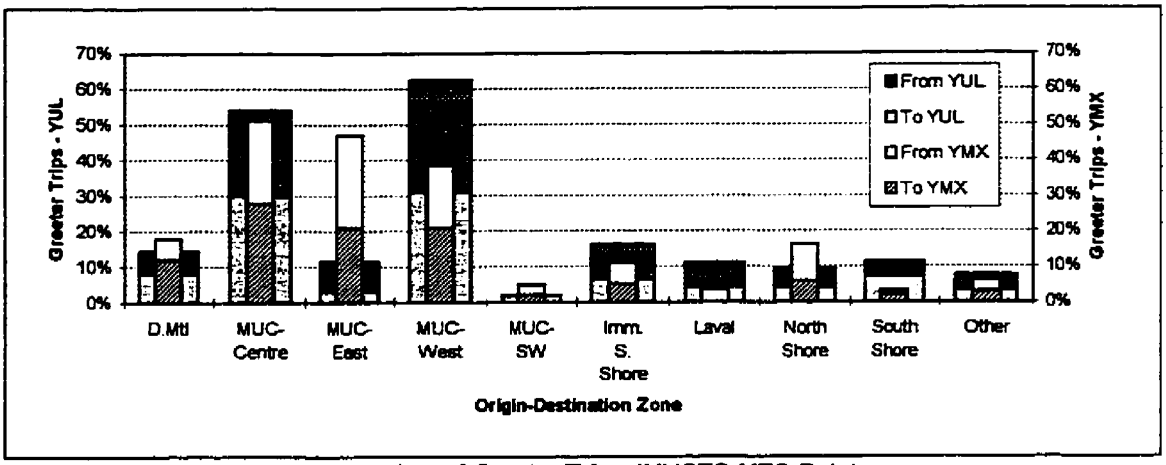


**Figure A3.13: Origin and Destination of Greeter Trips** (MUCTC-MTQ Data)

**Table A3.7: Greeter Trip Chains** (MUCTC-MTQ Data)

| Trip Chain Type | YUL | YMX | TOTAL |
|---|---|---|---|
| | Percent Trips | Percent Trips | Percent Trips |
| *61* | 9.8% | 1.9% | 6.4% |
| *63* | 71.4% | 60.7% | 66.7% |
| *64* | 5.3% | 8.3% | 6.6% |
| *65* | 6.8% | 0.0% | 3.8% |
| *66* | 6.8% | 29.1% | 16.5% |

As was discovered with the ADM data analysis of greeter trips, the automobile is the predominant mode of transportation selected by passenger greeters, with over 95% of all greeter trips to both airports using a car (Figure A3.14).

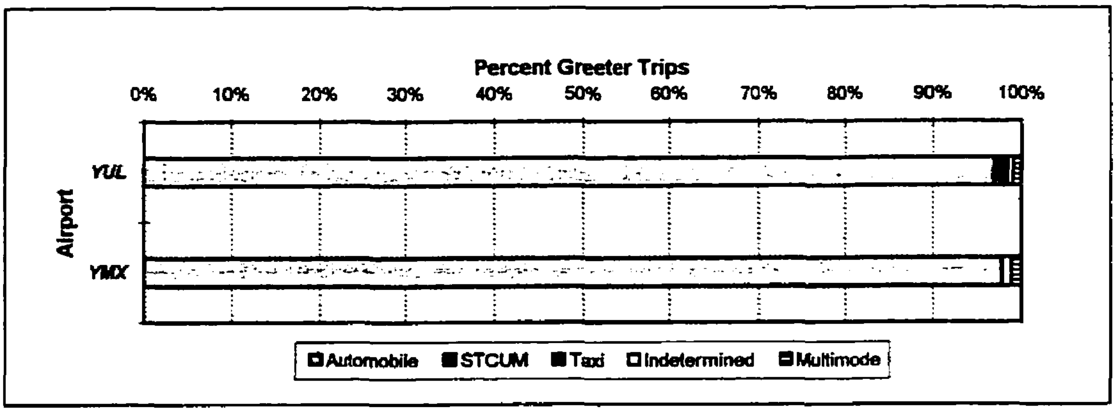


**Figure A3.14: Modal Choice of Passenger Greeters (MUCTC-MTQ)**

Analysis of the temporal distribution of the greeter trips to both airports, as well as the duration of the "greeting" activity shows some differences compared to the ADM data. Firstly, the MUCTC-MTQ data shows the peak period for trips to both airports to be the late afternoon at approximately the same time. The peak for Dorval Airport is 5:00p.m. while the peak hour for Mirabel Airport is 4:00p.m.. This is later than what was observed from the ADM data. The peak hour for the second airport trip, the trip from Dorval and Mirabel Airports, occurs at 7:00p.m.. This time is also later compared to the ADM data.

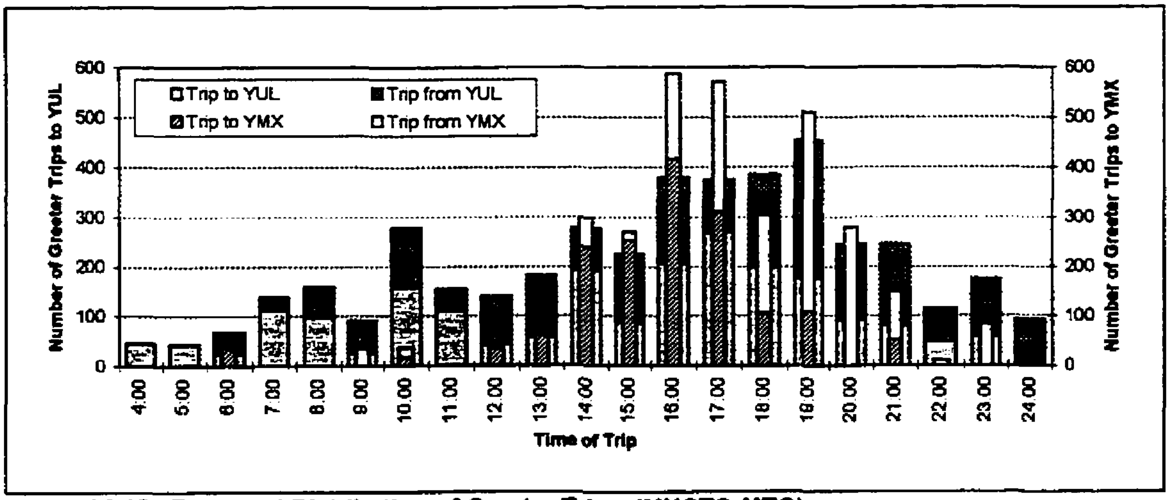


**Figure A3.15: Temporal Distribution of Greeter Trips (MUCTC-MTQ)**

The differences in the peak hours are attributable to the lack of information on the time departed from the airport (ADM Data). The departure time for the trip from the airport using the ADM O-D data, is estimated using the time the respondent was surveyed. Consequently, differences also occur in the "greeting" activity duration for each airport. The duration of the greeting activity determined using the MUCTC-MTQ data is generally longer than the duration calculated using the ADM data. Table A3.8 shows that the average greeter activity duration is 128 minutes versus 62 minutes from the ADM data.

**Table A3.8: Duration of Greeter Activity** (MUCTC-MTQ Data)

| Airport | AVERAGE DURATION OF GREETER ACTIVITY (min) |
|---|---|
| *Dorval Airport* | 113 |
| *Mirabel Airport* | 149 |
| TOTAL | 128 |

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