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The Ottawa-Carleton Institute for Civil Engineering

**Developing a Framework for a National Strategy for
Baggage Handling at Airports**

Researched and Written by:

Joanne Kelly Pagani, B.Eng., P.Eng.

A thesis submitted to the
Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Civil and Environmental Engineering
Carleton University
Ottawa, Canada
November 2001

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Faculty of Graduate Studies and Research
acceptance of this thesis

Developing a Framework for a National Strategy for Baggage Handling at Airports

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in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

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ABSTRACT

Background research shows that the design standards for baggage handling systems (BHS) do not consider the level of service (LOS) as perceived by the passengers. Moreover, it is evident that a national strategy for defining the LOS of BHS and the means to improve it are lacking. A LOS model that can ascertain the LOS being achieved by the BHS would be beneficial to airlines, passengers, and airport designers. Such a model would enable airport authorities and airlines to determine when improvements are required and to develop a strategy for implementing the needed changes. This thesis presents a study performed at six Canadian airports, where over 800 passengers rated the LOS provided by the overall BHS and its different components. The results confirm that traditional time and space standards; currently used by aviation agencies, airports, airlines, and baggage handlers; are not adequate. Subsequently, regression analysis was performed to develop aggregate and disaggregate user perceived LOS models. The aggregate model, created from all collected data, is a comprehensive tool for the preliminary evaluation and analysis of the perceived LOS of BHS's and should be used as part of the overall LOS evaluation of airport systems. The disaggregate model, based on annual airport volumes, allows for a more detailed evaluation of the perceived LOS of the BHS and provides an additional tool for overall terminal analysis and design. Finally, a disaggregate model was developed for each of the six participating airports for future evaluation of these specific airports.

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ABBREVIATIONS

AC - Air Canada	55, 60, 62, 63, 65, 77, 82
ACI - Airports Council International.....	3, 19, 52, 344
ACI-NA - North American Branch of Airports Council International.....	3
AIF - Airport Improvement Fee.....	22, 23
ATR - Air Terminal Redevelopment Project.....	144, 145, 146
BAA - British Airport Authority.....	92, 235, 239, 241, 243, 246, 247, 248, 260, 261
BHS - Baggage Handling System	iii, 7, 13, 16, 52, 77, 82, 84, 88, 97, 98, 99, 100, 101, 108, 129, 169, 202, 205, 207, 209, 214, 215, 217, 220, 228, 233, 235, 236, 241, 253, 265, 268, 274, 278, 284, 287, 288, 289, 291, 292, 295, 307, 317, 318, 326, 327, 329, 330, 331, 336, 337, 338, 340, 342, 397, 417, 421, 423
BSM - Baggage Source Message.....	55
BTM - Baggage Transfer Message	55
BWB - Blended Wing Body	97
CAA - Civil Aeronautics Administration	18
COMFORT - Rating of personal comfort and safety in reclaim area	221, 290, 302, 303, 308, 312, 315, 332, 415, 429
EDGSPACE - Rating of frontage (linear metres) along conveyor belt	214, 215, 216, 234, 282, 283, 284, 286, 415, 427
EIA - Edmonton International Airport.....	142, 143, 144, 147
EXPECT - Passenger's Expected Waiting Time.....	199, 278, 279, 416
FAA - Federal Aviation Agency.....	18, 47
GTAA - Greater Toronto Airport Authority.....	156
HGAS - Hudson General Aviation Services.....	67, 68, 74, 80, 81, 82, 86
IATA - International Air Transport Association	34, 89, 91, 92, 93, 95, 144, 217, 235, 239, 240, 241, 243, 246, 247, 248, 250, 251, 252, 260, 261, 263, 328, 330
ICAO - International Civil Aviation Organization	3, 5, 47, 348, 349
IROPS - Irregular Operations	63
LBPIA - Toronto's Lester B. Pearson International Airport	156, 157, 158, 159

LOS - Level of Service.....	iii, 15, 16, 27, 28, 45, 50, 82, 84, 86, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 106, 107, 125, 126, 134, 135, 144, 165, 167, 168, 169, 170, 174, 184, 192, 199, 203, 204, 207, 208, 209, 214, 216, 217, 221, 222, 224, 225, 226, 228, 232, 233, 234, 235, 241, 242, 243, 244, 248, 249, 250, 251, 252, 258, 259, 261, 262, 263, 267, 268, 273, 274, 291, 292, 293, 294, 295, 297, 298, 303, 304, 313, 314, 318, 326, 327, 328, 329, 330, 331, 334, 336, 337, 338, 339, 341, 351, 415, 417, 418, 420, 421, 422, 424
NAS - National Airport System.....	21, 22, 24
OVRSPACE - Rating of overall space in reclaim area	216, 218, 219, 234, 285, 287, 308, 315, 330, 335, 418
PIL - Primary Inspection Lineup	71
RF - Radio Frequency Tags	34, 35, 341, 342, 343
SEATING - Rating of amount of seating provided in reclaim area	219, 220, 221, 287, 420
SITA - Société Internationale de Telecommunications Aeronautiques.....	58, 59, 61
SPSS - Statistical Package for Social Sciences..	171, 172, 180, 181, 192, 194, 226, 227, 264, 266, 298, 397, 398, 411, 412
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TC - Transport Canada.....	22, 93, 95, 250, 252, 328, 330
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WAITTIME - Rating of waiting time in reclaim area ...	184, 209, 213, 234, 278, 279, 280, 281, 282, 300, 302, 303, 312, 315, 332, 422, 424
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WALKTIME - Rating of walking time between arrival gate and reclaim area.....	205, 206, 207, 208, 234, 275, 276, 277, 302, 303, 304, 309, 312, 315, 422, 423
YEG - Edmonton International Airport	131, 142, 172, 173, 415, 418
YOW - Ottawa Macdonald-Cartier International Airport	131, 140, 172, 173

YQT - Thunder Bay International Airport.....	131, 137, 172
YUL - Dorval International Airport.....	131, 153, 172, 173
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Chapter 1

1 INTRODUCTION

1.1 Overview

Worldwide air travel is experiencing a continual increase in the demand volume. The International Civil Aviation Organization (ICAO) reported continued growth in scheduled passenger traffic during the 1990's (Figure 1-1). The total number of worldwide passengers carried on scheduled air services exceeded 1.25 billion in 1995 (International Civil 1995) and exceeded 1.5 billion in 1999 (International Civil 1999b). The ICAO also reported a growth in scheduled traffic, measured in passenger-kilometres, from 1987 to 1997, and a forecasted growth through 2002 (Table 1-1). Between 1998 and 1999, the North American Branch of Airports Council International (ACI-NA) showed a 3.7% increase in North American passengers, a 4.4% increase in cargo and a 2.4% increase in aircraft operations (Airports Council 1999). The Canadian air transportation system, fully observing this increase in demand, must be able to accommodate the ever-increasing number of people requesting air service. The increase in the number of passengers affects every aspect of the air transportation system from the ground access system, to the terminal processing facilities, to the airside aircraft services. The capacity of the parking facilities, curbside access and egress areas, check-in areas, terminal space,

queuing areas, gates, aircraft fleet, baggage reclamation belts and personal services must all be increased to accommodate the increase in the passenger demand. Both the airside and the groundside facilities within the airport complex (baggage handling, security, customs, parking services, aircraft services, etc) should therefore initiate comprehensive capacity analyses, for each individual facility and for the overall airport system. Figure 1-2 presents the various components of the airport system. These capacity analyses will enable airport authorities and airlines to determine whether or not the current services are adequate, when changes should be implemented based on forecasted volumes, and what are the most appropriate methods to increase the capacity while considering cost and space restrictions.

The amount of baggage to be accurately, efficiently and safely transported within the airport system is directly proportional to the number of passengers. Surveys have indicated that passengers consider baggage handling to be a very significant issue, placing it near or at the top of their list of air travel priorities (Ashford et al. 1984). Therefore, it is very important that the objectives of the baggage handling system be accomplished successfully, while minimizing damage, loss, and pilferage to the baggage, and reducing the amount of delay time to the passenger.

Figure 1-1: World Scheduled Passenger Traffic 1990-1999 (International Civil 1999b)

A delay in the baggage handling system can adversely affect the whole operation of the airport facility. A delay in outbound baggage (baggage to be loaded onto an aircraft for departure) can detain an aircraft in a gate longer than necessary, resulting in poor usage of the terminal gate. This results in the subsequent aircraft being unable to enter the gate in a timely fashion. A delay in the inbound baggage (baggage unloaded from an aircraft upon arrival) causes unnecessary congestion in the terminal building. The baggage reclaim area becomes congested with passengers awaiting for their delayed baggage, and with additional passengers arriving from later flights. The processing of baggage, also

referred to as 'bags' or 'luggage', remains a very important aspect for air travellers and a very expensive item for air carriers. This is not only because of the delays if the system fails, but also because of the possibility of damaged, lost and stolen luggage. During the last six months of 2000, Bruce Hood, the Complaints Commissioner in charge of overseeing passenger complaints with respect to air carriers and air transportation, received 3515 complaints from 1,248 individuals (Rubec 2001). The majority of the complaints were regarding cancelled or delayed flights, service quality, and lost or damaged luggage. It is unknown how many people were unsatisfied with the service yet did not register a complaint.

Table 1-1: ICAO Scheduled Passenger Traffic Forecast for 1999-2002 (International Civil 1999a, International Civil 2000)

Year	Scheduled Passenger Traffic		
	Passenger kilometers (Billion)	Percent Change	Calculation Method
1987	1589.5		Actual
1988	1705.6	7.3	Actual
1997	2753.1		Actual
1998	2627.7	-4.6	Actual
1999	2791.0	6.2	Actual
2000	2956.4	5.9	Estimated
2001	3117.9	5.5	Forecast
2002	3284.4	5.3	Forecast

Figure 1-2: The Airport System (Ashford et al. 1984)

The purpose of this thesis is to assess the current baggage handling systems at Canadian airports and subsequently develop a user-perceived level of service (UPLOS) model that can ascertain the perceived quality of service being provided by each baggage handling system. The model will facilitate the identification of systems that require modifications due to, among other reasons, inadequate capacity, inefficient physical layout, or inferior service considerations. Also, the model will assist in the identification of appropriate strategies for airport improvements. The following sections outline the thesis objectives and the research methodology, while providing background information on baggage handling systems.

1.2 Airport Baggage Handling System

The baggage handling system (BHS) at an airport consists of components of the handling operation both within the airport terminal and on the airside apron. The entire operation can be divided into two main components of departures and arrivals, the same two components used to separate passengers, flights, and curbside areas. The departure component includes the check-in counters, the sortation room, and transportation to the aircraft. The arrival component includes transportation from the aircraft to the reclaim area and the reclaim area distribution system (conveyors). Conveyor belts facilitate transportation between areas within the terminal building, while transportation between the terminal and the apron is achieved with towing vehicles, baggage carts and baggage cans. Figure 1-3 shows baggage and passengers flow through the terminal building.

Figure 1-3: Passenger and Baggage flow Through an Airport Facility (Parizi 1995)

1.3 Functions of the Baggage Handling System

The main objective of any handling system is to deliver the product to the customer by the most economical and efficient method. Postal service companies, department stores that deliver their wares, food delivery services and airport baggage handling system, all have the same objectives. More specific objectives of an airport baggage handling system are:

- ◆ to transport the luggage from the passenger to the aircraft at departure in a secure, undamaged and efficient manner; and
- ◆ to transfer the luggage from the aircraft to the passengers in a secure, undamaged and efficient manner upon arrival at the passengers final destination.

1.4 Problem Definition

The reason for the undertaking of this thesis stems from the great discrepancies observed between airlines, airports and baggage handlers in terms of their physical ground handling systems, the lack of standard measures for lost baggage, and their varying levels of service. From a preliminary assessment of two Canadian airports the following deficiencies were found to exist within the current system:

- ◆ Baggage handlers do not operate as efficiently as is possible. They do not necessarily place baggage within the hold area based on order of destinations.

- ◆ There is a lack of recent records as to the time taken to unload baggage and the amount of baggage mishandled.
- ◆ A consistent method for reporting the amount of mishandled baggage does not exist.
- ◆ A comprehensive study to determine all factors affecting the level of service provided to the passengers has not been conducted.
- ◆ Common measures for the level of service provided to the passengers are lacking.
- ◆ There are no Canada wide standards explicitly identifying the quality of service that should be provided.
- ◆ Established methods for improving the baggage handling system (by reducing the amount of lost, stolen, damaged or otherwise mishandled baggage; by increasing the level of service provided to the passengers; by increasing the operating capacity; and by improving the security) are not available.

Due to these obvious deficiencies in the Canadian baggage handling system, the need for research in this area of air transportation is clearly evident.

1.5 Objectives

The main thrust of this thesis is to improve the baggage handling system in Canadian airports. The goal is to increase quality and efficiency of the entire baggage handling system from a planning, management, and operations perspective, while considering

economic and security implications. The analysis considers the safety, security, convenience, cost and delay characteristics imposed on the passengers, airlines, baggage handling companies, and airport authorities. The specific objectives of this research are:

- ◆ to assess the present state of the baggage handling facilities at a selected number of major Canadian airports that are representatives of the entire Canadian airport system,
- ◆ to study and evaluate the service provided to the passengers by the baggage handling facilities,
- ◆ to investigate and determine any discrepancies between the service provided by the airlines and the service expected by the passengers,
- ◆ to identify the main factors that affect the level of service of the baggage handling system,
- ◆ to develop a model for identifying the level of service that is currently being provided to the passengers,
- ◆ to recommend more reliable techniques with which airlines and airport authorities can improve their baggage handling systems based on the factors affecting the level of service determined above.

1.6 Scope of Study

The proposed research involved assessing the baggage handling systems at a selection of major Canadian airports. The airports chosen formed a representative sample of small,

medium, and large airports, based on passenger volumes. The research focused on the *arrival* baggage handling system and how the BHS was perceived by arriving passengers. However, the system assessment looked at the entire baggage handling system including the handling equipment used for sortation, transportation and reclamation. The questionnaire used to solicit information from the passenger focused on the terminal space leading from the arrival gate to the baggage reclaim area, and the reclaim area itself. In terms of time of day, the study was carried out during both peak and off-peak periods.

1.7 Rationale for the Research

It has been observed that the air traffic forecasts used to design airport infrastructure were consistently lower than actual air traffic volumes (Meredith, 1992). The effect of this under-designed infrastructure has been a general congestion at airports and an inability to deliver goods worldwide with utmost expediency. It was suggested that airport authorities should develop comprehensive “master plans” in order to meet the high levels of demand being imposed on the airport complex (Meredith, 1992).

An independent organization called the Air Transport Action Group was established to examine all aspects of congestion by enlisting the help of all interested parties – consumer groups, chambers of commerce, airport authorities, travel agents, tour

operators, aircraft manufacturers, and aircraft leasing companies. The priorities of this group are to transfer useful suggestions, statistics, and information efficiently between interested organizations. This is being accomplished in the hopes that all necessary areas of congestion, including the airside gates, the airport access and parking requirements, the operation of the baggage handling system and the airport security systems, can be addressed as soon as possible.

As the demand for air transportation is growing, all airports and airlines will encounter this problem of congestion. They will face the same situation of having limited, and very often, inadequate capacity to handle the significant annual increase in the amount of baggage to be processed. Without improving the capacity of the airport terminal facilities to match this increase in the amount of baggage, the overall quality of service offered by Canadian airports is deemed to deteriorate.

One indication of the quality of service provided by the baggage handling system is the amount of baggage recorded as mishandled. Lost baggage costs airlines millions of dollars annually. A large North American airline estimated that the cost of delayed, lost and damaged luggage can be in the area of \$30 million to \$40 million annually (Ashford et al. 1984).

The amount of baggage reported mishandled varies greatly from airline to airline. In 1998, American Airlines recorded that just over 5 bags per 1000 passengers were mishandled, which includes delayed, damaged, lost and stolen bags (Gilje 1999). The Toronto Star noted that airlines that have good records for baggage handling, like Northwest Airlines, lose about 1 bag for every 1000 bags they sort (Brahmam 1999). Due to lax guidelines for reporting mishandled baggage, it is very difficult to compare these two airlines and the two different levels of service that they reported.

With the ever-increasing number of passengers, the equipment used for baggage handling and the terminal space provided for the baggage handling operation will reach capacity. As the number of passengers increases and capacity is exceeded, a decrease in the LOS provided by baggage handling systems results. Due to the varying levels of service, and the differences observed between reporting practices of mishandled baggage, the need for clear guidelines is obvious. It is the intent of this thesis research to identify the factors that affect the level of service, putting an emphasis on the passenger's needs and perceptions, and to evaluate the LOS being provided at each airport. The research will enable airlines and airport authorities to improve the level of service of the baggage handling system in the most cost effective and timely manner.

1.8 Organization of Thesis

This final thesis report is organized into nine chapters. The first chapter introduces the reader to the topic of baggage handling at airports and explains the rationale behind this research topic. Chapter 2 illustrates the dramatic increase in travel demand since the beginning of air transportation and presents the current Canadian airport system. Additionally, the typical means with which baggage flows through an airport terminal and variations of the system are presented in Section 2.2. Chapter 3 summarizes the preliminary airport assessments that were conducted at the Dorval International Airport and the Ottawa Macdonald-Cartier International Airport. Chapter 4 defines level of service, discusses current level of service evaluation methods, describes the research plan and presents the proposed user-perceived level of service (UPLOS) model for baggage handling at airports. Chapter 5 describes the method of data collection and summarizes BHS characteristics of the participating airports. A summary of passenger characteristics and responses is provided in Chapter 6. Chapter 7 discusses the LOS provided to the passengers by the airport authorities, airlines and baggage handlers based on current space, waiting time and baggage delivery standards. The UPLOS regression model is presented and discussed in Chapter 8. Finally, Chapter 9 provides important conclusions and recommendations, and suggests possible future research work.

Chapter 2

2 LITERATURE REVIEW

2.1 Overview of Canadian Air Navigation

2.1.1 History Of Air Navigation

The field of air transportation began nearly 100 years ago, when the Wright brothers' attempted to fly. They were the first to accomplish the feat of flying in December 1903, when they used a motor driven plane (Legault 1960). The total flight distance recorded was 260 metres (850 feet), at a speed of less than 32 km/h (20 miles per hour) using a gasoline motor with less than 20 horsepower. Since that time, many advancements and records in the field of air transportation have been achieved. The following list highlights some of these accomplishments (Legault 1960).

1910 - World's record cross-country flight was 272 kilometres (169 miles).

1911 - Record for height was 3352 metres (11000 feet), and up to 12 passengers had been carried in one plane.

1918 - May 15: Inauguration of air mail service from New York City to Washington, D.C., with one stop in Philadelphia, a distance of 350 kilometres (218 miles). During 1918, 25744 kilometres (16000 miles) were flown over that route.

- 1919 – Flight from Chicago to Cleveland commenced. Shortly after a flight from New York to Cleveland started. Following that, flight was extended from Cleveland to Omaha.
- 1920 – September: Flight paths grew to include a route from Omaha to San Francisco.
- 1926 – 3,630,124 airplane kilometres (2,256,137 airplane miles) were flown that year; route mileage was 5788 kilometres (3597 miles).
- 1927 – The contracts for flying mail commercially were let on a competitive basis, when the U.S. Post Office Department withdrew from direct participation in the air mail operations.
- 1930 – Prior to this date, mail service lines did not carry any passengers.
- 1938 – An independent agency, the Civil Aeronautics Authority, regulated air carrier regulations. A 5-man board, called the Civil Aeronautics Board, was created in 1940 to fix rates for commercial carriage of mail and passengers. The administration of civil aeronautics was handled by the Department of Commerce under a Civil Aeronautics Administration (CAA). The Federal Aviation Agency (FAA), which was created by the Federal Aviation Act of 1958, replaced the CAA.
- 1939 – There were 13,772 registered civil aircraft and 30,000 student pilot certificate registrations.
- 1940 – More than 1.6 million passenger kilometres (1 million passenger miles) and 16000 ton-kilometres (10,000 ton-miles) of mail were flown on domestic routes.

- 1945 – There were 30,000 registered civil aircraft and 70,000 student pilot certificate registrations. A large increase from the numbers recorded in 1939.
- 1950 – 12.9 billion passenger kilometres (8 billion passenger miles) on scheduled domestic airlines were recorded.
- 1958 – The 12.9 billion passenger kilometres (8 billion passenger miles) recorded in 1950 increased to 39.7 billion passenger kilometres (24.7 billion passenger miles) on scheduled domestic airlines (Legault 1960).
- 1964 through 1984 - The number of Canadian passengers increased by 473%, while aircraft movements increased by 309% during the 20-year period (Statistics Canada 1999).
- 1980 – There were 70307 registered Canadian licenses (Transport Canada 1999) and 7,065,000 Canadian aircraft movements.
- 1990 – There were 70932 registered Canadian licenses (Transport Canada 1999) and 6,058,000 Canadian aircraft movements.
- 1997 – Airports Council International (ACI) recorded 1,317 million passenger trips, 28,836,000 metric tonnes of transported cargo and 33,911,000 airplane operations from North American airports (Airports Council 1998).
- 1998 – Airports Council International (ACI) recorded 1,346 million passenger trips, 29,452,000 metric tonnes of transported cargo and 34,336,000 airplane operations from North American airports (Airports Council 1998).

Annual passenger and aircraft movements in Canada and worldwide continue to increase. Airports and airlines must anticipate this increase in traffic and modify their air transportation systems accordingly. The Canadian government is seeking to improve service through commercialization of Canadian airports. The following section outlines the current Canadian airport system.

2.1.2 Canadian Airport System

The air transportation system within Canada includes 10 international airports and over 300 smaller commercial airports (Figure 2-1). Air Canada (who purchased Canadian Airlines during the conduct of this research) is the major level I carrier that travels both domestic and international routes. Together with smaller regional airlines, Air Canada links the entire country to other international route systems. Air Canada is a member of a strategic global alliance that includes other major international carriers, providing easy access to worldwide destinations.

On July 13th, 1994 Federal Transport Minister Douglas Young announced plans to commercialize federally owned, operated and funded Canadian airports (Transport Canada, 1995). The new air transport strategy focused on improving Canada's Air Navigation System and creating the National Airport Policy. "The federal government will maintain its role as regulator but will change its current role from airport owner and

operator, to that of owner and landlord” (Transport Canada, 1995). Under the new National Airport Policy, a National Airport System (NAS) was formed of Canada’s 26 largest and busiest airports. These airports, at the time of initiation, handled 94 per cent of all air passenger and cargo movements. They covered their operating expenses from earned revenue. Regional, local and small airports, many operating at a financial loss (with less revenue than expenses), handled the remaining 6 per cent of air traffic. In order to reduce the unfair burden on taxpayers, the National Airports Policy was created. The policy requires the formation of airport authorities whose mandate would be the financial

Figure 2-1: Canada's Major Airports

and operational management of the 26 Canadian airports within the National Airport System. Local community groups were also sought to own and operate the regional and local airports. The new strategy gives communities more control over the management and operation of their airports. However, aviation safety and security standards continue to be the responsibility of Transport Canada (TC). TC is accomplishing this through policy setting, transfer agreements, and certification and regulation of airports.

For continued operating viability and to ensure that those benefiting from the airport services pay their share of the cost, the operating authority has the option of introducing user fees and charges for capital projects. Table 2-1 summarizes the major Canadian Airports that are currently implementing a user fee, also known as the Airport Improvement Fee (AIF).

In 1994, Transport Canada owned, operated or subsidized 149 of 726 certified airports within Canada. These airports are divided into categories based on passenger numbers and location, which include the NAS, regional and local, small, remote and arctic airports.

Table 2-1: Summary of User Fees at Major Canadian Airports (Ottawa International 1998-1999b)

<i>Major Canadian Airport</i>	<i>AIF in place</i>	<i>Airline collection*</i>	<i>Amount</i>
Toronto	No		
Calgary	Yes	Yes	\$10
Dorval	Yes	No	\$10
Edmonton	Yes	No	\$5 - \$10
Vancouver	Yes	No	\$5 - \$10- \$15
Winnipeg	Yes	Yes	\$10
Ottawa	Yes	Yes	\$10

*As shown above, at Vancouver, Edmonton and Dorval, AIF's are collected directly from passengers at the airport, prior to departure, rather than included by the airline in the ticket fee.

(a) Airport Classifications

National Airport System

The National Airport System included the 26 airports that handled 94 per cent of air passengers and cargo in 1994 (Table 2-2). Although the operation, management and

development of the NAS airports has been given to local airport authorities, Transport Canada has retained ownership in order to ensure the continued integrity and long-term survival of the NAS.

Airports within territorial, provincial and national capitals are included in the NAS, as well as any airport with at least 200,000 passengers per year. Airports can be included in the NAS if the airport maintains a traffic level of at least 200,000 passengers annually for three consecutive years. If an NAS airport, other than the territorial, national or provincial capitals, does not maintain 200,000 annual passengers for three consecutive years, it could be removed from the NAS. Since the inception of the NAS, the airport in Sudbury, Ontario has been removed from the NAS, while Iqaluit, in Nunavut was added. The remaining airports have been divided into categories based on their location and size.

Regional and Local Airports

Airports that serve scheduled passenger traffic, but handle fewer than 200,000 passengers annually are classified as regional and local airports. Provincial and local governments, airport commissions, private businesses and or other interest, in that order, were offered ownership of these airports. Except for a specific warranted case, all funding was withdrawn from these airports as of March 31st, 2000. Operational management decisions at these airports are based on community needs and objectives.

Table 2-2: Airports within the National Airport System (Statistics Canada 1998)

<i>Airport Name</i>	<i>Enplaning &Deplaning Passengers. 1997 (1000's)</i>	<i>Airport Name</i>	<i>Enplaning &Deplaning Passengers. 1997 (1000's)</i>
Toronto	24808	Gander	101
Vancouver	14041	Kelowna	741
Calgary	7295	Quebec	629
Dorval	6592	Thunder Bay	485
Edmonton	3629	London	288
Winnipeg	3130	Prince George	267
Ottawa	2997	Moncton	226
Halifax	2624	Yellowknife	218
Mirabel	2104	Fredericton	203
Victoria	1039	Saint John, N.B.	191
Saskatoon	761	Charlottetown	173
St. John's, N.F.	756	Sudbury	166
Regina	753	Whitehorse	131

Small Airports

Transport Canada owned a total of 31 small airports that did not provide any scheduled passenger service. Many of these airports were used for recreational flying purposes.

These airports were sold to local interest groups and are no longer funded. It should be noted, however, that the small airports that served as satellites for international airports were offered to the same airport authority that took over operation of the international airport.

Remote and Arctic Airports

Remote airports provide year-round transportation service to isolated communities. The federal government will continue supporting the remote airports, while attempting to improve their operating efficiency. The operation of federal airports in the Arctic was offered to the territorial governments.

(b) Advantages and Disadvantages of the National Airport Policy (NAP)

The benefits of this new policy are numerous and are detailed in the information folder published by Transport Canada (Transport Canada, 1995). The advantages anticipated by Transport Canada include:

- ◆ Ensuring a safe, effective, efficient, and secure national airport system that is viable over the long-term.
- ◆ The cost of operating Canadian airports will be transferred from taxpayers to those people who actually benefit from the services provided by airports.
- ◆ Airports will be more responsive to the needs and objectives of communities and customers.
- ◆ Federal safety and security standards will ensure passengers are adequately served and protected.

Although the NAP presents many advantages to both airport customers and the general Canadian public, some disadvantages may have resulted from these changes. Reducing the standards imposed by Transport Canada may have affected the level of service provided by airport authorities to the customers. In terms of the operating facilities at airports (check-in counters, waiting areas, baggage handling, etc...) the level of service provided to a customer can vary from one airport to another and from one airline to another. Without knowing the level of service provided, a customer is unable to make an informed choice as to the most appealing mode of travel based on the true value of the service provided. With the deregulation of these operating facilities by Transport Canada, the user is unaware of the quality of service provided and subject to unwanted variation within the industry. A means of measuring the LOS provided will allow airports and

airlines to evaluate the prevailing LOS, enable passengers to make informed choices, and assist airlines and airports in improving and maintaining a reasonable LOS.

2.2 Overview of Baggage Handling Systems

2.2.1 Sequence of Baggage through Terminal

Regardless of the size of the airport, certain tasks must be carried out in order to transfer baggage from the passenger to the airplane and return it to the passenger in a safe and efficient manner upon arrival at the destination (Table 2-3). Although the sequence of activities required to transport the baggage is essentially the same for each airport, the methods used to accomplish this task can vary significantly from airport to airport. The sequence of activities used to complete the task varies for departing and arriving baggage.

The amount of luggage (also known as baggage) in the airport system at one time depends on many factors, including:

- ◆ the number of passengers departing from, arriving to and transferring at the terminal,
- ◆ the number of aircraft being serviced simultaneously,
- ◆ the trip purpose of the airport user (visitors have more luggage than business travellers), and

- ◆ the charge for overweight luggage.

Table 2-3: Baggage Travel Through Airport Grounds

<i>Departing Baggage</i>	<i>Arriving Baggage</i>
1 - Carry baggage to check-in desk	1 - Unload baggage from aircraft
2 - Tag and check-in baggage (weighing)	2 – Transport to terminal building
3 - Transport baggage to airside (conveyors)	3 - Sort transfer baggage from final destination baggage
4 - Sort baggage into flights	4 - Load final destination baggage onto reclaim device (conveyor)
5 - Assemble baggage into loads	5 – Forward transfer baggage to sort room or to waiting aircraft if it is on the apron
6 - Transport baggage to aircraft	6 – Reclamation of baggage by passengers
7 - Load onto aircraft	7 - Carry baggage away from claim device

2.2.2 Departing Baggage Handling System

At most airports four elements make up the outgoing baggage handling system. These elements are the baggage check-in, transportation to the baggage collection room, sortation and, finally, transportation to the appropriate aircraft.

(a) Baggage Check-in Counter

Passenger baggage check-in should occur as early as possible after entering the terminal building to minimize the distance that baggage is carried. This distance depends on the layout of the airport, appropriate and adequate signage, and the availability of curbside check-in, trolleys, and porter service.

Although off-airport baggage check-in locations are convenient for passengers, drawbacks of off-airport baggage check-in include (Ashford et al. 1984):

- ◆ the airline takes on a greater responsibility for the baggage because it gets checked-in by the passenger at a much earlier time (resulting in a greater chance of loss and delay), and
- ◆ a less economic use of staff as they are split between two or more check-in locations.

Individual passenger check-in times vary between 45 seconds and 3 minutes (Ashford et al. 1984). In order to reduce delays at the check-in counter and ensure a reasonable quality of service, any unusual request or problem is handled at a separate desk. Airlines without a separate desk for problems have found that lengthy line ups and long delay times result. Barriers are usually provided to direct the passengers into an organized queue, otherwise efficient flow of passengers throughout the terminal is compromised.

The number and weight of bags are verified at the check-in desk. Each airline has specific limits as to the number and weight of luggage being transported by each passenger. Once the maximum limits are checked and adjustment fees are charged for overweight and additional baggage, the airline employee at the check-in counter accepts the luggage from the passenger. At this point, the airline takes responsibility for the baggage.

Different baggage check-in counter configurations are used (Figure 2-2). The most traditional arrangement is a linear counter where travellers have access to one side while the different airlines have controlled access to the other side. A system of feeder conveyor belts, equipped with weighing scales, is located on the airline side. The number of feeder conveyors depends on the number of companies that are managing the baggage sortation and distribution within the airport facility. On one extreme, a single ground handling company, such as Hudson General Aviation Services, can be used to manage all baggage transportation needs at the airport. On the other extreme, each airline can manage their own passengers' baggage. The feeder belts deliver the baggage from the check-in desk to the mainline conveyors.

(a) Linear.

(b) Island.

(c) Flow-through.

○ Passenger and baggage

☆ Airline employee

Figure 2-2: Typical check-in counter configuration (Horonjeff et al. 1994)

One advantage of this linear arrangement is good visual presentation. However, the waiting lines required for this arrangement lead to an inefficient use of terminal space. Passengers that have been served must usually cut through the lines of waiting passengers in order to continue their trip through the terminal.

Another type of check-in counter is the island type. It is arranged such that the airline personnel are back-to-back with a conveyor belt between them, thus the conveyor belt is more efficiently loaded from both sides. As with the linear arrangement, passengers attempting to leave the check-in area are constantly interfering with those passengers still awaiting check-in service. The configuration with the least amount of congestion between waiting and leaving passengers is the flow-through method. Two airline employees are stationed beside each other with a conveyor belt on their opposite sides. The passengers are on the far side of the conveyor belt from the airline employee. The passengers move in the direction of their baggage until they reach an employee, proceed with the check-in and then continue in the same direction. The passenger, and not the airline employee, is required to lift the luggage onto the conveyor, thus reducing the amount of physical labor required of the airline employee. Backtracking is unnecessary and passenger conflicts (and congestion) are reduced. The halls for check-in are required to be deep and thus such a check-in configuration must usually be built into the original terminal design.

(b) Current Baggage Tag Technology

At present, laser scanners and bar codes are the normal method of baggage handling at airports. A new technology is radio frequency tags (RF). The International Air Transport Association (IATA) has standards for the RF tags that were approved in October 1999. The RF technology costs about \$1.00 per tag, whereas the more common barcode tags cost only \$0.03 to \$0.05 per tag. The polypropylene barcode tags are very durable and thus, are not often torn off the bag. It is more likely that the entire handle, possibly in a damaged condition pre-flight, will be separated from the bag. Air Canada spends \$15 to 17 million annually on the commonly used barcode tags. United Airlines handles about 7 times the amount of luggage and thus, expends about 7 times as much in cost.

The barcode on the baggage tag always contains ten digits. The first digit refers to whether the bag remains online or transfers to another airline. The next three digits are the airline code (for example '014' represents Air Canada). The final six digits represent numbers 1 through 999999 and are assigned in numerical order across Air Canada, to each item of baggage as the ticket is printed. No two baggage items will be assigned the same number until the 999,999 numbers have been assigned, then the numbers repeat again. Air Canada ticketing agents are all equipped with automated printers that print the next bar code number directly onto the ticket. For those airports that use the new RF tags, the tags have the signal and chip embedded in the ticket during manufacturing. The

printers then imprint a bar code onto the RF tag so that airports without the advanced RF technology can still read the tag in the usual manner with laser scanners.

Laser scanners are about 95% successful in reading the bar code on the initial read. The sorting machines are then 80% to 90% successful in sorting the baggage to the appropriate pier. For the baggage that is unsuccessfully read on the first pass, the baggage is recirculated to the laser scanners and is generally read without difficulty. For connecting (transfer) baggage that has been previously read at another airport, loaded, and unloaded, the read is only successful 50% to 60% of the time, as the bar code becomes more worn or crumpled. Effort has been made recently to improve the readability of the bar codes.

RF technology, although promising, has one major drawback – the ticket price. Until the baggage tag price is reduced considerably, RF technology will not grow rapidly in the airline industry. The initial equipment to read the RF tags requires a certain cost, plus the modifications required at the check-in counters cost a small amount. The cost to implement the new system at all of Air Canada locations is in the area of \$ 2 to 3 million. The cost of RF scanners is in fact one-tenth ($1/10^{\text{th}}$) the cost of laser scanners. This total cost is not large, compared to the price of baggage tags. Before RF tags are used on a large scale in airports, they will have to be introduced first by delivery companies that require many more of them. Through the increased use of RF tags by package delivery

companies (such as Fed Ex), the tag price will drop considerably, making their use at airports more viable.

(c) Transportation to the Baggage Collection Room

Baggage is generally transported to the baggage room directly from the check-in area, along the system of conveyor belts used at the check-in counters. Irregular items, such as strollers and hockey or golf bags, are manually carried to the sorting room. Once in the baggage room, the luggage is sorted to bag carts or containers that will later be transferred to the waiting aircraft. Baggage in carts must be loaded onto and unloaded from the plane individually, whereas luggage within a container (also known as a can) remains in the can and the entire can is transferred onto the plane at the origin and off the plane at the destination. From 20 to 40 average sized bags can be placed in a container.

There are three means of sorting baggage: manual, semi-automated and fully automated. Manual sorting is often carried out using a single conveyor belt. If this belt fails, system wide delays can result. When designing an airport ground transfer system, the potential for breakdown should be considered. By having two belts servicing the check-in counters, some counters can remain operational in the event that one belt is out of commission. At large airports, a racetrack shaped conveyor belt can be used for manual

sorting. The linear conveyor belts lead to the racetrack where numerous employees are engaged in sorting the baggage.

Semi-automated systems, as the word suggests, use both manual and computer methods to sort baggage. A manned computer reads the baggage tags (either the tag code is manually fed into the computer or a scanner reads the code). The computer then instructs a pulley arm to direct the baggage to a certain area for future manual sorting, if required, and loaded onto carts.

Automated systems are commonly used for departure baggage, which reduces labor cost and misdirected baggage, and increases the speed of transit through the terminal building. A computer recognition code is included on the baggage tag. The computer reads the tags and directs the baggage to the appropriate plane for manual loading onto the flight. Using the automated system, the baggage is lead directly from the check-in point to the required aircraft without manual interference. At the Frankfurt Airport in Germany, the automated system uses 40 km of track.

(d) Baggage Sort Room Concepts

Three types of baggage sorting areas are used within airport terminals and are most often determined during the terminal design process. In a centralized airport such as Chicago

O'Hare, Manchester or Amsterdam, there are one or more main baggage rooms.

Extensive sorting systems are required to serve the large amount of baggage being processed, however, manual labor in this type of system is well utilized. Airports such as Kansas City and Dallas/Fort Worth have decentralized sort and storage rooms, each leading to a few gates. These systems have a lower demand for sortation, but require more manpower over the course of the day as employees cannot be used as efficiently during off peak periods. A remote bag room is a third choice of sorting area and is used at the Atlanta airport. Where much of the baggage is being transferred from one aircraft to another, a remote room allows baggage sortation to be carried out away from the main terminal building, thus reducing the turnaround time for aircraft by removing the travel time that would otherwise be required to and from the terminal building.

2.2.3 Inbound Baggage Handling System

The baggage claim area varies greatly in size depending mainly on the amount of available space, the number of aircraft operations anticipated daily and at the peak periods, and the number of passengers expected within the area at one point of time.

Visitors within the baggage claim area have been found to cause congestion and result in an inefficient baggage claim area (Ashford et al. 1984). Some airports, such as Terminal 2 at Lester B. Pearson International Airport in Toronto, ban all visitors from the baggage claim area for security and efficiency.

There are four main claim devices used to transfer luggage from the airside of the terminal to the passengers (Figure 2-3). Linear counters, which are a non-mechanized method, are used at small airports where there are low passenger flows. The linear counter is essentially that, a counter whose length depends on available space. The baggage is placed on the counter and passengers come in turn to claim their luggage. The baggage does not move, as it would on a mechanical claim device. For larger airports with higher passenger flows, linear conveyors are used. As passengers gather in front of the conveyor, baggage moves past the passengers. Any unclaimed baggage is stored at the end of the conveyor. There is no mechanical means of returning the baggage from the end of the conveyor to the starting point so that it circulates past the passengers for a second time. For yet larger and more modern airports, carousels and racetracks are used. These two baggage claim devices circulate baggage continuously until the passengers have collected all the baggage. The racetrack, or flatbed, conveyors are horizontal devices that can vary greatly in length, width and overall layout. They are loaded from behind a secure wall by airline employees. The carousel devices carry luggage on inclined, flat surfaces and circulate baggage in a circular or elliptical pattern. The baggage is loaded by airline employees onto a flat, horizontal remote conveyor, which then feeds the luggage onto the center of the carousel. This arrangement has a greater area for claiming luggage by allowing passengers to gather on all sides of the carousel,

Figure 2-3: Typical Reclaim Devices

unlike the racetrack conveyors that are fixed against a wall at the loading point. Except for the linear counter, the baggage moves while the passengers remain stationary.

The linear conveyors and racetracks are designed as a flatbed device with a moving belt. The belt is generally between 0.8 and 1.0 m wide and elevated about 0.5 m above the floor. They can flow in almost any pattern around the reclaim area. The maximum speed for such devices is about 0.45 m per second, which allows passengers a reasonable amount of time to gather their luggage. The calculation used to compute the maximum number of bags that can be displayed on any conveyor assumes that no bags are removed by passengers during the loading process. In normal operation, it is assumed 20 bags/minute can be loaded onto a device.

2.2.4 Performance of Operating Systems within the Terminal Building

(a) Check-in Counter

In order to determine the level of service provided to passengers at the check-in counter, two criteria are commonly used. The number of people or length of the waiting should be recorded. Ashford et al. (1984) determined that no more than five passengers should be in the check-in line at one time. The second important criterion is the total amount of time

that passengers spend at the check-in area. An acceptable waiting and processing time, used by airlines for performance measurement, is five minutes.

Baggage can be misdirected or damaged because of errors or omissions made by airline employees or the passenger at the check-in counter. In order to reduce the number of mistakes made at this point and to reduce the chance of damaged and lost luggage, airlines and passengers should ensure that the following items are verified (Ashford et al. 1984).

- ◆ The correct final destination is on the tag.
- ◆ The correct interline and transfer tags are used.
- ◆ Any packages with fragile contents are well labeled.
- ◆ All bags received in damaged condition are suitable marked as to their condition pre flight.
- ◆ All heavy bags should be so labeled so as to reduce injury or strain to staff when the bags are lifted.
- ◆ Adequate external and internal owner identification should be on all bags.

By ensuring that the above items are satisfactorily accomplished, the number of lost and damaged bags can be minimized and the performance of the baggage handling system increases.

(b) Ground Transfer Facilities

This area of the baggage handling system includes the sortation system, transportation of the baggage to the aircraft, loading onto and removal of the baggage from the aircraft and transportation of the luggage to the baggage claim devices. The performance of the ground transfer facilities can be evaluated by recording the number of mishandled, damaged, and lost bags per flight, per airport or per airline. The number of mishandled, damaged, and lost bags is generally recorded per 1000 bags handled. Airlines then compare the achieved value with the target value of mishandled, damaged, and lost baggage to determine if the quality of service provided by the baggage handling system is increasing or decreasing.

(c) Reclamation of Arriving Baggage

A large number of passengers can be thrust upon the reclaim area during a certain period of time. The total number of passengers present is affected by such factors as the time of day, week or year; the number of aircraft landing; and the aircraft's future destinations (amount of transfer baggage). The speed with which the reclaim area can process passengers greatly affects the overall performance of the baggage handling system and the level of service given to the passengers. Thus, by maximizing the performance of the

reclaim area, the passenger's perceived level of service will increase. The factors that influence the performance of the reclaim area include (Ashford et al. 1984):

- ◆ the airport layout,
- ◆ the density of airside ground traffic,
- ◆ the baggage handling equipment, and
- ◆ the availability and allocation of baggage handling personnel.

None of the above variables consider the performance felt by the passenger. The performance provided by an airline and the passenger's perceived performance can vary greatly. As an example, the airport in Kansas City boasts a short walking distance from the aircraft to the reclaim area. A passenger can wait a noticeable amount of time for luggage to arrive at the carousel, even if less than 10 minutes it may be unpleasant. To the passenger, the 10 minutes taken for baggage to arrive might provide poor service. On the other hand, the Paris Orly airport and the Atlanta airport have longer walking distances. Thus, the baggage might take longer than 10 minutes to arrive, but since the passengers also took longer, the level of service may seem higher. This demonstrates how the level of service is greatly influenced by both the quality of service and skill displayed by the baggage handling company, and also by the airport layout. Thus, an important consideration is the difference in time between the arrival of the baggage and the arrival of the passengers. As another example, the International Terminal 3 at Heathrow's airport also has a great distance between the aircraft and the reclaim area. The first passenger

might take 15 or 20 minutes to reach the baggage claim area and find luggage already waiting. However, previous studies have indicated that from a passenger's point of view, the service at Heathrow airport is perceived as better than at the Kansas City airport, when the baggage handling system could in fact have been slower (Ashford et al. 1984). Both the passenger's walking distance and the speed of delivering baggage must be balanced to optimize the level of service provided by the reclamation segment of the overall baggage handling system.

For international airports, a delay to the passengers through customs procedures actually provides more time for baggage to be delivered, while still retaining a good level of service perceived by the passenger. The level of service (LOS) felt by the passenger varies from airport to airport depending on the distance and time required for the passenger to reach the reclaim area, while from a baggage point of view, LOS depends on airport layout and handling equipment. Because of such occurrences, passengers often place their blame for delays in the wrong hands due to this system of components that must work together to provide an acceptable level of service.

Performance of the reclaim area should be measured by recording such variables as:

- ◆ time taken to unload the first and last bags,

- ◆ the percentage of bags delivered to the reclaim area within a set amount of time (regardless of the amount of time taken by the passenger to reach the reclaim area), and
- ◆ the number of lost, stolen and misdirected bags.

Performance monitoring charts for baggage delivery, showing percent of baggage versus time to unload, are a good visual means of presenting the amount of baggage delivered within a set number of minutes. According to Ashford et al. (1984) 80% of baggage should be on the reclaim belt within 14 minutes of arrival and 92% should be on the reclaim belt within 22 minutes. Although the unloading time is related to the size of the aircraft, other factors also play a role. A British survey found that the unloading time can vary considerably, even between identical aircraft with similar loads (Ashford et al. 1984). Thus, the size of aircraft alone is not a good indicator of performance. However, Air Canada uses the aircraft type to set standards for unloading times and thus to determine performance. Clearly, a more accurate identifier or combination of variables should be used.

2.2.5 Security and Baggage Handling

Among the objectives and concerns of the security system personnel at an airport are the investigation of bomb threats, the seizure of drugs, unlawful money transactions, and

illegal immigration into the country. Some of these activities occur through the use of the baggage handling system and are facilitated by an inadequately managed and poorly supervised system. To ensure complete airport security, the Federal Aviation Administration (FAA) is focusing, as usual, on passenger screening, but also on the total airport system which includes (Hamory, 1992):

- ◆ Drop-off and pick-up of passengers
- ◆ Parking lot areas
- ◆ General aviation locations
- ◆ Cargo/maintenance areas
- ◆ Access controls
- ◆ Perimeter security
- ◆ Passenger and cargo screening areas, and
- ◆ Physical separation of screened and unscreened persons

In February 1990, the International Civil Aviation Organization (ICAO) published a security “problem checklist” (Hamory, 1992). Listed below are some of the security concerns that affect the baggage handling system at airports and which are being addressed in the United States.

- ◆ A comprehensive screening process for checked baggage.
- ◆ The screening of passengers and hand baggage.
- ◆ The achievement of full and reliable reconciliation of passengers and their baggage.

- ◆ The security problems faced by cargo, mail, and courier services.
- ◆ The problem of controlling access at airports.

The U.S. is implementing such measures through intensive interviews, X-ray of all baggage, metal detection devices, cataloging all electronic equipment on board, complete match between passengers and baggage, screening of cargo, and controlled access to aircrafts for international flights.

By initiating these measures, the baggage handling system is greatly affected. The process of interviewing passengers lengthens the required service time at the check-in counter, causing congestion and negatively affecting traffic flow through the terminal. In order to screen baggage that is being placed in the hold area, screening devices must be placed at the check-in counters. This is the most appropriate location because the passenger is present during screening and can remove and display questionable items in the baggage. Yet, this process has space requirements and causes congestion.

The goal of matching passengers to baggage is possible when passengers remain on-line (remain with the same airline) and/or are originating (beginning their trip). The advantage of on-line passengers is that the passengers' information (identification and flight plan) is already in the computer system. The difficulty arises with interline passengers, those that transfer from a different aircraft and a different airline. Until a common tracking and

identification system is used by *all* airlines, the ability to match 100 percent of the baggage on the aircraft with the passengers on that aircraft is impossible to achieve.

Due to increased travel demand and subsequently inadequate capacity, major modifications were recently undertaken at the Manchester International Airport. A new terminal complex was built at the airport and some added systems were incorporated into the design to ensure compliance when and if new regulations were implemented in the future. The newest terminal, Terminal 2, was designed to include a screening device allowing 100 percent of the baggage entering the aircraft hold area to be screened (Muirhead, 1992).

Hamory (1992) stated that “we must continue our efforts to push the envelope of technology in such areas as explosives detection, access controls and computerized baggage match”. By improving our baggage matching capabilities, airlines will be able to reduce the number of mishandled bags and improve the level of service provided to the clients. A computer system could notify the airline prior to the flight if a passenger was on board without his or her baggage and whether there was baggage on board without a passenger. This would reduce misdirected bags considerably, reduce airline costs, and would ensure, from a security point of view, that no baggage was being transported without an owner.

With a matching system in place, any baggage that gets accidentally left behind or was not loaded due to space limitations can be summarized and presented to the airline. The passengers that are without baggage due to these circumstances can be informed of the situation during the flight. This ensures that the passenger is not looking for baggage on the claim device upon arrival, when the baggage is not there. This reduces passenger anxiety and frustration, and improves the quality of service provided. Thus, by improving airport security, the baggage handling system and the LOS provided by the baggage handling system are affected in both beneficial and non-beneficial ways.

On Tuesday September 11, 2001 horrendous acts of terrorism occurred in the cities of New York and Washington in the United States of America. More than 5000 people, including aircraft passengers, flight attendants, pilots and individuals on the ground, were killed when four hijacked aircraft crashed into the World Trade Center, the Pentagon and a rural field in Pennsylvania (near Camp David, the Presidential retreat). Following the collision of two aircraft into the World Trade Center, both towers fell to the ground killing numerous building occupants and emergency workers. Even with the security measures currently in place at airports, the simultaneous hijacking of four aircraft was accomplished successfully. Albeit that these four aircraft amount to a very small percent of the total number of flights departing and arriving in the United States annually, people are now more hesitant to travel by air. Clearly, the security measures in place are inadequate and must be revised to ensure such events cannot be repeated. Specifically,

the check-in security screening of both baggage and passengers must be improved. The revised measures must be implemented in such a way as to alleviate passenger anxiety without causing excessive delays.

One measure that could be implemented for improved security is the reduction in the allowable amount of carry-on baggage. With this reduction, passenger security screening could be conducted more thoroughly, without increasing the waiting time required. This measure would result in a greater amount of checked baggage, affecting both outbound and inbound baggage handling systems. Without making changes to the current systems, an increase in the amount of checked baggage would result in longer waiting times, more misplaced baggage and a lower level of service. In the first week following this very unfortunate tragedy, passengers have indicated that they are willing to tolerate longer waiting times. At this time, it is important to determine exactly how a passenger's perception toward the waiting time has been affected. Additionally, it is imperative to determine all variables that influence a passenger's perception of the level of service provided by the baggage handling system. Now, more than ever, the passenger's perception of the baggage handling system needs to be investigated to ensure airlines and airport authorities implement changes that are perceived by passengers as important and effective. This research has provided a framework for the evaluation of baggage handling systems and can assist in assessing proposed changes to airport security systems.

Chapter Three

3 CURRENT STATE OF AIRPORT BAGGAGE HANDLING SYSTEMS

Two airports were visited to conduct the preliminary assessment of the baggage handling systems and to observe deficiencies in the current systems. The following sections describe two airports in the national airport system and compare their baggage handling systems. Subsequently, a more comprehensive study was conducted at six Canadian airports to collect data pertaining to the actual service provided by the BHS and the service as perceived by the passengers.

3.1 Montreal's Dorval Airport

Montreal's Dorval Airport is situated approximately 20 minutes west of the City of Montreal, in the City of Dorval. As determined during the 1996 census (Statistics Canada 1996) the city of Montreal had a population of 1,016,376, and the census metropolitan area had a population of 3,326,510. According to Airports Council International (ACI), whose member airports account for over 90 percent of all North American air traffic, Dorval airport ranked 44 out of 154 airports in terms of the number of passengers carried. Dorval airport provided air transportation for 7,913,859 passengers during 1998. The airport had 209,173 airplane operations during that same year, ranking it 59 of 159 airports in greatest number of operations. (Cargo airports have operations, but do not

carry passengers, and thus a larger number of airports were compared in terms of operations.)

Two different companies undertake the baggage handling at Dorval airport. Hudson General Aviation Services handles baggage for all airlines except Air Canada, while Air Canada has company employees operating their baggage handling system. Air Canada was contacted and the information gathered was used as an initial study for this research. The following information was obtained from an interview with two Air Canada personnel familiar with the baggage handling systems at airports and from a tour of the baggage system at Montreal's Dorval Airport, conducted by an Air Canada employee.

3.1.1 Departure and Arrival Sequence

International and domestic passengers are separated from transborder passengers at departures. Domestic and international passengers give their baggage to the airline at check-in, whereas transborder passengers retain their baggage until they have passed through the U.S. customs and immigration. After successfully clearing these facilities, the passengers put their baggage on a conveyor and proceed to the transborder departure lounge. Departing passengers enter the aircraft using one of the boarding gates available.

Upon arrival at Dorval Airport, the international and transborder passengers proceed through customs and then claim their baggage on one of six available conveyors, including four racetrack style conveyors and two flatbed conveyors. For domestic passengers, there are two flatbed style conveyors available for baggage claim.

3.1.2 Air Canada Baggage Restrictions

The following are the weight and number restrictions imposed by Air Canada.

- ◆ Each passenger is allowed two carry-on items with size and weight restrictions.
- ◆ Each passenger is allowed 2 checked items.
- ◆ Neither checked item can exceed 32 kilograms (70 pounds).
- ◆ The sum of the three dimensions (length, width, or height) of the baggage cannot exceed 157.5 centimetres (62 inches).
- ◆ The cost of additional bags or overweight bags varies with the destination. For example, for a one way trip from Toronto to Vancouver the cost is \$45 plus taxes per piece one way. For a one way trip from Toronto to Montreal the cost is \$25 plus taxes per piece one way.
- ◆ For international flights it also varies with destination. It could be as high as \$175 per piece, one way.

3.1.3 Sorting Method

At Canadian airports, Air Canada (AC) operates their own baggage sorting and distribution systems. At points outside of Canada, AC contracts the work to the local baggage handlers. Air Canada baggage handling at larger airports, like Montreal and Toronto, is semi-automated with piers. The very small ports still use manual sorting. With scanners, the baggage tag is scanned and read by a computer. The computer sorts the baggage to the appropriate pier. At least one person is at the end of each pier in order to transfer baggage onto the carts or into the cans. At busy times, more than one person is operating on each pier.

Once the baggage tag is issued at check-in, a baggage source message (BSM) is sent to the baggage room computer. The information on the BSM includes name of passenger and trip itinerary. The BSM informs the computer in the sort room that a certain bag will be coming shortly. When the scanner in the sort room reads the tag number, it recognizes that the number is associated with a specific trip and passenger and directs the baggage item to the correct pier for loading. A baggage transfer message (BTM) is used between airlines to inform carriers when a certain item of baggage is being transferred from one airline to another. BTM's are currently used by six or seven airlines. A BSM is used within one airline, whereas the BTM will be inter-airline. After the baggage is sorted to the appropriate pier, the baggage handler is still supposed to manually check the tag to

ensure that the baggage is being loaded onto the correct flight. The purpose of this check is to catch baggage that was incorrectly sorted following scanning. Upcoming equipment changes include hand held scanners in the baggage room so that handlers would scan the baggage instead of manually reading it. Manual reading is subject to a greater chance of error than the scanners.

Containers are not used on small planes because of space restrictions and awkward locations for baggage storage (tail of plane or at rear of passenger seating area). Air Canada uses containers for the Airbus A320 and any larger planes. For example, the A320 holds 132 passengers and seven containers for luggage. The DH-8 (37 passengers) and the DC-9 (90 passengers) do not have hold areas for containers and are instead bulk loaded. For planes that use containers, the container is designed for the hold area of a specific plane and thus cannot be transferred from plane to plane. The material for fabrication is variable and can be plastic or metallic. Some planes carry one container across the entire width of the plane (A320) while other planes fit two cans across the body of the plane.

Air Canada has recently put an emphasis on more efficient airplane usage. A result of this is that the aircraft are flying more hours and the connection times have been minimized. Thus, the time frame available to transfer baggage from the arriving flight to the connecting flight has been shortened. Pilots must consider that the aircraft might miss its

allotted landing slot at the arrival destination if the aircraft waits for the luggage. Pilots have to decide whether they should take-off without the transfer luggage, which would affect only the luggage owners, or wait for the luggage, thus causing delays to all aircraft passengers upon arrival. On-time performance versus the number of bags being mishandled (by missing the connecting flight) must be considered. However, subsequent to the events of September 11th, 2001 (terrorism attacks in the United States) it is possible that airlines will ensure 100% baggage match between passengers and baggage such that no item of baggage will travel without the owner on board the aircraft.

3.1.4 Standards for Delivery Times

(a) Priority Baggage

The priority baggage must be the first baggage unloaded from the aircraft 100% of the time. All priority bags must be available to the passenger before any other baggage. The time target for priority baggage is that 90% of the time all the priority bags must be on the belt within the time frames shown in Table 3-1.

(b) Regular Baggage

For regular baggage, the time target is such that 90% of the time all regular baggage must be on the reclaim belt within the time frames shown in Table 3-1.

Table 3-1: Summary of Aircraft Unloading Standards

<i>Type of Aircraft</i>	<i>Standard Timeframe for Unloading Baggage</i>	
	<i>(Minutes after wheelstop)</i>	
	<i>Priority Baggage</i>	<i>Regular Baggage</i>
B747 / A340	< 15	< 30
A319 / A320 / B767	< 12	< 20
DC9	< 12	< 17
CRJ	< 12	< 15

3.1.5 Tracking Mishandled Baggage

Recovery of lost luggage is done with the use of a software system created by Société Internationale de Telecommunications Aeronautiques (SITA), which is a non-profit organization that designs, owns and supplies computer software and systems to airlines. Air Canada, along with 350 other airlines worldwide, buys the right to use the software from SITA. It is better for one common system to be used globally; otherwise you could not trace luggage that was transferred accidentally from one airline to another airline.

Luggage that was left unclaimed on the reclaim device and baggage that does not arrive on the reclaim device is traced at the airport for five days. The tracing system attempts to

match the found (unclaimed) baggage with the passenger claims for missing baggage. If, after 5 days, an owner for the found (unclaimed) baggage cannot be located, the baggage is sent to the central office in Montreal for a more detailed search. When, after extensive searching and a waiting period of roughly three months (or four months if space is available in the warehouse), the owner cannot be found, the luggage is sold to a company that deals with this commodity. Items (not necessarily checked baggage) that have been left behind by the passenger in either the airport terminal or the aircraft (but not mishandled) are also sold after three or four months, depending on storage availability. However, items such as eyeglasses, clothing and books are given to charities. Many strollers were evident in the warehouse in Montreal, indicating that people often leave behind items that are not typical.

3.1.6 Records of Mishandled Luggage

When luggage is mishandled, Air Canada records the claim report within the SITA system. Each item registered receives a unique report number and a full description is input into the system including flight itinerary, owner's name and contact information, and a bag description. The SITA system is able to search all records within the system and identifies possible matches. Any matches are reviewed more closely in the hopes of obtaining a positive match. If the baggage is not found within 48 hours, more information, such as the contents of the baggage is then input into the system.

For Air Canada, about 1% of all luggage handled is misplaced. This luggage is mostly delayed for 2 to 24 hours. Of this 1% mishandled luggage, 99% of it usually gets returned to the passengers. Only 1% (of the 1%) actually doesn't get returned to the passenger. As an example, assume 1.0%, or 10 in every 1000 bags handled are mishandled. Of these claims, 97% are dealt with within 48 hours. Another 2% are dealt with within the next week. Only about 1% is not retrieved and returned.

Air Canada uses an average cost per misplaced bag to estimate the overall cost required to cover claims resulting from misdirected bags. The value used by AC is estimated from experience and averages the legitimate claims where baggage was lost, stolen, damaged, delayed, or otherwise misdirected with any fraudulent claims. There is a maximum amount, under the Warsaw convention, that claims can cost an airline. For international flights, the maximum that an airline will pay for lost luggage is \$634.90 US. Flying within, to, or from the United States, a passenger can be reimbursed \$1,200 US. The Warsaw convention also has a weight limit of \$20 US per kilogram (\$9.07 US per pound) to a maximum of 32 kilograms (70 pounds) (Brahmam, 1999).

For internal measurements, when calculating the number of bags lost versus the number of passengers carried, the mishandled interline baggage is first removed. This is because airports are held responsible for mishandled baggage that is within their control and it is not easy to determine who is at fault when interline baggage is mishandled. A "Reason

for Loss Code” is used for each unclaimed item in order to place the blame in the right place. Table 3-2 shows the loss codes used by Air Canada, allowing them to distinguish between such mistakes as tagging errors made at the check-in counter, and errors made when sorting or loading the luggage.

Different airlines, especially U.S. Airlines (due to lack of common standard for measuring) calculate their amount of mishandled luggage differently from Air Canada. Some airlines remove all interline baggage before calculating the total number of mishandled bags. Yet others do not enter the missing luggage reported by a passenger if the airline has already been informed by the previous airport destination that the bag did not make it on the flight. Thus, the baggage *was* mishandled, but not reported. Yet other airlines keep two records of reported losses. One record is on a local computer. The other is on the SITA system. This is because most lost luggage arrives on the subsequent flight. The airline can therefore wait until the next flight comes in, check the luggage and any items still missing are input into the SITA system. This gives the airline a very low level of mishandled luggage, but makes it difficult for one airline to be compared against another.

Table 3-2: Air Canada Reason for Loss Codes (Air Canada 1998)

<i>Code Category</i>	<i>Code No.</i>	<i>Reason for Loss</i>	<i>Point of Error</i>
Tagging Errors 10	11	Incorrect or no entries made on tag/old tag not removed	Originating
	12	Bag not checked to final destination	Originating
	16	Passenger rerouted from one AC flight to another AC flight	Boarding
Short- Shipped 20	21	Bag correctly tagged but left-off (at station of origin only)	Originating
	22	Bag received late from check-in	Originating
	26	Not carried due space/weight restrictions	Originating
Loading 30	31	Bag loaded wrong container, aircraft or flight	Loading Station
	32	Through baggage off-loaded in error	Transiting
	33	Baggage not off-loaded and over-carried	Transiting
Arrival Baggage Delivery 40	41	Bag delivered to wrong claim area	Terminating
	43	Bag delivered late to claim area	Terminating
Transfer Baggage 50	53	Online misconnection (AC and Connectors)	Connecting
	54	Interline misconnection	Connecting
	56	Passenger failed to claim/clear bag at Customs	Connecting
	57	Star Misconnection. Any misconnections or identifiable errors (such as tagging, loading, left-offs, & No-shows) from/by a Star Alliance Member	Connecting/ Origin of AC travel
(Table continued on following page.)			

<i>Code Category</i>	<i>Code No.</i>	<i>Reason for Loss</i>	<i>Point of Error</i>
IROPS 60	61	Mishandling due labor dispute/ slowdown	Station with Problem
	62	Mishandling related to irregular operations (IROPS) due weather	Station with Problem
		Airport power outages	Station with Problem
Miscellaneous 70	65	Belt jams and baggage system breakdowns	Station with Problem
	72	Bag checked but passenger did not travel	Boarding
	73	Passenger did not see delivered baggage	Terminating
	74	Bag switch (Bag taken by another passenger)	Terminating
	75	Employees rerouted without bags	Originating
	76	Bag found without tag	On-Hand Station
	77	Identifiable errors by other airlines (such as tagging, loading, left-offs, and no-shows)	Origin of AC Travel
	78	Reason for mishandling not detectable (to be used as a last resort only)	Originating
Damage 80	80	Damage to baggage	N/A
	81	Damage to wheelchair	N/A
Pilferage 90	90	Pilferage	N/A

3.2 Ottawa Macdonald Cartier International Airport

3.2.1 General Overview

The Ottawa Macdonald-Cartier International Airport is located 10 km (6.2 miles) south of the city of Ottawa at an elevation of 114 metres (374 feet). As determined during the 1996 census (Statistics Canada 1996) the city of Ottawa had a population of 323,340 and the census metropolitan area of Ottawa-Hull had a population of 1,010,498. The airport observed 3,110,548 passenger movements and 77,202 aircraft operations during 1998. Table 3-3 lists the airlines that operate out of the Ottawa airport and the destinations these airlines travel to.

On February 1, 1997, the Ottawa International Airport Authority officially assumed operation and control of the Ottawa Macdonald-Cartier International Airport. They signed a 60-year lease transfer agreement that included a renewal option for an additional 20 years of operation.

The Airport Authority became incorporated as a not-for-profit company without shareholders. Based on the Bylaws, a 15-member Board of Directors was created. The directors are nominated by the federal and provincial governments, the City of Ottawa (formerly known as the Regional Municipality of Ottawa-Carleton), La Communaute

Urbaine de L'Outaouais, and with input from the Ottawa-Carleton Board of Trade, Ottawa-Carleton Economic Development Commission, and the local chambers of commerce (Ottawa International 1998-1999a).

Table 3-3: Airlines Operating at the Ottawa International Airport (Ottawa International 1998-1999c)

<i>AIRLINE</i>	<i>DIRECT FLIGHTS TO:</i>
Air Canada (AC) (Air Alliance, Air Nova, Air Ontario)	Toronto (City Centre & Pearson), London ON, Thunder Bay, Winnipeg, Regina, Edmonton, Calgary, Vancouver, Montreal (Dorval), Quebec City, Sept-Îles, Fredericton, Halifax, St. John NB, St. John's NF, Wabush, Boston, Chicago (United Airlines Code Shared UA), Newark (Continental Airlines Code Shared CO), Washington Dulles (United Airlines Code Shared UA), London (Heathrow)
American Airlines (AA)	Chicago, St. Louis
Bearskin Airlines (JV)	North Bay, Sudbury, Thunder Bay
Business Express (DL) (Delta Connection)	Boston, New York-LaGuardia
CANADA 3000 (MM)	Vancouver, London (Gatwick) UK
Canadian Airlines International (CP) (Canadian Regional)	Toronto, Kingston ON, Calgary, Vancouver, Victoria, Quebec City, Halifax, St. John's NF, Raleigh-Durham, NC, London (Heathrow)
Continental Express (CO)	Newark

First Air (7F)	Montreal, Cambridge Bay, Iqaluit, Kuujjuaq, Nanisivik, Resolute, Yellowknife
Northwest Airlink (NW) (Mesaba Airlines)	Detroit
Royal Airlines (QN)	Cancun,* Puerto Vallarta,* Varadero*
Trillium Air (PD)	Kitchener, Waterloo, Ontario
US Airways (US) (US Airways Express)	Philadelphia, Pittsburg

Note: Direct flights may include an enroute stop but not an aircraft change.

* Denotes seasonal service

A comprehensive master plan was created to guide the airport through the next decades, ensuring an economically viable airport with sufficient space requirements for the air travel demands. An analysis of the air terminal building was undertaken, which revealed the need for extensive terminal renovation and expansion (Ottawa International 1998-1999d). The report suggested that a northerly expansion of the terminal was the best option. Included in this expansion is a need for a greater number of gates. The airport is currently equipped with 19 gates, but studies have found that 23 gates are needed to accommodate the increasing air traffic at the Ottawa Macdonald-Cartier International Airport.

During the creation of this plan, a detailed analysis of air travel demands was undertaken. It was estimated that the 1996 passengers movements would nearly double in quantity, increasing from approximately 3 million annual passenger movements to 5.8 million by

the year 2020 (Ottawa International 1998-1999d). An increase in the number of passengers increases the amount of baggage in the airport system, increases the size and number of personal services required and increases the number of visitors within the airport terminal. The operating systems at the airport will need to be reviewed and improved in order to provide adequate service levels for the anticipated passenger demand volume increases. The following sections discuss the baggage handling system at the Ottawa airport at the time of this research. (Subsequent to the research, an extensive renovation is underway to accommodate this increased volume.)

3.2.2 Ground Handling Companies

Two separate companies manage the baggage handling requirements at the Ottawa International Airport. Air Canada has their own employees overseeing the baggage handling requirements for all passengers on Air Canada flights. Hudson General Aviation Services (HGAS) operates the baggage handling for passengers on all other airlines. HGAS was bought out by Tanza Corporation in the early part of 1999 and is now known as Globe Ground. However, throughout this thesis the company is referred to as HGAS or Hudson General. The cost breakdown for handling baggage is approximately 75% labor, 15% equipment and 10 % miscellaneous items including leases, damaged and stolen articles.

The managerial employees oversee the ice and ramp crews. The ice crew maintains the exterior condition of the aircraft, when necessary, as ice buildup develops. The ramp crew sorts, transports, loads, unloads, and transfers baggage. The total ramp crew personnel includes about 80 employees, with an approximately equal number of part-time and full-time employees. The employees work seven days on, three days off, seven days on, and four days off. This cycle repeats itself. During the seven workdays, the employees are assigned three – eight hour day shifts and four - eight to nine hour night shifts or four – eight hour day shifts and three – eight to nine hour night shifts (for a total of seven shifts). The usual shift rotations start at 5 a.m. and 1 p.m. The baggage crews can leave when they have completed the baggage handling for their final pre-assigned flight (usually between 9 and 10 p.m.). Although a few flights do arrive after 10 p.m., HGAS reduces their work force to a minimum.

3.2.3 Canadian Airlines Baggage Restrictions

Although Canadian Airlines has been purchased by Air Canada, the information collected in this section still indicates how certain flight variables vary by airline. Canadian Airlines, in this instance, represents any airline as a comparison with Air Canada standards. Passengers were allowed a maximum of two bags. Although bags were weighed at the check-in counter, the weight was not recorded on the ticket, nor were the total weights accumulated using a computer program. An average weight of 11.3

kilograms (25 pounds) per bag was used to calculate the total weight of baggage within the aircraft hull and subsequently to decide whether the aircraft was prepared for flight, from a safety perspective.

The following were the weight and number restrictions imposed by Canadian Airlines.

- ◆ Each passenger was allowed two carry-on items with weight and size restrictions.
- ◆ Each passenger was allowed two checked items.
- ◆ Neither checked item can exceed 32 kilograms (70 pounds).
- ◆ The length plus the width plus the height of the luggage can not exceed 157.5 centimetres (62 inches).
- ◆ For additional bags or overweight bags, the cost was \$35 plus taxes per piece one way for domestic travel and travel to the U.S.
- ◆ For international travel, the cost of additional bags or overweight bags varied with destination. For example, travel from Ottawa to England, one way was \$140 plus taxes, per piece.

3.2.4 Baggage Flow Through Airport

(a) Transborder Flights

The second level of the Ottawa International Airport, at the east end of the building, has been dedicated to transborder flights (to the U.S.) since July 7, 1997. These transborder

passengers are completely separated from the domestic and international flights, having separate conveyor belts for baggage and separate gates for passengers. The U.S. custom and immigration checks for transborder passengers occur at the Ottawa International Airport prior to departure. This is a change from the previous system where the customs check was done upon arrival at the U.S. destination. However, with the old system, passengers that do not pass the customs check have already landed at their U.S. destination and must be returned to their point of origin. These pre-clearance changes were implemented in order to solve a common delay occurrence in the United States. Passengers were constantly missing their connecting flights while they attempted to clear customs, especially when they were arriving at airports with high volumes of traffic. A secondary reason for implementing pre-clearance checks was so that the total time required between connecting flights could be reduced, thus increasing the quality of service given to the passenger.

The transborder passenger arrives at the check-in area and fills in the customs declaration form. Once the form is completed, the passenger proceeds through check-in and receives a seat number. The passenger retains baggage as he/she proceeds through U.S. customs and immigration. Areas are available for secondary custom and immigration checks when these checks are necessary, as well as a cashier for payment of duty. Once through these checkpoints, the passenger places his/her baggage on a conveyor belt and proceeds through personal and carry-on baggage security, leading to the transborder passenger

departure lounge. The sequence of activities involved in the sorting and transportation of transborder baggage is identical to that for domestic and international flights, although as noted, the two types of baggage are completely isolated from each other.

Upon arrival, transborder and international passengers are merged together, and separated from domestic travellers. Transborder and international passengers wait in the primary inspection lineup (PIL) for Canadian customs. Secondary check areas are available if required. Passengers needing immigration are directed through the immigration checkpoint, while the remainder of the passengers proceed to the reclaim area and claim baggage. Once checked baggage has been collected, goods are then declared and duty paid. Passengers then proceed through a secure set of doors to meet waiting greeters.

(b) Domestic and International Flights

The passenger checks baggage at one of the airline check-in counters. Baggage for passengers on Air Canada flights is segregated from all other baggage as Air Canada manages their own ground handling services. General Hudson is responsible all other airlines which include, among others, American Airlines. Each item of baggage is given a tag that displays all transfer locations and the final destination in reverse order. The last location on the list is the first location where the baggage must be flown. For example, a tag with the letters YYZ refers to baggage going to Toronto. The baggage owner is given

a claim ticket that matches the numbers on the luggage tag. Any item that the passenger wishes to take on the plane must fit within a metal frame that is available at the check-in counter. The size of the metal frame is determined such that the carry on items will fit either under the seat or in the overhead compartments. Any item that does not fit in the frame must be checked-in and put in the baggage hold area.

The baggage is taken from the passenger and placed on a moving conveyor belt. The conveyor belt carries the baggage out of sight, where an employee removes the bag from the conveyor and places the baggage in a specific cart or can, based on the destination. In advance of the flight, carts and cans are labeled as to their final destination. Baggage is segregated extremely well between type and destination. Online baggage, those that must change carriers are placed in a separate cart or can, as are intraline baggage, those that change aircraft, but remain within the same airline. Each item of baggage is noted on a flight sheet so that the total number of bags on the aircraft and the number of bags for each destination are known.

Generally, passengers are not allowed to check-in within fifteen minutes of the scheduled take-off time. This deadline is established so that the ramp crew has adequate time to transfer the baggage to the plane, and load it into the hull of the aircraft. A ramp crew personnel decides where in the aircraft the luggage will be placed based on the amount of baggage accumulated for each destination and the size of the baggage hold fore and aft of

the wings. For Air Canada, the load plan (location of baggage in the aircraft hold) is determined by a load planning system rather than by baggage handling personnel. This information is entered into the computer and distributed to various parties. The pilot is informed of the amount of baggage, and the placement of the baggage within the hold area. The information is relayed to the ramp crews at the various destinations so that in advance of the plane's arrival, the ramp crew knows which luggage must be removed, what items must be transferred to other planes and what luggage must remain on board. The pilot and any other necessary parties are notified of any odd items of baggage, including pets. The pilot and ground crews at other airports are notified of the location, number, possible transfer locations and final destinations of all late articles of baggage, those that are not placed in the correct area or appropriate hold due to tardiness.

At the 15 minute cut off point, baggage is then transferred to the waiting plane and loaded according to the established locations. The cargo areas fore and aft of the wings are named such that references can be made to specific areas of the aircraft hull. This allows for efficient location of baggage. Baggage at the Ottawa International Airport is placed such that the baggage exiting at the first stopover is placed nearest the door. Not all airport ground-handling companies operate in this manner, although this is obviously the most efficient method for unloading purposes. Priority bags (for first class passengers) are also placed closer to the door for easy removal. Bags are loaded onto the plane manually or with conveyor belts, while cans are lifted with hydraulic loading

devices and guided manually (pushed) or with operated rollers. HGAS arranges workers into groups of three to load the baggage. One of the workers is in the airplane hold while the other two remove baggage from the cart, and pass it up into the plane. Once the baggage is loaded, mesh partitions secure the loose baggage in place so that it does not move around during the flight. When cans are being loaded, pushing the cans over rollers manually is often more efficient than using the mechanical controls. Cans are secured to the floor of the cargo area. Pets are placed nearest the doors and are given adequate extra space for breathing. However, the cargo area is dark and noisy. The pilot will circulate heat to all holds that contain pets, hence the importance of notifying the pilots when pets are on board. One disadvantage of carrying a pet on board is that the amount of space required for one pet is approximately equal to the space required for ten items of regular baggage.

The decision to use cans depends on the size of the aircraft. Larger planes benefit from the improved loading efficiency of the cans, whereas smaller planes don't observe the same benefits. For smaller aircraft, the hull area is not ideally shaped for the use of cans. Luggage is often located in small and hard to reach places, such as in the tail of the aircraft. The Airbus, A320, has space for seven cans in total; three cans fore of the wings and four cans behind the wings. The A320 airbus, having seats for 132 passengers, has a 40-minute turn around time, which is faster than manually loading baggage for that number of passengers. About twice that amount of time is required if cans are not used

for larger aircraft. No records are kept as to the time benefit of the cans. Through use, it is known that they are beneficial, both in timesavings and manual effort. The cost of a single can is approximately \$10,000.

When an aircraft reaches a destination, the baggage handling crew must wait until the engines are shut down. They then proceed to unload the cans and/or individual items. For efficiency, the workers are informed in advance of the flight's arrival, of the number of bags to be removed from the plane, the presence of irregular items (such as pets) and their locations within the hold area. The bags that must be transferred from one plane to another are also known in advance, both in number, location and future destination. The required cargo doors are opened and the luggage removal takes place. Items are loaded into carts depending on their destination. Connecting (transferring) baggage is loaded onto specific carts and separated from the baggage that has already reached its final destination. If the next connecting aircraft is not ready for loading, all transferring luggage is brought to the storage area. However, if the connecting plane is ready, the luggage is transported directly to the plane, by-passing the storage area. This saves employee time and effort, and reduces the risk of baggage being left behind. Baggage that has reached the final destination is driven into a secure area within the terminal building, where the employee unloads it onto a predetermined conveyor belt in the reclaim area. The Ottawa International airport has three conveyor belts for domestic flights and one conveyor for international routes. When there are a considerable number of transborder

and international flights, a second conveyor can be added to the international and transborder area with securely fastened wall dividers, thus reducing the number of conveyors for domestic travellers by one. As with transborder flights, international travelers pass through Canadian customs and immigration, proceed to collect baggage, and then declare goods and possibly pay duty, before exiting the separated area to meet greeters.

Any irregular baggage that cannot easily pass through the conveyor system is brought manually to the conveyor. This includes skis, golf clubs, strollers and any other items of irregular proportions. If an employee fails to remove these items manually and instead places them on the conveyor belt with the regular luggage, damage and congestion can result. The possible damage affects not only the irregular item, but also other items of luggage on the conveyor belt and the ground handling equipment itself. There is a high chance of congestion (especially at corners) within the conveyor system that results in wide spread delays.

Once baggage reaches the reclaim area, the domestic passenger collects personal baggage from the reclaim devices and departs the airport facility. Although not the case at the Ottawa Airport, some terminals require that passengers show their baggage claim tags in order to exit the terminal facility. However, this is not usually the case and therefore theft of baggage is made easier. As an example, the following was taken from the Seattle

Times in July 1999. It found that American Airlines does not match tickets with baggage at either the Los Angeles or the New York airports. At the Phoenix airport, America West Airlines, Southwest Airlines and Continental Airlines all require luggage tag matches at terminal 4, but American, Delta, Northwest, TWA, United and US Air airlines do not check for baggage matches at terminals 2 and 3 (Gilje 1999). Thus, the degree of security surrounding the baggage handling system varies between airlines, not only from airport to airport, but also from terminal to terminal.

(c) Air Canada Baggage Handling System

Much like the system used by Hudson General Aviation Services, the BHS that Air Canada uses at the Ottawa airport is a manual system, with a centralized sorting area. At check-in, the Air Canada feeder belts lead to two main conveyor belts that transfer luggage to the sort room. Once in the sort room, both conveyors deposit baggage onto an oblong shaped racetrack that circulates the baggage continuously. AC baggage handlers manually read the tags and sort baggage onto carts for bulk loaded aircraft or lower deck (LD) containers for transferring baggage to the aircraft. A flight information display system (FIDS) is located in the sort area to notify the baggage handlers of the flight number; the early, on-time or delayed arrival and departure time; the appropriate gate number; the tail number of the aircraft; the airline; and the identification number for the handling crew responsible for the flight.

3.2.5 Baggage Theft

Although not a major problem at the Ottawa airport, baggage has recently been stolen at other larger airports. There are numerous ways in which to steal luggage, one more ingenious than the next. One method used recently involved airport personnel. The thief was removing the correct destination tag, replacing it with a tag destined to an airport in Florida, and retaining the claim ticket himself. The baggage would be transferred to Florida, where after being unclaimed was moved to a storage area. After a number of bags were transferred to Florida, the thief would travel to Florida using one of his flight coupons, and claim all the luggage. The coupons are part of the employees benefit package. They have a certain number of coupons that can be used to fly anywhere within a certain specified range. By ensuring a 100% match between on-board passengers and baggage, this situation would be impossible. It would be known that certain passengers were travelling without their baggage on-board, while some baggage was being transported without the passenger on-board.

Other scams reported in local newspapers are quite common. The Toronto Star reported that organized gangs have recently been preying on travellers at Pearson International Airport. Police discovered \$43,000 US in a Toronto home, possibly taken from purses and wallets at the airport. Stolen baggage, jewelry and cameras in the amount of

\$100,000 was also found. The criminals belonged to a group that has been operating at Pearson for over two years (The Toronto Star 1999). The Montreal Gazette reported that a passenger had baggage stolen at the carousel while waiting to collect more baggage (Curran 1998) from the reclaim devices. There is a continual supply of articles detailing these illegal situations. Clearly, better baggage security is required within the terminal building to discourage such criminal activity.

3.2.6 Airline Standards

The baggage handling company is required to heed the standards set by the airline that it services. Hudson General has their own standards, but must follow the airline's guidelines, which vary from airline to airline and airport to airport. For Canadian Airlines, when it existed, the standards varied with the size of aircraft. A small-bodied aircraft, containing less than 6 seats across, must ensure that the priority bags are on the reclaim conveyor belt within 5 minutes of wheel stop. The rest of the bags must be on the belt between the 7-minute mark and the 17-minute mark of the plane's arrival. The total seating capacity of small-bodied planes varies considerably. The Airbus A320 seats 132 people, a B737 seats 100, and an F28 seats 55 passengers. A wide-bodied aircraft has six or more seats across the width of the aircraft. As with the small-bodied aircraft, the total number of seats varies. For example, a B767 has more than 200 seats. For large-bodied

aircraft, the priority bags must be on the reclaim belt within 5 minutes and the rest must be on the belt between the 12-minute mark and the 23-minute mark (Table 3-4).

Table 3-4: Standard Delivery Times By Aircraft Type and Baggage Priority

<i>Type of Aircraft</i>	<i>Standard Timeframe for Unloading Baggage (Minutes after wheelstop)</i>	
	<i>Priority</i>	<i>Regular</i>
Small-bodied aircraft, containing less than 6 seats across (ex. A320, B737, F28)	< 5	7 - 17
A wide-bodied aircraft has six or more seats across the width of the aircraft (ex. B767)	< 5	12 - 23

3.2.7 Mishandled Baggage

Hudson General Aviation Services retains records for about 15 of the usual 65 daily flights. They keep track of the time that the first bag is on the reclaim belt and the time that the last bag arrives on the belt. No other data is recorded by Hudson General, such as the time that 80% of the bags are on the conveyor, or how many bags are removed per minute. Every month, these data are summarized and sent to the airlines. The airlines also keep some records of their own to verify those records that HGAS gives to them. This information was not available for inclusion in this thesis.

Although the baggage handling company does not keep track of lost, misdirected, mishandled, or stolen baggage, the airlines do. The information is then provided to HGAS so trends can be seen and a measure of the level of service provided can be understood. HGAS provided one example of the amount of mishandled baggage, provided by Canadian Airlines, which was purchased by Air Canada Airlines. During the period of August 3 to 9, 1996, about 30 bags at Ottawa International Airport were mishandled per day. There were about 65 flights per day and about 70 bags on average per flight. That results in a total of 4,550 bags handled at the airport per day. Therefore, mishandled baggage during that period accounted for 0.7% or less than 1% of the total amount of luggage handled. This is more commonly referred to as '7 bags mishandled per 1000 bags handled'.

Delayed baggage is brought directly to the passenger at their convenience with all shipping expenses paid. If the passenger requires an item from the luggage immediately, (e.g. a shirt for a meeting) the airline can give the passenger adequate money with which to purchase the necessary item. A passenger with damaged luggage can request that the airline repair the luggage free of charge, provided the luggage was not damaged before the flight took place. Airline personnel reduce fraudulent damage claims by taking note of such things as broken zippers, handles and any other damage that makes the item of baggage not trip worthy. No monetary compensation is given to such claims. A passenger

with misplaced baggage that is never returned can receive compensation, depending on the articles of luggage lost and any applicable insurance. A claim for lost luggage must be filed in order to receive the compensation. Canadian Airlines had a Ramp Operations Improvement Team to deal with mishandled luggage. They used service records, which were originally collected by HGAS, to improve the quality of the baggage handling system.

3.3 Comparison of Ottawa and Montreal Airport Service Levels

Hudson General Aviation Services (HGAS) was the primary source for the information related to the baggage handling services for all airlines, except Air Canada (AC), at the Ottawa Airport. The information concerning the baggage handling system (BHS) at Montreal's Dorval Airport was obtained from two AC managers and thus, reflects the means with which baggage is handled by AC. Certain information regarding the BHS is not airline specific and thus, is applicable to all the airlines using the airport facility. For comparison, the information can be divided into two broad categories: airport and airline considerations.

3.3.1 Airport Considerations

The LOS provided by the BHS is influenced by four factors that relate to the airport terminal: the number of aircraft movements, the total number of passengers, the airport

layout, and the peak traffic. As published by Pagani et al. (2000) the general findings were (Table 3-5):

- ◆ Montreal's Dorval Airport is a much larger airport than the Ottawa Airport. Dorval Airport has almost 3 times the number of aircraft movements and carries more than two and a half times the number of passengers.
- ◆ Dorval Airport has only twice the number of conveyors for both domestic and international passengers.
- ◆ Dorval uses a semi-automatic sorting system, while Ottawa uses a manual sorting system.

Records for the amount of mishandled baggage by airport are kept by each airline. In recording this data, a number of factors affecting the level of service remain constant. At the Ottawa airport, these consistent variables include the airport layout, the equipment available, the sorting method, the total airport traffic for aircraft and passenger levels, and the peak operating times. Therefore, any difference in the amount of mishandled baggage recorded by different airlines must be caused by varying operating procedures between the baggage handling employees, different recording practices for mishandled baggage, and/or the varying levels of passenger traffic associated with each airline.

The above results display the immense variability that exists between airports and demonstrates the difficulties involved in comparing them. Clearly all factors must be

analyzed together in order to determine how each factor influences the operation of the baggage handling system and affects the level of service.

Table 3-5: Comparison of Selected Factors Affecting the Baggage Handling System at the Dorval and Ottawa Airports.

<i>Criteria</i>	<i>Montreal's Dorval Airport</i>	<i>Ottawa Airport</i>
Aircraft Movements in 1998	209,173	77,202
Rank for Aircraft Movements	59 of 159	100 of 159
Passengers Carried in 1998	7,913,859	3,110,548
Rank for Passengers Carried	44 of 154	73 of 154
Number of Gates	37	19
No. of Conveyors – International	4 racetrack, 2 flatbed	1 racetrack, 2 flatbed
No. of Conveyors – Domestic	2 flatbed	1 racetrack
Sorting Method	Semi-Automatic	Manual

3.3.2 Airline Considerations

The airlines have control over three factors that influence the LOS of the BHS: the cost of additional or overweight baggage, the capacity of the handling equipment and the operating procedures of the baggage handling personnel.

Prior to the takeover of Canadian Airlines by Air Canada, some variations existed between the baggage requirements of these two competitors. The two airlines both allowed two carry-on bags and two items of checked luggage. Both airlines stipulated that each item of checked baggage could not exceed 32 kilograms (70 pounds). However, Table 3-6 indicates how the charge for overweight baggage varied between the two airlines. Since the takeover, the policies for carry-on and checked baggage, including charges, are now identical.

Table 3-6: Comparison of Selected Factors Affecting the Baggage Handling Operation of Air Canada and Canadian Airlines

<i>Criteria</i>	<i>Air Canada</i>	<i>Canadian Airlines</i>
Baggage Allowance	1 carry-on, 2 checked	1 carry-on, 2 checked
Baggage Weight	Each item < 32 kg (70 pounds)	Each item < 32 kg (70 pounds)
Baggage Size	Length + Width + Height < 157.5 cm (62 inches)	Length + Width + Height < 157.5 cm (62 inches)
Cost for Overweight Bags – Domestic	Varies with destination	\$35 plus taxes one-way
Cost for Overweight Bags - International	Varies with destination	Varies with destination
Unloading Time Standards – Airbus 320	Priority: < 12 min. Regular: < 20 min.	Priority: < 5 min. Regular: 7 to 17 min.
Unloading Time Standards – Boeing 767	Priority: < 12 min. Regular: < 20 min.	Priority: < 5 min. Regular: 12 to 23 min.

The standard unloading rates for two selected aircraft are presented in Table 3-6. It is important to note that the standard unloading times used by Air Canada do not vary from airport to airport. On the other hand, the rates obtained from HGAS (the baggage handlers for Canadian Airlines) pertain to the Ottawa Airport. It is evident that the two airlines determine unloading rates based on different criteria. The unloading rates obtained from Hudson General were based on the total aircraft seating and size, and thus recognized a difference between the Airbus 320 and the Boeing 767. Air Canada standards, however, do not distinguish between these two aircraft.

The above results, collected from the two preliminary airport inspections, illustrate the variability of standards both between airlines and within airports. These two initial surveys indicate that the LOS perceived by the user is affected by more than just processing time and space. The LOS is affected by such factors as the number of passengers, the airport layout, and the equipment used for baggage handling. There is an obvious need to obtain complete data from all airlines and airports that relates to the baggage handling system. To determine the prevalent LOS, all factors affecting that LOS must be evaluated. An exhaustive set of data must be compiled before a comprehensive level of service model can be created to distinguish between various levels of service at airports. By conducting a detailed inspection of each airport baggage handling operation, the factors that affect the LOS, mentioned in the previous sections, can be evaluated.

From an analysis of this information, a method of evaluating the LOS perceived by the user can be developed.

Chapter Four

4 RESEARCH PLAN

4.1 Level of Service

A level of service (LOS) measurement allows designers and operators to evaluate the system of interest (highway, walkway, queuing area, BHS, etc.) at the different load conditions that may be encountered during the life of the system. The LOS provides a basis for determining when improvements are necessary in the system's lifetime.

4.1.1 Highway Level of Service

Highway capacity analysis was the earliest use of the concept of LOS. Capacity in its early stages was defined by three values – basic, possible and practical capacity.

The *basic capacity* was defined as “the maximum number of vehicles that could pass a given point on a roadway in one hour under ideal road and traffic conditions”. The “maximum number of vehicles that could pass a given point during one hour under prevailing road and traffic conditions” was known as the *possible capacity*. The *practical capacity* was defined as “the maximum number of vehicles that could pass a given point without the traffic density being so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to maneuver under the prevailing road conditions”

(U.S. Department of Commerce, 1950). The vagueness of these definitions made it difficult for designers to evaluate the prevalent LOS when the number of vehicles using the roadway exceeded or fell below the practical capacity (Ashford 1988).

To improve upon this initial method for highway capacity analysis, the concept of LOS was introduced in 1965 (Highway Research Board), increasing the sensitivity of the capacity analysis. The Highway Capacity Manual provides a means to evaluate LOS for a variety of facilities (freeways, local streets, etc.) through a relationship between the speed and the volume/capacity ratio. Six levels of service, with levels from A through F, were defined to indicate the LOS based on this relationship (Table 4-1). It is easy to understand how altering the amount of traffic on a roadway, alters the LOS provided by that facility.

Table 4-1: Highway Level of Service (Transportation Research Board 1998)

<i>LOS</i>	<i>Level</i>	<i>Description</i>
A	Excellent	Free flow, no delays, excellent comfort level
B	High	Stable flow, very few delays, high comfort level
C	Good	Stable flow, acceptable delays, good comfort level
D	Adequate	Unstable flow, passable delays, adequate comfort level
E	Inadequate	Unstable flow, unacceptable delays, inadequate comfort level
F	Unacceptable	Cross-flow, system breakdown, unacceptable delays and comfort level

For highway capacity analysis it was determined that the level of service depended on the driver's freedom of movement and the ease of traffic flow. These variables were evaluated from three criteria: the driver's ability to choose his speed; the ability to overtake; and the ability to maneuver (Ashford 1988).

4.1.2 Pedestrian Corridors

Fruin (1971) applied the concept of LOS and capacity analysis of roadways to pedestrian areas. He observed that the maximum capacity of pedestrian spaces was obtained when there was a dense crowding of users, consequently reducing convenience and freedom of movement. Thus, Fruin devised a scale to evaluate pedestrian design standards based on user convenience. The same six levels of service used in highway capacity analysis were used to determine the prevailing LOS of pedestrian walkways, with a relationship between the pedestrian flow and the amount of space provided for each pedestrian. Not only was Fruin's work applicable to pedestrian walkways, but his work established guidelines for the evaluation of levels of service for stairways and queues (Table 4-2).

For pedestrian capacity analysis it was determined that the level of service depended on the user's freedom of movement and the ease of flow, as in highway capacity analysis. These variables were evaluated from three criteria: the user's ability to choose walking

speed; the user's ability to overtake; and the ease of cross flow and reverse flow movement (Ashford 1988).

Table 4-2 – Summary of Pedestrian Space standards (Fruin 1971)

<i>(sq. ft. per person)</i>	<i>Level of Service Ranges</i>					
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>
Walkways	35 or more	25-35	15-25	10-15	5-10	5 or less
Stairways	20 or more	15-20	10-15	7-10	4-7	4 or less
Queues	13	10-13	7-10	3-7	2-3	2 or less

4.1.3 Airport Terminal Level of Service

The state of LOS evaluation in airport terminals is much less advanced than that of highway analysis. Methods used for terminal evaluation have evolved in the past, but one single, generally used method has not been developed (Ashford 1988). Some evaluation methods, such as a cost benefit analysis, optimizes a single parameter, but ignores all other variables concerning service quality. Other methods, used in the past, evaluated the LOS for the overall terminal facility (Modak and Patkar 1984; Blankenship 1974; IATA 1976; Paquette et al. 1982). However, it is important for designers and operators to have the ability to measure the LOS provided by individual facilities within the entire system (Ashford 1988).

Ashford (1988) stated: “There is no standard method of dealing with a design passenger volume in terms of the levels of service or design service volumes as is now well established in the sphere of highway engineering. Although airport operators and designers individually have a clear idea of what are acceptable service levels, these are neither universally agreed within the airport community, nor is the design service level set within a range of service levels as has been shown to occur in highway design. Currently service levels are set simply in terms of standards that the authority attempts to meet either in terms of design (space standards) or in terms of operation (time standards). In a number of facilities, standards are set in terms of both time and space, but the interaction of time and space has never been examined.”

Table 4-3 shows a comparison between the space and time standards used by the British Airport Authority (BAA), the International Air Transport Association (IATA), Schiphol Airport Authority, and Aeroports de Paris in 1982 for the baggage check-in area and the baggage reclaim area. The approach used by these organizations is to set time and space standards for each facility, however, these standards do not reflect varying levels of service.

Table 4-3: Design Service Standards for Baggage Reclaim Area (Revised from Ashford 1988)

Organization	Baggage Reclaim Area	
	Space Standard	Time Standard
BAA Standards	1.25 m ² per domestic pass., 2.0 m ² per short haul international pass., 3.25 m ² per long haul passenger.	Max of 25 minutes from first pass. out of immigration to last bag on unit
IATA Standards	0.8 m ² per domestic and short haul international pass., 1.6 m ² per long haul passenger.	Max of 25 minutes from first pass. in hall to last bag on unit. 90% of pass. wait <20 minutes for baggage.
Schiphol Airport Authority		<15 minutes for narrow bodied aircraft, <20 minutes for wide bodied aircraft
Aéroports de Paris	Reclaim frontage of 1.0 m for every 5 pass. Length of: 60 m for B747 sized a/c; 45 m for A300; 30 m for B727. 8 m min. between units, 4 m min. between unit & wall.	Max. of 25 min. between arrival of first passenger in hall and reclaim of last bag from unit.

Transport Canada (1979) proposed a method that sets different levels of space provisions for the six different levels of service (A to F), similar to the evaluation of highway LOS (Table 4-4). The space provisions proposed by Transport Canada (TC) are shown in Table 4-5. This table also provides the more stringent standards suggested by IATA in a 1990 update (IATA 1990). The linearity of the relationship between space provisions and

LOS suggests a lack of a relationship between these space provisions and the LOS perceived by users (Ashford 1988).

Table 4-4: Airport Level of Service Framework Proposed by Transport Canada (1979)

<i>Level of Service</i>	<i>Description</i>
A	Excellent level of service; condition of free flow; no delays; direct routes; excellent level of comfort.
B	High level of service; conditions of stable flow; high level of comfort.
C	Good level of service; condition of stable flow; provides acceptable throughput; related subsystems in balance.
D	Adequate level of service; condition of unstable flow; delays for passengers; condition acceptable for short periods of time.
E	Unacceptable level of service; condition of unstable flow; subsystems not in balance; represents limiting capacity of the system.
F	System breakdown; unacceptable congestion and delays.

Table 4-5: Air Terminal Building LOS Space Standards (Revised from Transport Canada 1979 and IATA 1990)

<i>Facility</i>	<i>Operational Level of Service Ranges (Minimum Square Meters per Occupant)</i>					
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>
TC -Baggage Reclaim Area (without device)	> 1.6	1.4	1.2	1.0	0.8	< 0.8
IATA – Baggage Reclaim Area (without device)	> 2.0	1.8	1.6	1.4	1.2	< 1.2

Table 4-6: Level of Service of Processing Time (minutes) for Birmingham International Airport, Great Britain (Ashford, 1988)

<i>Facility</i>	<i>Level of Service A (GOOD)</i>	<i>Level of Service B (TOLERABLE)</i>	<i>Level of Service C (BAD)</i>
Check-in:			
Charter	<11	11-21	>21
Scheduled Long Haul	<15	15-25	>25
Scheduled European	<7.5	7.5-14	>14
Security Check	<6.5	6.5-10.5	>10.5
Passport Control (Outbound)	<6.5	6.5-10.5	>10.5
Immigration (Inbound)	<6.5	6.5-14.5	>14.5
Baggage Claim	<12.5	12.5-22.5	>22.5
Customs Control	<6.5	6.5-11.5	>11.5

This linear relationship led Mumayiz and Ashford (1986) to develop a perception response model, by introducing the user's perception as an additional criterion for determining LOS. Three categories for measuring the LOS were used to relate the time passengers spent in various facilities with their perceived LOS. Level A indicated a *good* LOS, while B and C indicated a *tolerable* and *bad* LOS respectively. Passengers were asked which level they felt they were being provided. The results from Birmingham International Airport are shown in Table 4-6.

Ashford (1988) noted three deficiencies with the perception response model. First of all, the survey sample was too small to ensure the validity of the results. Secondly, the relationship between available space and time spent in the different processes was not considered. Thirdly, the model was applied to airport processing facilities and not holding areas, thus the model would need additional testing to be applicable throughout the terminal building processes. An additional drawback of the model was that the surveys were conducted solely at British airports and thus the model was not valid internationally.

The state of LOS analysis of airport terminal processes lags greatly behind the LOS analysis of highways. Ashford stated (1988) "To produce more comprehensive level of service standards an industry-wide approach to data gathering will be necessary to enable cross comparisons of design and operational standards across a large range of airports (Ashford 1988)."

4.2 National Strategy for Airport Baggage Handling

From the previous discussions, it is evident that a national strategy for defining the LOS of BHS's and the means to improve this LOS are needed. Moreover, as the demand for air transportation is growing all airports and airlines will face the same situation of having limited, and very often, inadequate capacity to handle the significant annual increase in the amount of baggage to be processed. Airbus Industries, McDonnell Douglas and Boeing are currently developing two different concepts of larger aircraft with greater seating capacities, and thus greater amounts of baggage. The first new aircraft concept is a double-decker jet, with the same cylindrical body of typical 747's, but with an expected 30% increase in seating capacity. The second design concept is a blended wing body (BWB) much like the Northrop B-2 stealth bomber. These new designs are anticipating seating capacities of greater than 800 passengers for the BWB design, and 840 passengers for Airbus' A3XX double-decker design (Sweetman and Brown 1995).

Without improving the capacity of the airport terminal facilities to match this increase in the number of passengers and the amount of baggage, the overall quality of service offered by Canadian airports is deemed to deteriorate. Clearly, a LOS model that can ascertain the LOS being achieved by each BHS would be beneficial to airlines,

passengers and airport designers. The development of such a model would enable airport authorities and airlines to determine when improvements are required and to develop a strategy for implementing the needed changes.

4.2.1 Deficiencies in Canadian Baggage Handling System

Based on a preliminary assessment of baggage handling systems, several deficiencies were identified. The systems differ between airlines, airports and baggage handlers in terms of system configuration, standard measures for mishandled baggage, and LOS. As discussed in the previous chapters, these deficiencies are:

- ◆ Baggage handlers do not operate as efficiently as is possible.
- ◆ There is no information available on recent records concerning the time taken to unload baggage and the amount of baggage mishandled.
- ◆ Current methods for evaluating LOS don't reflect user perception.
- ◆ There is no universally established method for measuring LOS.
- ◆ There are no Canada wide standards explicitly identifying the quality of service that *should* be provided.

Due to these obvious needs in the Canadian baggage handling system, research in this area is important and needed. This research should focus on the significance of the BHS

with respect to the overall quality of service offered by the air aviation system; the LOS provided by the airlines and airport authorities; and the factors affecting the LOS as it is perceived by passengers. The need for developing a model that can determine the LOS provided by the BHS and perceived by airport users is clearly evident (Pagani et al. 2001).

4.2.2 Level of Service Model for Airport BHS's

A LOS model would allow airports and airlines to analyze their BHS's and determine the LOS being provided to the passengers. Although a six level framework for the LOS exists (levels A through F), there are currently no established guidelines for determining which of the six levels of service a facility is operating at, as perceived by the user. The model would facilitate the identification of systems that require modifications due to, among other reasons, inadequate capacity, inefficient physical layout, or inferior service considerations. An LOS model could lead to the identification of appropriate strategies for airport improvements based on the factors that affect the LOS of baggage handling.

The LOS analysis and the suggested improvements would consider the safety, security, convenience, cost and delay to the passengers, the airlines, the baggage handling companies, and the airport authorities. The proposed LOS model would also consider the

commonly used variables of space requirements and service times, but would put emphasis on user preference and perception.

The previous chapters have already outlined some factors that affect the capacity of the BHS. A comprehensive assessment of the current baggage handling facilities at a number of airports was conducted to evaluate these factors, which include:

- ◆ airport layout;
- ◆ annual number of passengers;
- ◆ baggage handling equipment and frontage provided;
- ◆ baggage handling sort room concepts and operation methods;
- ◆ distance and time required for the passenger to reach the reclaim area; and
- ◆ difference in time between the arrival of the baggage and the arrival of the passengers.

Following an evaluation of these factors, regression analysis was used to identify the effect of each variable on the LOS perceived by the airport user. Because of the random nature of people and their perceptions, deterministic models were found inappropriate for use in this thesis. Instead, a statistical analysis, including regression, was conducted. The model was evaluated and calibrated using a comprehensive survey of six Canadian airports. The multiple regression relationship was of the form:

$$UPLOS = a + \sum_{i=1}^k b_i f_i(X_i)$$

where:

$UPLOS$ = user-perceived level of service,

$f_i(X_i)$ = function of independent variable X_i , and

a and b_i = constants.

It was anticipated that this model would determine the user-perceived LOS based on the above noted variables and other indicators of the user's perceived service level. This UPLOS would correspond with one of the six defined levels of service developed by Transport Canada (1979).

By examining the correlation between each variable in the regression model and the UPLOS, a guideline for improvements to the BHS can be created, thus allowing the airlines and airport authorities to instigate effective modifications to the BHS. This provides a tool to airport operators to establish a new strategy for BHS modifications that take into account the preferences of the main users, the passengers.

4.3 Outline of Research Strategy

4.3.1 Research Objectives

The aim of this thesis was to develop a means of evaluating the current LOS and proposing methods to improve the quality of the baggage handling system in Canadian airports. The analysis and suggested improvements considered the convenience, cost and delay characteristics imposed on the airport users. The objectives of this research were presented in Section 1.5 and provide the framework for the research plan that was followed in the completion of this thesis. The research plan was designed to meet the objectives of the thesis in five phases, as described in the following sections (Figure 4-1).

4.3.2 Phase One: Development of Research Plan

The first phase of this research plan was completed between September 1999 and March 2000. It consisted of a number of tasks including a comprehensive literature review of information related to airports, baggage handling, and levels of service; development of the thesis objectives; an evaluation of whether the thesis objectives could be accomplished successfully; and development of the main elements of a framework for a working research plan. The information that was available on the subject of baggage handling at airports was presented in the previous chapters. As the demand for air

Figure 4-1: Stages of Research Work

transportation is growing all airports and airlines must accommodate the increasing volume of passengers and baggage, yet retain a desirable LOS. A review of recent literature has demonstrated that little research is currently underway on this very important topic.

Numerous airlines, baggage handlers, airport authorities, government agencies and air transportation organizations have provided information thus far. Along with the two airport case studies, this information has been presented and discussed in the preceding chapters. These preliminary studies demonstrated that the data required for the completion of this thesis was available and obtainable. From these organizations and based on an analysis of the two case studies investigated, a definite need for this research study was demonstrated.

4.3.3 Phase Two: Data Collection and Analysis - Organizations

The second phase of the research involved selecting the airports that formed the study group and soliciting more detailed information from various organizations. The information required from airport authorities, airlines, baggage-handling equipment suppliers and baggage handlers was as follows:

- ◆ From the airport authority, a flight schedule was obtained for the duration of the site visit and the peak periods were identified.
- ◆ The baggage handlers were contacted to determine operating procedures and whether any statistics (i.e. time to unload aircraft, etc...) were available.
- ◆ The baggage-handling equipment suppliers (e.g. BAE Automated Systems, Inc.) were contacted to obtain sizes and layouts of typical baggage claim devices.

This data did not fully take into account the LOS perceived by the passenger, which was evaluated in phase three during the actual airport inspections.

4.3.4 Phase Three: Airport Evaluation

The third phase of the research involved airport visits and on-site data collection. Phase three was carried out simultaneously with phase two (data collection and analysis - organizations). A visit was made to six Canadian airports where a survey of their baggage handling system was conducted. The layout of the airport, focusing on the area for arriving passengers, and the equipment and methods used for handling baggage was documented. A questionnaire was developed (Section 4.4) and circulated to passengers at the selected airports. The passenger and baggage arrival times, and the passenger waiting times in the reclaim area were compared to determine where deficiencies existed between

the LOS being provided by the airlines and airport authorities and the LOS perceived by the users.

4.3.5 Phase Four: Development and Calibration of Level of Service Model

Phase four involved analyzing the data collected during phases two and three of this research. The information obtained from the airport visits was used for regression analysis. The regression analysis identified the factors that had the greatest influence on the perceived LOS. Regression was carried out for three separate data groupings. The first analysis considered all cases as one aggregate model. The second grouping was based on annual number of passengers and three models were created for small, medium and large airports. The third set of models considered the six airports individually. As anticipated, the models were of the form shown in Section 4.2.2.

4.3.6 Phase Five: Verification of LOS Model and Recommendations

The developed UPLOS model was verified using some of the data collected in phases two and three to ensure transferability between airports. Once the factors affecting the UPLOS were determined, an ordered list of recommendations was created detailing how changing each factor affected the overall baggage handling service. From these relationships, methods for improving the baggage handling system were recommended.

Designers of new terminals, as well as designers for renovations and expansion projects, can consider the independent variables in the UPLOS model when analyzing a proposed airport layout and thus, determine the best location, spacing and arrangement for the baggage handling system.

With annual passenger levels increasing, the capacity of each airport to handle passenger, baggage and/or cargo is being reached and exceeded. The LOS model developed in this research can evaluate the current baggage handling system LOS, as perceived by the user, and suggest measures with which to improve the operation of the baggage handling systems. Based on the UPLOS model, suggested modifications to the baggage handling system for increased capacity and improved LOS can be applied internationally.

The information collected, evaluated, and analyzed during the five phases of the research was compiled in this thesis. More specifically, this thesis contains the background research, the data obtained from airlines, airport authorities, baggage handlers, baggage-handling equipment suppliers, and other air transportation organizations. From the UPLOS model, suggestions for improving the airport baggage handling systems have been identified and are presented in a manner which facilitates use of the model by other individuals (i.e. airport authorities, airport developers, airlines).

4.4 Questionnaire Development

An important part of the research was to develop an effective questionnaire for collecting data from the passengers that would indicate their perception of the baggage handling system. As indicated in section 4.3.4, the questionnaire was used during phase three of this research.

Questionnaires are commonly used to measure variables related to the quality of a process or product. These measurements assist organizations in evaluating how well the process is working, knowing where changes should be made to improve the quality of the process, and determining if the changes actually led to improvements (Hayes, 1998). As noted by Hayes (1998), the “entire American economy seems to be revolving around the phrase customer satisfaction”. Questionnaires provide the information necessary to successfully modify the process to better satisfy the needs of the customers, thereby increasing customer satisfaction and hence the monetary value of a process.

The purpose of the baggage-handling questionnaire used in this research was to understand the attitude that passengers have vis-à-vis the baggage handling system. The comments and concerns that passengers had with the service they received, and what their priorities were concerning the overall service of BHS’s were determined.

As defined by Montgomery (1996), quality is the extent to which products meet the requirements of people who use them. Quality can be measured by evaluating either an objective value or a subjective value. Measurable quantities, such as a period of time or a number of objects, are objective (or hard) indices. Soft measures, such as a person's attitude or perception, are subjective indices and are more difficult to measure.

Depending on the purpose of the research, the questionnaire might evaluate objective and/or subjective types of measures.

To create a comprehensive and well-designed questionnaire, the customer and the product must be understood. Once the needs and desires of the customer are known, the product or service can be fully described in terms of 'quality dimensions'. Quality dimensions are characteristics of a product that can be evaluated to indicate the service being provided. Quality dimensions indicate the actual service level being provided, as well as the service level desired by the customer. For example, responsiveness, availability, professionalism, convenience and timeliness are quality dimensions that can be used to describe the service provided and the quality of that service. Two methods are commonly used to identify important quality dimensions to describe a product or service. The first method is the quality dimension development approach (Hayes 1998), while the second method is the critical incident approach (Flanagan 1954).

4.4.1 Questionnaire Development Approaches

(a) Method One: Quality Dimension Development Approach

In this approach, the service or product provider determines the quality dimensions, or the customer requirements. The service or product provider understands the purpose and function of the product or service being delivered to the customer and is therefore in a good position to determine the customer requirements. The first step of this approach is to identify the important quality dimensions, while the second and final step is to define these dimensions with specific examples.

Recalling that the dimensions are used to define the service quality, a list of these dimensions can be generated by reading scientific and trade journals. Five dimensions of service quality that were published in a scientific journal include tangibles, reliability, responsiveness, assurance, and empathy (Zeithaml et al. 1990). Kennedy and Young (1989) published five quality dimensions to measure staff support in a trade journal and included availability, responsiveness, timeliness, completeness, and pleasantness.

Alternatively, the quality dimensions can be determined by examining the service or product with the help of people actively involved in the business process. These

individuals are extremely knowledgeable regarding the purpose of the product or service and would be aware of any concerns expressed in the past by customers.

Once the dimensions are listed, specific examples should be developed to adequately describe each quality dimension. The specific example should be a declarative statement describing a specific instance of the dimension, and should contain either an action verb or an adjective. The action verb or adjective describes a specific behaviour of the service or product. Figure 4-2 provides examples of three quality dimensions and 10 specific examples. Four or five unique statements should be generated to fully describe each quality dimension.

(b) Method Two: Critical Incident Approach

In this method, information is obtained directly from the customer to generate a list of quality dimensions. The previous approach involved collecting input from the service or product *provider* rather than from the service or product *user*. Relying on the service provider alone can generate an inaccurate or incomplete list of customer requirements (quality dimensions). The first step of this approach involves defining a number of critical incidents and the second step involves grouping similar incidents into categories that indicate a quality dimension.

Availability of Support

- 1) I could get help from the staff when needed.
- 2) The staff were rarely available to help.
- 3) I could contact the staff at any time I needed.
- 4) I could arrange convenient meeting times with the staff.

Responsiveness of Support

- 1) They were quick to respond when I asked for help.
- 2) I waited a short period of time to get help after I asked for it.
- 3) They made me wait a long time before they helped me.

Completeness of Support

- 1) They ensured that every aspect of the job was completed.
- 2) They completed everything they said they would do.
- 3) They completed only part of what they said they would.

Figure 4-2: Quality dimensions with specific examples (Hayes 1998)

A critical incident “is a specific example of the service or product that describes either a positive or a negative performance” (Hayes 1998). As with the specific examples used in step two of the first approach, a critical incident should be specific and should describe the service provider in behavioral terms, or the service or product with specific adjectives (Figure 4-3). Critical incidents can be generated by interviewing 10 to 20 customers either individually or in groups. Each person should describe 5 to 10 good instances and 5 to 10 bad instances of past service experience.

- 1) I waited in line for a long time.
- 2) The teller was quickly servicing the customers.
- 3) The teller carefully listened to my request.
- 4) I received immediate service for my transaction.

Figure 4-3: Examples of critical incidents (Hayes 1998)

Once a list of these critical incidents is compiled, incidents with similar experience should be grouped. A satisfaction item can be written for each group of incidents. The satisfaction item should be a specific declarative statement. All redundant statements should be removed at this stage. Similar satisfaction items should then be grouped, forming a customer requirement (known as a quality dimension in the previous approach). Figure 4-4 presents examples of one customer requirement, two satisfaction items and five critical incidents.

Both approaches are similar in terms of the creation of a list of quality dimensions and statements to describe these quality dimensions. The main difference between the approaches is the source for describing the quality dimensions. Whereas the service or product *provider* created the quality dimension list for the first approach, the second approach involved asking the service or product *user* directly for his or her requirements.

Final Written Report

- 1) The written report was sufficiently detailed.
 - a) The write-up of the project was detailed.
 - b) The written report was not complete.
 - c) The document needed to be more comprehensive.
- 2) The written report contained what I needed.
 - a) Everything I asked for was in the report.
 - b) The report contained part of what I asked for.

Figure 4-4: Examples of a customer requirement, satisfaction items and critical incidents (Hayes 1998)

The quality dimension development approach was used for the construction of the airport baggage-handling questionnaire. The product *providers*, Air Canada and Hudson General Aviation Services, were solicited for information concerning the product requirements. Journal articles were a secondary source of information for creating the quality dimensions and specific statements concerning these quality dimensions.

4.4.2 Questionnaire Construction Steps

Following the development of critical incidents or satisfaction items, four main steps were involved in creating the final questionnaire. The first step involved choosing and rewording possible statements and/or questions. The second step involved selecting the

response format that provided the best information. Writing a clear and straightforward questionnaire introduction was the third step of the process. The fourth and final step was the selection of statements and/or questions for the final questionnaire, from the statements and/or questions developed in the first step.

(a) Step One: Select Possible Questions

The specific examples of quality dimensions created using the quality dimension development approach (Hayes 1998) can be reworded to form possible statements and/or questions. Alternatively, the satisfaction items created using the critical incident approach (Flanagan 1954) can be rewritten to form the possible statements and/or questions. The statements developed using either approach should be rewritten as neutral statements, rather than negative or positive comments (Table 4-7).

Table 4-7: Neutral Statements (Hayes 1998)

Initial Example or Satisfaction Item	Reworded Neutral Statement
I waited a short period of time before I was helped.	Period of time waited before I was helped.
The service started promptly after I arrived.	Promptness of service when I arrived.
The teller was very personable.	Way in which teller conducted the transaction.

These statements should be specific and unambiguous. Non specific statements or those statements containing more than one thought can lead to a variety of answers and yield useless results. If two ideas are present in a single question, a negative response could indicate either the respondent believes the first idea is negative, or the second idea is negative or that both ideas are negative. This type of response will not provide a means of improving service efficiently because the actual cause of the negative response is not known. An ambiguous statement leads each respondent to read and understand the statement differently; thus the responses provided will be answers to different statements. By using precise wording, respondents will understand the statement in the same way and will therefore provide useful feedback. As stated by Berdie (1986), a reliable questionnaire item is one "that consistently conveys the same meaning to all people in the population being surveyed." It is also important to use language that the intended respondents are familiar with. Statements should contain relevant information. Respondents will otherwise become confused with the purpose of the questionnaire and less apt to complete it accurately. The statement should be to the point and no superfluous or confusing words should be used. Words with more than one meaning should be avoided. No statement should contain two negatives, as this makes the statement difficult to understand. Hypothetical questions should not be used.

In summary, statements should be clear, precise, to the point, unambiguous, and relevant; should contain only one thought; and should not contain double negatives. These guidelines were used to develop the statements for the baggage-handling questionnaire.

(b) Step Two: Determining the Response Format

The response format determines how customers respond to the data and how the data will subsequently be used (Hayes 1990). Several scaling methods have been developed in the past and include Thurstone's method of equal-appearing intervals (Thurstone 1929), the Likert scaling method (Likert 1932), and Guttman's scalogram approach (Guttman 1950). Both the Thurstone and Guttman methods are more labor intensive than the Likert method, and it has been found that higher reliability coefficients with less items are achieved using the Likert scale rather than the Thurstone method (Edwards and Kenney 1946). The Likert-type format and the checklist type format will be discussed herein.

Checklist Format

The number of positive and negative comments that customers provide regarding a product or service can indicate the quality of that product or service (Hayes 1990). Respondents provide either a 'yes' or 'no' response to each statement indicating that either they agree with the statement or that they disagree with the statement. These responses indicate whether the customer is satisfied or dissatisfied with the service or

product. The checklist format questionnaire is simple to create by using the specific examples developed using the quality dimension development approach or the satisfaction items developed using the critical incident approach. The checklist format response is easy for the customer to complete and easy for the service or product provider to analyze by calculating the number of positive and negative responses to each statement.

Likert-type Format

The quality of a service or product can be indicated by the *strength* of the response, rather than by the positive or negative response generated with the checklist format (Hayes 1998). Instead of a simple 'yes' or 'no' response, customers rate the service or product in varying degrees of agreement or disagreement. The scale developed by R.A. Likert (1932) represents a bipolar continuum where the low end indicates a negative response while the high end indicates a positive response. Table 4-8 presents three bipolar continuums that are used for different types of responses.

There are three major advantages to the Likert-type format. First of all, this type or response format allows respondents to express their opinion more accurately by providing a degree of agreement or disagreement. Secondly, from statistical perspective, scales with five response options are more reliable than scales with only two response options (Hayes 1998). Thirdly, the percentage of positive and negative responses using

the Likert-type format can be calculated, as with the checklist format, by combining the ends of the Likert scale. For example, referring to the first scale of Table 4-8, responses of 'Strongly Disagree' and 'Disagree' can be combined to provide the percentage of negative responses, while the responses for 'Agree' and 'Strongly Agree' can be combined to yield the percentage of positive responses. Thus, the five-option scales presented in Table 4-8 can be reduced to a three-option scale with negative, neutral and positive responses.

Table 4-8: Examples of Likert-type Response Formats (Hayes 1990)

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Very Dissatisfied	Dissatisfied	Neither Satisfied nor Dissatisfied	Satisfied	Very Satisfied
Very Poor	Poor	Neither Poor nor Good	Good	Very Good

Since the Likert-type scale is able to distinguish between the negative and positive responses generated from a checklist format, and the five response Likert-type scales are more reliable than the two-option checklist scale, a scale similar to the Likert-type scale was used to develop the baggage-handling questionnaire. However, since a six level of service scale has been widely used in traffic engineering applications and has been

suggested for airports (Table 4-1), it was selected as the most appropriate scale for the baggage-handling questionnaire. As previously mentioned, the six levels of service are excellent, high, good, adequate, inadequate, and unacceptable. These levels could be considered to include four positive responses (excellent, high, good, and adequate) and two negative responses (inadequate and unacceptable). This six level of service scale was compared against a traditional scale from 0 (unacceptable) to 10 (excellent) to ensure that respondents were able to distinguish between the six categories.

(c) Step Three: Writing the Introduction

As with the specific statements within the questionnaire, the introduction should be clear and concise. The introduction should contain the purpose of the questionnaire; how the data will be used; brief, but clear instructions for completing the questionnaire; and a short explanation for the chosen scale. People are more interested in filling out the questionnaire and respond with greater accuracy if they are aware of the purpose of the questionnaire and how the information will be used. If the customer feels his or her opinion is valued and will increase the quality of the service or product, they put more effort into their responses, thus creating a more reliable and useful set of data for product improvements. Any redundant questions, those that appear outside the scope of the questionnaire, or those questions that seem very similar to each other should be commented on in the introduction.

(d) Step Four: Final Item Selection

When the critical incident approach is used to develop satisfaction items or the quality dimension development approach is used to develop specific examples of quality dimensions it is possible to compile a list containing more statements than are necessary (Hayes 1998). When only a few satisfaction items or specific examples are collected all can be used in the final questionnaire. Otherwise, removing items from a small list reduces the reliability of the questionnaire study. When there are time restrictions on the number of possible statements, two methods are available to reduce the number of items to a manageable level: human judgement and mathematical indices (Hayes 1998).

Method One: Judgmental Item Selection

This method involves using the best judgement of the questionnaire designer to include the items that best represent the customers' requirements. Two individuals from the product or service provider should be selected to independently choose a specified number of satisfaction items from the original list developed. Those items selected in common should be retained in the revised smaller list. If there is low or no agreement between the satisfaction items selected by the two individuals, then all items are equally good indicators of the customers' requirements. In other words, people completing the

questionnaire would be unable to distinguish between the items and therefore, any of them could be used in the final questionnaire. If there is no agreement between the items selected by the two individuals, a method of random selection should be used. Since all satisfaction items are equally good indicators, any random selection from the original large list would be a representative sample. Other than a random selection, the odd or even satisfaction items from the original list could be selected for the final questionnaire.

Method Two: Mathematical Item Selection

The mathematical item selection method is more demanding, both in terms of time and effort, than the judgmental selection method. The objective of this method is to retain satisfaction items that differentiate between satisfied and dissatisfied customers. This method involves administering the entire questionnaire to a number of actual customers. The results are then analyzed for correlation between the individual satisfaction items. Although more labor intensive, this method provides results which are more mathematically reliable.

Item total correlation is the correlation between one item and all the remaining items in that quality dimension (Hayes 1998). For example, correlation between one satisfaction item and all satisfaction items within the quality dimension of 'responsiveness'. If three satisfaction items existed within the quality dimension of 'responsiveness', the

correlation between item 1 and the sum of items 2 and 3 would be calculated. Also, we would calculate the correlation between item 2 and the sum of items 1 and 3, and the correlation between item 3 and the sum of items 1 and 2. The item with the lowest correlation with the other satisfaction items in that quality dimension would be removed.

A second mathematical method used to remove items is the group differences approach (Hayes 1998). Again, actual customers complete the original lengthy questionnaire and two specific groups of respondents are compared. For each quality dimension (i.e. professionalism, responsiveness) the top and bottom 10 percent of the survey sample are selected to form two groups of respondents representing the two extreme attitudes of dissatisfied and satisfied. For each satisfaction item within the quality dimension, a mean is calculated for each group. Then for each item, a *difference score* is calculated as the difference between the high mean of the satisfied extreme group and the low mean of the dissatisfied extreme group. The *difference score* reflects how the attitudes of the two groups can be differentiated for each satisfaction item. The higher the score, the better the item can differentiate between the two extreme attitudes. A difference score of zero indicates that the satisfaction item did not differentiate between the two groups. Satisfaction items with low and zero difference scores can be removed from the questionnaire. Both methods result in similar outcomes (Likert 1932).

(e) Step Five: Final Questionnaire Design

A few general rules should be followed when creating the final version of a questionnaire. The title of the research study should appear in bold letters on the first page of the questionnaire. This should be followed by the introduction and then a few simple questions to get the respondent interested. Questions should be numbered and organized into logical sections. Smooth transitions should be made between these sections. Empty spaces should be left to avoid overcrowding the questionnaire. For double-sided questionnaires, as was the case with the baggage handling questionnaire, 'Please turn over' or 'P.T.O.' should be included on the bottom of the first page (Berdie 1986).

During the research, all developed satisfaction items were considered equally important and were included in the final questionnaire. They included walking time and distance, expected and actual waiting times, conveyor frontage, overall space, seating, and personal comfort and safety. An important criterion for developing the questionnaire was the total length of time that was required by a passenger to complete it. A duration of four to five minutes was selected as the maximum reasonable length of time that a traveler would be willing to spend completing a questionnaire in the reclaim area.

The quality dimension development approach (Hayes 1998), the first method described, was the main method used to develop the important quality dimensions. Possible factors affecting the passenger's perceived LOS were obtained from scientific journals (Brunetta et al. 1999; Mumayiz and Ashford 1986; Park 1999; Mumayiz 1991), while discussions were held with individuals involved with the day-to-day aspects of baggage handling. Specifically, a number of employees from both airlines and ground handling companies were consulted. Once the important quality dimensions were determined, specific examples were developed to describe these dimensions. Both subjective (using a scale of excellent to unacceptable) and objective (expected and actual waiting time) questions were included in the survey.

Following these steps, an initial questionnaire was developed and circulated to professionals attending a conference in London, Ontario in June of 2000. The responses obtained, which included comments, were used to modify the questionnaire in a number of ways. Changes were made to simplify the language (the phrase 'reclaim device' was changed to 'conveyor belt'), to remove an unanswerable question (arrival gate number?), and to rearrange the layout for clarity.

The final questionnaire was a two-page document with a brief introduction and three sections. The first section contained flight information questions, the second section determined personal information, and the third section contained straightforward

statements and questions to determine the LOS perceived by the passenger. The questionnaire can be found in Appendix A.

4.4.3 Desired Response Rate

The response rate is a ratio of the actual number of respondents to the number of questionnaires that were originally distributed. Berdie (1986) indicated that a response rate in excess of 90% was a high rate. Where the questionnaire is carried out as an interview, the response rate is determined by recording the number of people *asked* to fill in the survey and the number of actual interviews completed. A common error made in the past has been to incorrectly record that a 100% response rate was obtained when the total number of questionnaires required (say 150) was achieved. In this case, people are interviewed *until* 150 individuals agree. Therefore, the number of questionnaires required is reached, thus leading to a very high, but incorrect response rate.

The calculation of response rates can be based on the entire questionnaire as a whole or can be broken down by section or by question. The benefit of calculating the response rate on a per question basis allows partially completed questionnaires to be used.

Collecting data from a sample instead of the entire population is efficient both in terms of time and money. Berdie (1986) found that using a sample improves the quality of a

survey because it is easier to get a high response rate from a smaller sample rather than the entire population. Additionally, a non-response bias, the result of not getting a high response rate, results in a larger bias than a sampling error, the result of using a sample to represent the population.

4.4.4 Interview Skills

Two important criteria determine whether a high response rate will be obtained during an interview method of data collection. First of all, the intended respondents must be successfully contacted. The time of day or day of week that the attempt to contact individuals is made affects the number of people reached. Also, the amount of resources available determines how many attempts can be made to contact the intended respondent. For telephone interviews, can a second and third phone call be placed?

The second important aspect of obtaining a high response rate is the ability of the interviewer to convince the intended respondent to complete the questionnaire. The professionalism of the interviewer, the verbal introduction and the response format affect the interest of the intended respondent. The interviewer must act in a professional and experienced manner, while conveying the importance of the study and the importance of the respondent's input. Research has shown that age (Singer et al. 1983), sex (Begin et al. 1979, Dillman et al. 1976) and race (Weeks and Moore 1981) of the interviewer can

affect the response rate. The verbal introduction should be restricted to a couple of short and direct questions conveying the importance and purpose of the study. The questionnaire layout, length and response format affect people's interest levels and should be simplified as much as possible.

During this research, there was but one chance to make contact and convince the passenger to complete the study. Passengers were randomly selected to complete the questionnaire as they arrived in the reclaim area. The author's experience validated the research done by Singer et al. (1983), Begin et al. (1979) and Dillman et al. (1976) in that female passengers and older passengers were less likely to agree to fill in the questionnaire. Male passengers, regardless of age, were less likely to refuse unless they had time constraints, such as a connecting flight. As the research was conducted with serious time constraints, an attempt was made not to discriminate based on gender or age when asking people to complete the survey, knowing that an older female was more likely to decline. During the research it was found that "a personal approach coupled with professional quality" (Berdie 1986) was the most effective method of convincing passengers to complete the questionnaire.

Chapter Five

5 DATA COLLECTION FROM SELECTED AIRPORTS

A selected group of airports was solicited to participate in the research study and provided data for the thesis. Once the study group was confirmed, the process of collecting data from specific airports was initiated. This chapter describes the airport selection process, the methods used to collect data from these airports, and describes the BHS characteristics of each airport within the selected study group.

5.1 Airport Study Group

As mentioned in Chapter 2, the Canadian airport system includes ten major international airports and over 300 smaller commercial airports. While many of these airports have less than 200,000 annual passengers, both the Vancouver and Toronto airports have more than 15 million annual passengers. The Canadian airports vary not only in passenger traffic levels, but also in the amount of freight transported and the number of annual aircraft movements. With so many variables, the selection process was based on two criteria: airport passenger levels and distribution within the country. The 1999 passenger levels (Table 5-1) were used to select the initial airport study group encompassing small, medium and large airports.

Nine airports within Canada were selected as possible airports to form the study group for this thesis research. Of the nine airports selected, three were considered to be small in size, while five were considered to be medium in size and one large in size. The selected airports were distributed across the country from Victoria, British Columbia, on the west coast, to Ottawa, Ontario, in the center, to Halifax, Nova Scotia on the East coast and thus formed a comprehensive representation of small, medium and large airports within Canada. The nine preliminary airports were:

- ◆ Victoria Airport
- ◆ Calgary International Airport
- ◆ Edmonton International Airport
- ◆ Thunder Bay International Airport
- ◆ Toronto International Airport
- ◆ Ottawa International Airport
- ◆ Dorval International Airport
- ◆ Charlottetown Airport Authority
- ◆ Halifax International Airport.

Table 5-1: Passenger Numbers for Canadian Airports in 1999 (Airports Council 1999)

City	1999 Passengers	Airport ¹ Size	Accepted for Study
Toronto, Ontario (YYZ)	27,779,675	L	*
Vancouver, British Columbia (YVR)	15,982,532	L	
Montreal, Quebec (YUL – Dorval)	8,297,614	M	*
Calgary, Alberta (YYC)	7,800,362	M	*
Edmonton, Alberta (YEG)	3,651,155	M	*
Ottawa, Ontario (YOW)	3,215,723	M	*
Winnipeg, Manitoba (YWG)	2,919,950	M	
Halifax, Nova Scotia (YHZ)	3,084,622	M	
Victoria, British Columbia (YYJ)	1,194,474	S	
Montreal, Quebec (YMX – Mirabel)	1,292,624	S	
Thunder Bay, Ontario (YQT)	518, 043 ²	S	*
Charlottetown, P.E.I. (YYG)	187,277	S	
Hamilton, Ontario (YHM)	22,561	S	

Notes:

1 - Size of airport L= Large, M= Medium, S= Small

2 - Thunder Bay Airport Authority.

These nine airports were contacted through the use of telephone, ground mail and electronic mail. The Edmonton, Calgary, Thunder Bay, Toronto, Ottawa, and Montreal airport authorities responded with enthusiasm and agreed to be part of the research study group. The Victoria Airport Authority responded with regret due to the present state of construction at the airport. Although numerous attempts were made to contact the Charlottetown and Halifax Airport Authorities, a response was never received and thus, they were eliminated from the study group. The final research group consisted of six airports including Calgary International Airport, Edmonton International Airport, Thunder Bay International Airport, Toronto Lester B. Pearson International Airport, Ottawa Macdonald Cartier International Airport and Dorval International Airport.

5.2 Method of Data Collection

The information concerning the baggage handling system at the six selected airports was collected by three methods: communication with the airport authority and the baggage handlers for general information, a tour of the terminal building and the distribution of numerous passenger questionnaires during the site visit. Communication with the airport authority and the terminal tour provided information specific to the airport regarding passenger levels and the baggage handling system. The data collected from the questionnaires was in regards to the level of service perceived by the passengers. The methods of data collection are described below.

5.2.1 Physical Airport Characteristics

Upon arrival at each airport, a meeting was held with the airport authority contact with whom communication had previously taken place. Information collected during the meeting and throughout the tour was related to the peak periods, physical airport layout, the equipment & methods used to transport baggage throughout the terminal building and other general information. Interviews were also held with baggage handlers and airline personnel to collect information about the operation of the baggage handling system and the service provided by it. These individuals also provided standard baggage delivery times (when known). Appendix B provides forms that were used to collect data from these individuals and organizations.

Information that was obtained during the tour and/or the discussions included the following:

- ◆ Distance between each arrival gate and each conveyor belt,
- ◆ Time to walk between each arrival gate and each conveyor belt,
- ◆ Names of baggage handling companies operating at each airport,
- ◆ Type of sorting area used,
- ◆ Type of sorting method used,
- ◆ Total number of aircraft gates,
- ◆ Total number of conveyor belts,

- ◆ Peak periods,
- ◆ Annual number of passengers,
- ◆ Unloading baggage standards (if available), and
- ◆ Other information about the baggage handling system and reclaim devices.

For each reclaim device that was observed operating during the research period, information concerning the device was collected. Recorded information included: style and layout of the conveyor belt, the type of flights using the belt, the accessible length of the belt, the size of the area surrounding the conveyor belt (that arriving passengers and greeters used), and the number of seats located adjacent to the conveyor belt.

The information noted above was collected at each airport and was used to determine the physical aspects of the baggage handling system currently provided. Many of these variables were also used to determine the LOS being provided by the baggage handling operators, the airlines, and the airport authority.

5.2.2 Level of Service Perceived by Passengers

As mentioned above, discussions were held to determine the quality of service being provided by the airlines, airport authorities and baggage handlers. Of greater importance, was the level of service perceived by the passenger. A questionnaire was used to

determine this LOS. The questionnaire (Appendix A) contained general questions related to the flight number, date, airline, route, etc; personal questions such as age category, gender, and number of flights taken per year for categorizing the respondents at a later date; and, finally, information to evaluate their perceived LOS. The questionnaire was two pages in length and a passenger spent approximately five minutes completing it. The questionnaire was distributed in the appropriate reclaim areas for domestic, international and transborder passengers. The questionnaire was administered during both peak and off-peak periods. The tables in Appendix C provide information about the flights that were observed during the research.

Upon arrival in the reclaim area, passengers were approached and a brief introduction was made. Willing passengers were given a clipboard with a questionnaire and a pen. Most of the questions were completed as the passenger waited for baggage to arrive, while a few questions had to be completed *after* their specific item(s) of baggage arrived. The clipboards and questionnaire were collected upon completion.

While questionnaires were being distributed, other data items were collected. Appendix B contains the forms that were used to collect this additional data. For each flight, the following items were recorded:

- ◆ Flight number and origin
- ◆ Conveyor belt number

- ◆ Time of arrival of first item of baggage
- ◆ Time of arrival of last item of baggage (if possible)
- ◆ Time of arrival of the first passenger
- ◆ Number of people in reclaim area at various time intervals following the arrival of the first passenger, and
- ◆ Time of departure of last passenger from reclaim area (for Edmonton only, due to adequate time spacing between flights for the collection of this statistic).

Following the departure of the last passenger, the airline provided the actual flight arrival time, the number of passengers exiting the aircraft, the number of bags being unloaded from the aircraft, and the arrival gate number. The information listed in the two previous sections (obtained from discussions, a tour and the questionnaire) was input into a statistical software package to compare, evaluate and analyze.

5.3 Summary of Data Collected from Study Group

Characteristics of the six Canadian airports that formed the study group, organized by increasing annual passenger volumes, are discussed in the following sections. Section 5.4 provides a comparison of these airport attributes. The results from the questionnaire are discussed in a subsequent chapter.

5.3.1 Thunder Bay International Airport (YQT)

Thunder Bay is the largest metropolitan center in all of Northern Ontario, with a city population is 113,662. The city includes two major educational institutions: Lakehead University and Confederation College. Located just 50 kilometres from the Canada/U.S.A. border, Minneapolis/St. Paul is the nearest major U.S. center at a distance of 545 kilometers. Winnipeg, Manitoba is the closest major Canadian city at a distance of 715 kilometers. In Ontario, Toronto is located at a distance of 1385 kilometers and Ottawa at 1505 kilometers from Thunder Bay (Development Thunder Bay 2000).

The third busiest airport in Ontario, Thunder Bay International Airport transported 518,043 passengers in 1999 (Thunder Bay Airport Authority). Domestic, regional and international airlines provide approximately 80 flights per day (Table 5-2). The international arrivals include two Northwest arrivals from Minneapolis daily. A recent introduction by WestJet is the non-stop service to Ottawa and Winnipeg, which started on November 20, 2000.

An evaluation of the Thunder Bay International Airport (TBIA) was undertaken between Wednesday November 15th and Friday November 17th, 2000. The TBIA includes a new terminal building, constructed in 1994, which is expected to provide a satisfactory level of service beyond the year 2015 (Transport Canada 1996). The building provides check-

in and baggage reclaim facilities on the ground level as well as arriving passenger entrances from the apron area for passengers arriving on smaller non-jet aircraft. The second level is equipped with arrival gates for larger jet aircraft, departure gates, departure lounge areas and some retail establishments.

Table 5-2: Airlines serving Thunder Bay International Airport

Airlines
Air Canada
Bearskin Airlines
Mesaba-Northwest Airlink
Nakina Air
Wasaya Airways
WestJet Airlines

The simple baggage handling system is very efficient for Thunder Bay's small airport size. Each airline (Table 5-2) has baggage handlers to undertake the individual needs of their airline's flights. Generally, for departure baggage, each airline is provided with a simple conveyor belt at their check-in counter to transport baggage to a small sort room (located directly behind the check-in counter). This is the basis of a decentralized sorting area. The baggage is manually sorted and subsequently transported to the aircraft using

motorized carts. Upon arrival, baggage is transported by cart to a secure area adjacent to the conveyor belts. Baggage is then placed on one of three belts provided on the ground level of the terminal building for use by all airlines.

Two racetrack-style reclaim conveyor belts are used for domestic baggage, while the third racetrack-style conveyor is generally used for the international flights. During the two days that research was carried out at the TBIA, the second conveyor belt (#2) for domestic baggage was only once seen distributing baggage. It was observed that the first domestic conveyor belt (located closest to arrival gates) was primarily used and was found to be adequate for the majority of time. The third conveyor belt (located nearest to the international flights) was used for the two daily international flights originating in Minneapolis, Minnesota.

Thunder Bay International Airport experiences peak travelling periods on Mondays, Thursdays and Fridays from 10:00 a.m. until 11:00 a.m. and from 3:30 p.m. to 4:30 p.m. The busiest months for travelling are March, July, August, October and December. Management strategies being implemented by Air Canada are affecting these peak periods as efforts are being made to increase capacity and even out the peak periods. One strategy includes having discount flyers travel at off-peak times.

5.3.2 Ottawa Macdonald Cartier International Airport (YOW)

The Ottawa Macdonald Cartier International airport was introduced in section 3.2 during an initial site visit. A subsequent visit, for the purpose of level of service evaluation, was conducted between Thursday September 7th and Friday September 8th, 2000. Some additional information, which pertains to the level of service, is provided in the following section. There are 12 gates at the Ottawa airport that can be converted to 23 total gates when required. According to the marketing representative at the Ottawa airport, the peak hours are from 6:00 to 9:30 a.m. and from 3:00 to 6:00 p.m. The busiest days are Thursday and Fridays while the busiest months at the Ottawa airport are June and October. The peak hour number of passengers is approximately 2000 and the total size of the reclaim area is approximately 1000 m².

The Ottawa airport authority is planning a \$300 million expansion and expects it to be completed by the spring of 2004 (Prentice 2001). Half of this amount will be invested in a bright and spacious new terminal, complete with a public observation area overlooking the arriving and departing aircraft. A multi-level 1700 vehicle parking garage will be linked by enclosed walkways to the new terminal, located West of the existing terminal. The construction, begun in May 2001, will create a terminal twice the size of the existing one. Once the new terminal is operational, the existing terminal will only be used if needed. Future plans are to demolish the existing terminal in 2010 at which time an

extension can be built onto the new terminal. Currently handling about 3.5 million passengers annually, it is anticipated that 6.5 million people will use the airport annually by 2004. Of this number, about 4 million will be passengers while about 2.5 million are expected to be greeting or saying goodbye to passengers.

The baggage handling conveyor systems at the Ottawa airport were manufactured by Matthew Conveyor Systems. Apart from the conveyor belts used to transfer baggage between locations within the airport terminal, there are five conveyor belts used to circulate inbound and outbound baggage to/from the passengers. Of these five conveyors, only the three conveyors (#1, #2, and #3) located in the domestic arrival reclaim area were observed during the site visit. The fourth belt is located in the U.S. Customs area and is used for departures, while the fifth belt is located in the Canadian Customs area for arrivals. Conveyor belt #1 is an inbound pallet loop conveyor used by Air Canada. It has a capacity of 100 bags, is 60 metres (196 feet) in length and moves at a speed of 30 metres per minute (98 feet per minute). Conveyor belt #2, used by all other airlines, is an inbound inclined baggage dispenser. The inclined dispenser is 70 metres (228 feet) in length, moves at a speed of 41 metres per minute (135.4 feet per minute) and has a capacity of 150 bags. Conveyor belt #3, also used by all other airlines, is an inbound pallet loop conveyor. It measures 60 metres (197.5 feet) in length, moves at a speed of 28 metres per minute (91.98 feet per minute) and has a capacity of 100 bags. Conveyor belt #4, located in the Canadian Customs area, is an inbound inclined baggage dispenser. The

inclined dispenser measures 36.5 metres (120 feet) in length, moves at a speed of 40 metres per minute (131.2 feet per minute) and has a capacity of 100 bags. Conveyor belt #5, located in the U.S. Customs area, is an outbound pallet loop conveyor. It measures 53 metres (175 feet) in length, moves at a speed of 30 metres per minute (96.67 feet per minute) and has an 80 bag capacity.

5.3.3 Edmonton International Airport (YEG)

Edmonton, Alberta, is approximately 290 kilometres north of Calgary, Alberta. Greater Edmonton, with 36 municipalities, is a metropolitan centre with a population of 919,413 in 2000 and an area of 9,537 square kilometres (Economic Development Edmonton, 2000). The City of Edmonton had a population of 616,306 in 1996 (Statistics Canada 1996) and has one of the lowest densities of any North American city. Based on a land area of 670 square kilometres, it is Canada's fifth-largest city.

Situated in the City of Leduc, Edmonton International Airport (EIA) is adjacent to the major highway linking the cities of Edmonton and Calgary. The airport lies about 5 kilometres south of the Edmonton city limits and about 25 km south of the downtown area. EIA is the fifth busiest airport in Canada by passenger volume and is Canada's most northerly 24 hour international airport. With an area of more than 7000 acres, EIA is the second largest airport in Canada measured by land area. Ideal flying conditions are an

important feature of the EIA. On average, the airport is fog-free 99% of the year and during the last 10 years, the airport has only been closed for 3 hours due to snow conditions (Edmonton Regional Airports Authority, Facility Information, 1999b). The four airports in the vicinity of Edmonton, including EIA, are operated by the Edmonton Airports Authority, which has a 50-year lease agreement with Transport Canada.

To accommodate the 116,868 aircraft movements recorded in 1999 (Airports Council 1999), the airport has two runways in an open “V” configuration. Each runway measures 61 metres in width and they are 3350 metres and 3100 metres in length. Although the airport can accommodate any size of aircraft, the typical aircraft using the airport include B727, B737, B747, B757, B767, DC8, DC9, DC10, A310, A320, F27, F28, DH7, and DH8’s. The ground handling crews can turn around (unload and prepare) a B747 in 34 minutes (Edmonton Regional Airports Authority 1999b).

Typically, the peak operating times include the months of July and August and the two weeks around Christmas. During 1999, the busiest months for passenger traffic were July and August with 343,762 and 366,243 passengers per month respectively (Edmonton Regional Airports Authority 2001). The peak days are Thursday through Sunday and the peak hours are from 7:00 to 9:00 a.m. and from 5:00 to 9:00 p.m. Domestic passengers form between 81% and 87% of the total passenger levels (Edmonton Regional Airports Authority 2001).

The original Edmonton airport terminal was constructed in 1963 to accommodate 2.5 million people annually. Since that time, the airport has seen a continuous increase in passenger traffic levels. During 1999, 3.65 million passengers (Airports Council 1999) used the airport facilities and it is anticipated that by the year 2015 passenger growth could reach 5.7 million. Thus, the Edmonton Airports Authority has commenced an Air Terminal Redevelopment Project (ATR) to accommodate future traffic growth by more than doubling the terminal size and apron area (Edmonton Regional Airports Authority, 1999a).

Before the ATR project was initiated, approximately 40% of the airport systems were operating at an IATA level of service less than C and many airport systems were operating at an IATA level of service of D and E. Generally, the EIA authority engineering and planning division designs new systems for a LOS of B, but will accept service if it declines to a LOS of C. Once the system is operating at a LOS of C, system modifications are initiated.

The first phase of the ATR was completed in December 1998 at a cost of \$42 million. It involved the construction of an 1800 stall four-storey covered parking garage with a car rental centre. Other airport modifications completed during the first phase included roadway improvements and repairs to the original terminal roof and ceiling.

Begun in June 1999, phase II of the ATR was completed and opened for passenger use in December 2000. It involved the construction of a new terminal for international and domestic flights at a cost of \$131 million. The new terminal is located southeast of the existing terminal and incorporates new Canadian and United States customs and immigration facilities, extra gate positions, passenger holdrooms and retail facilities. The construction work also included apron expansion and roadway improvements.

Phase III is the future construction of the Central Hall connecting the original and new terminal buildings. The Central Hall will include food and beverage services, retail concessions, central security processing, an information booth, an observation deck and a children's play area.

Phase IV involves future modifications to the original terminal building. Improvements will be made by using colours and finishes similar to the new terminal, by adding modern furnishings, and by upgrading both signage and lighting.

An evaluation of Edmonton International Airport was conducted between Tuesday January 16th and Thursday January 18th, 2001. Both the new southeast terminal and the original terminal separate departing and arriving passengers vertically by floor level. The lower level provides baggage reclaim areas equipped with baggage conveyors for arriving passengers and their guests. Check-in areas are located on the second level for

departing passengers. Various retail and food services are provided throughout the building with the majority currently located on the second level of the original terminal building. Airlines operating out of the Edmonton International Airport are listed in Table 5-3.

Table 5-3: Airlines Operating at Edmonton International Airport

Air Canada	LOT Polish Airlines
Air Jasper Charters and Air Tours	Martinair
Air Transat	Northwest Airlines
Canada 3000	Royal Airlines
Canadian North	WestJet Airlines
Horizon Air	

The completely manual baggage handling system uses conveyor belts and carousels to efficiently transport baggage throughout the airport. As part of the ATR, a new baggage handling system was implemented in the new terminal at a cost of \$5.5 million. The conveyor belt systems were designed and are maintained by GNS Mechanical, a Calgary based firm. Except for the check-in belts that travel at 49 metres/minute (160 ft/minute), all other conveyor belts travel at 27 metres/minute (90 ft/minute). Air Canada baggage handling personnel estimated that approximately 5 million bags were handled in 1999 (this is based on 1.4 bags per passenger and 3.65 million passengers per year).

Departure baggage enters the baggage handling system on the second level and is transported by conveyor belts to the lower level. In the new terminal, there are two main departure baggage sorting areas operated by Air Canada, each containing a large carousel for manual sortation. One area is used for transborder departure baggage that has already cleared U.S. Customs. The other room is used for domestic and international departure baggage. The old terminal contains two manually operated sort rooms: WestJet uses one, while Royal, Canada 3000 and Air Transat share the second. Although EIA has a low amount of transfer baggage, conveyor belts are in place to circulate transfer baggage to the appropriate areas. Ground handling companies at the EIA include Hudson General Aviation Services, ATS (previously known as Can Com Air) and Air Canada. Hudson General handles Canada 3000 flights, ATS handles WestJet flights and Air Canada handles the remainder of the flights.

Arrival baggage is transported to the terminal and placed on one of nine conveyor belts. Priority baggage is not always differentiated from regular baggage because with a single trip, all baggage can be brought to the terminal building within the excepted time limits. The international reclaim area, located in the new terminal, contains two large carousel style conveyor belts (numbers 2 and 4). These identical conveyor belts are 1.2 metres (4 feet) longer than any other conveyor belts operating at Canadian airports and can each handle baggage from a full 747 flight. Located within a four-metre distance of the

carousel, one conveyor belt provides 8 seats while the other conveyor belt has 16 seats with unobstructed views. The domestic reclaim hall in the new terminal, used for Air Canada flights, contains two identical racetrack-style conveyor belts (numbers 6 and 8). Both the international area and the domestic area in the new terminal building are spacious and well lit. This is aided by a minimum ceiling height of 3.6 metres (12 feet), while the minimum ceiling height in the old terminal is 3.0 metres (10 feet). The new terminal provides a large amount of edge space along the conveyor belt, and has electronic display boards to indicate which flight's baggage is circulating on the belt.

The older terminal contains an additional five reclaim conveyor belts. WestJet Airlines uses two racetrack-style conveyor belts (numbers 12 and 14). Air Transat, First Air, Canada 3000 and Royal Airlines share the other three belts. Plenty of seating (53 seats in total) is provided around the conveyor belts used by WestJet and all conveyors have electronic display boards immediately overhead. The reclaim area is not as spacious, modern or well lit as in the new terminal.

5.3.4 Calgary International Airport (YYC)

Calgary, Alberta is located in the foothills of the Rocky Mountains at a distance of 673 kilometers from Vancouver, British Columbia. It is situated about 3 hours from the Saskatchewan border, 2 hours from the British Columbia border and approximately 4

hours north of the U.S. border (About.com, Inc. 2000). With a population of 842,388 in April 1999, Calgary is the 6th largest city in Canada by population (City of Calgary, City Clerks Department, Civic Census 1999).

Calgary's international airport was built on 21 square kilometres of land which is located 17 kilometres northeast of Calgary's business district. Calgary's main runway (16-34) is the largest civil aviation runway in Canada with a length of 3,863 metres. More than 75 million passengers have used the Calgary International Airport since it was first opened in November 1977. During 1999, more than 7.8 million passengers used the airport and over 248,000 aircraft movements took place. By the year 2006 annual passenger levels are expected to reach 10 million and by 2007 the number of aircraft movements is expected to reach 300,000 annually. More than 50 million people located within a 24-hour drive are served by Calgary's international airport. In July 1992, the Calgary Airport Authority was created to oversee the management, operation and expansion of the airport. The authority has a six-year lease with the Federal Government and is fully responsible for the airport's operating and capital expenses (Calgary Airport Authority 2000).

In a survey completed at Calgary's airport, it was found that 54% of travelers were male and 46% were female (Calgary Airport Authority 2000). The average traveler was found to be 38 years of age, making an average of 8.2 trips annually and having an average household income of \$71,000.

A visit was made to the Calgary International Airport between Tuesday October 24th and Thursday October 26th, 2000. The three-storey terminal building contains 77 passenger check-in positions on the second level, four aircraft concourses, 18 aircraft loading bridges, and 17 ground loading positions. Approximately 200 independent companies, providing various aviation-related services, are located at the airport (Calgary Airport Authority 2000). The airport provides direct employment to almost 14,000 people living in the Calgary area. Table 5-4 lists the airlines currently serving Calgary's International Airport.

Three individual baggage handling companies operated at the airport. Air Canada transported baggage to and from Air Canada flights; Can Com Air transported baggage for WestJet Airlines; and Hudson General Aviation Services transported baggage for the other airlines. For departure baggage, all checked bags were transported on conveyor belts to a large sorting area at the East end of the terminal. From there, they were sorted and transported to the aircraft using carts and cans (or containers). Baggage was sorted both manually and semi-automatically. Calgary commonly uses three sizes of cans depending on the size of storage area available in the aircraft. The first size used was a full container that was as wide as the body of the aircraft (commonly used for A320, F28, B737 aircraft) and carried about 40 bags. The second size was as high as the first container, but only half the width of the aircraft body (B767). The third size was half as

wide as the body, but taller than the first two sizes described (A340) and fit about 50 bags.

Table 5-4: Airlines serving Calgary International Airport

Airlines	
Air BC	Delta Airlines
Air Canada	Horizon Air
Airtours	JAL
Air Transat	Lufthansa
Alaskan Airlines	Martinair
American Airlines	Northwest Airlines
Britannia	Peach Air
British Airways	Royal
Capital City Air	SAS
Canada 3000	Skyservice
Central Mountain Air	United Airlines
Continental Airlines	WestJet Airlines

The arrival baggage was transported to one of three sorting areas where baggage was then transferred to one of three baggage reclaim halls located on the lower level of the terminal. WestJet Airlines had the exclusive use of one sorting area and reclaim area at

the West end of the terminal. The sorting area led baggage via conveyor belts to a reclaim hall containing two domestic racetrack-style conveyor belts (#5 and #6). International baggage was transported to a secure sorting area near the centre of the terminal. The sorting area was linked by conveyor belts to a reclaim hall where two carousel-style conveyors (#7 and #8) and one linear conveyor belt were available for use by the international airlines. The remaining domestic baggage was transported to the largest sorting area located at the East end of the terminal building (same area used for departure baggage). This sorting area had conveyor belts leading to a reclaim area at the East end of the terminal where four carousel-style domestic conveyor belts (#1, #2, #3, #4) were available for the use of all other airlines. Beside each reclaim conveyor belt was an electronic display board where flight number and origin were displayed indicating which flight's baggage was being placed on the conveyor belt.

The baggage delivery standards used by Canadian Airlines prior to amalgamation were that flights on narrow-bodied aircraft (< 6 seats across) were to have priority baggage unloading within 7 minutes and regular baggage unloaded within 17 minutes. For wide-bodied aircraft (> 6 seats or any aircraft using cans) the priority bags were to be unloaded within 10 minutes and the regular bags within 25 minutes. Although these standards are not identical to those provided by a Hudson General employee at the Ottawa airport (Section 3.2.6) they are quite similar. In Ottawa, Hudson General used 5 minutes for priority bags instead of 7 minutes, and aircraft with more than 6 seats had regular

baggage delivered between 12 and 23 minutes, instead of 10 and 25 minutes. Since amalgamation of the two airlines occurred immediately prior to the Calgary airport visit, the baggage delivery standards used by Canadian Airlines and based on the number of seats across the aircraft body were still being used. According to an Air Canada employee (previously with Canadian Airlines) these unloading rates were usually achieved.

At the time of the visit, one problem being resolved was the amount of transfer baggage arriving on the Canadian Regional flights (operated by Air Canada). The transfer baggage was taking priority over the local baggage and thus the local bags were taking longer to arrive on the reclaim conveyor belts. To alleviate the problem, the Air Canada baggage handlers decided to implement a *local* bag runner for the regional flights to concentrate on transferring local bags from the aircraft to the terminal. Other Air Canada baggage handlers were designated to transport the transfer baggage to the appropriate aircraft. This demonstrated the expeditious implementation of solutions to problems arising from the Air Canada and Canadian Airlines amalgamation process.

5.3.5 Dorval International Airport (YUL)

Some aspects of the baggage handling system, including information about mishandled baggage, were described previously in Section 3.1 following an initial visit on Thursday December 9th, 1999. A subsequent visit was made to the Dorval International Airport on

Thursday September 21st and Friday September 22nd, 2000. During the second visit, the questionnaires were distributed and specific flight and baggage handling system information was obtained. For simplicity, all airports are referred to in this paper by their geographic location, and thus, the Dorval International Airport is referred to as the Montreal Airport.

The semi-automated baggage handling system has a centralized baggage sortation room for distribution of baggage to and from the departure and arrival gates. The 45 gates are located in three main areas within the airport facility. The first area is for domestic departures and arrivals. The second area, located at the opposite end of the terminal, is for international and transborder departures and arrivals. The third area is a remote section for arrivals and departures that is used by domestic flights at one end, and transborder & international flights at the other end. A number of gates in each area are assigned to certain airlines for their exclusive use. Table 5-5 lists the airlines that operate at the Dorval International Airport.

According to the coordinator of Public Affairs and Communications at Montreal-Dorval International Airport the busiest periods are between 5:00 and 8:00 p.m. Monday through Friday during the entire year.

Table 5-5: Airlines serving Dorval International Airport

Air Alma	Canada 3000	Northwest Airlines
Air Canada	Continental Airlines	Olympic
Air Creedec	Czech Airlines	Romanian
Air France	Delta Airlines	Royal Airlines
Air Inuit	Egypt Air	Royal Air Maroc
Air St-Pierre	El-Al	Royal Aviation
Air Transat	First Air	Sabena
Aeroflot	Hydro-Quebec	Swissair
American Airlines	KLM	US Air
British Airways	Mexicana	

While conducting the thesis research, it was observed that the international reclaim area was very congested during peak periods. Although six conveyor belts were provided, including four very large carousel and racetrack style conveyors, the area was insufficient for the volume of passenger traffic attempting to identify personal baggage. The flow of passengers (with carts and baggage) departing from the area after collecting baggage was impeded by the passengers (and carts) still waiting to collect baggage. There was essentially gridlock due to the high volume and the cross flow of traffic.

5.3.6 Toronto Lester B. Pearson International Airport (YYZ)

Toronto, Ontario's capital city and the largest metropolitan area in Ontario, is located on the north shore of Lake Ontario. In 1996, the population within the city was approximately 654,000 while the population of the census metropolitan area was nearing 4.3 million (Statistics Canada 1996). Toronto's Lester B. Pearson International Airport (LBPIA) was evaluated between Wednesday November 29th and Saturday December 2nd, 2000.

Toronto's LBPIA is located 27 kilometres north west of the downtown area, just north of Highway 401 and south of Highway 407 (the two major east-west links traveling north of Toronto). Although two airports exist in the area of Toronto, LBPIA has been the main airport since 1939 and was originally called Malton Airport. (The second airport is located on Lake Ontario in downtown Toronto.) The airport covers 1792 hectares (4492 acres) of land. Terminal 1 of LBPIA, opened by Prime Minister Lester B. Pearson in 1964, was designed to handle 3.5 million passengers annually. Subsequent modifications have increased the capacity of Terminal 1 to 6.5 million passengers annually.

The Terminal Development Project, organized by the Greater Toronto Airport Authority (GTAA) is currently under construction. These construction efforts will expand Terminal 2 towards Terminal 1 resulting in one combined new terminal, T-New. The first phase of

T-New is expected to open in 2003. Terminal 1 (T1) will be demolished when construction of the new terminal (T-New) is completed.

Terminal 2 (T2), with an annually capacity of 12 million passengers, was opened in 1972. A total of 40 aircraft bridges and 15 commuter stands are provided by T2. This includes nine commuter gates and 15 commuter aircraft positions located in a satellite terminal attached to T2's main building. Air Canada's domestic and transborder (U.S. destinations) flights are operated within Terminal 2.

Terminal 3 was opened in 1991 and is currently used by all airlines other than Air Canada. The combined capacity of T-New and Terminal 3 will be 50 million annual passengers. T3 contains a total of 37 aircraft bridges and commuter stands. Because of time restraints and Air Canada's financial support, the baggage handling research at LBPIA was conducted in Terminal 1 and Terminal 2, both used by Air Canada.

In terminals 1 and 2, the baggage handling needs of Air Canada flights are managed and operated by Air Canada personnel. For non-Air Canada flights, baggage in terminal 3 is handled by a number of airlines and baggage handling companies. The airlines in T3 include American Airlines, British Airways, Canada 3000 Airlines, Continental Airlines, Delta Air Lines, Northwest Airlines, Royal Airlines, and US Airways. Handlex, Hudson

General Aviation Services, and Ogden Aviation are three baggage handling companies that operate at LBPIA.

As different types of flights (domestic, international, and/or transborder) result in different peak periods, the peak times vary between areas *within* a single terminal and *between* terminal buildings. There is also some variation between arrival and departure peak times, however, since this research deals with arriving passengers, the arriving peak periods are discussed here. In terminal 1 (which contains only international traffic) the peak hours are from 3:00 to 5:00 p.m. and again from 7:30 until 9:00 p.m. During the summer months, when the amount of holiday/ pleasure travel increases, an additional peak between 1:30 and 2:30 p.m. occurs. In terminal 2, the transborder peaks occur between 6:00 and 7:30 a.m. and again between 8:30 and 10:00 a.m., although these peaks involve low amounts of baggage. An increased amount of baggage is observed during the peak times from 12:00 to 4:00 p.m. and again from 8:00 to 10:00 p.m. For domestic flights in T2, the peak hours are from 6:00 to 7:30 a.m., 8:45 to 9:45 a.m., 12:00 to 1:30 p.m. and from 4:00 p.m. until 12 midnight. Rapidair flights, which carry mainly business travellers with a small amount of baggage, have peak periods between 7:15 and 9:30 a.m., 12:00 to 1:30 p.m. and from 4:00 p.m. until 8:00 p.m. The busiest days of the week are Thursdays, Fridays, and Sundays, as well as Saturday evening. Terminal 3 observes peak periods in customs area A from 3:00 to 4:00 p.m. and from 1:00 to 2:30 a.m., depending on the late night delays. Customs area C (in terminal 3), although open daily

from 12 noon until midnight, only observes peak period when two flights arrive simultaneously.

Terminal 1 at LBPIA is currently being used for Air Canada international flights. The upper level of T1 is organized for departing passengers, while the lower level is for arriving passengers. T1 has a total of 20 bridges and commuter stands for aircraft arrivals and departures. A decentralized baggage sorting area is located within T1 with four main sorting rooms for international baggage. The Air Canada baggage handlers in T1 use a manual sorting method to separate departure baggage to the appropriate flights.

Arrival baggage is placed on one of five racetrack-style conveyor belts available in the reclaim hall of T1 (numbered 1 through 5). The ceiling height in this area varies from approximately 3.6 to 4.3 metres (12 to 14 feet). Electronic display boards indicate the flight number for the baggage being circulated on the conveyor belt. As T1 was opened in 1964, the floor area provided around the conveyor belts is not as large as the reclaim area provided in the newer T2. Conveyor belts number 4 and 5 each have 8 seats provided nearby (approximately 8 metres away), whereas conveyors 1, 2, and 3 have none.

As with T1, passengers in Terminal 2 are separated vertically with departures on the upper level and arrivals on the lower level. T2 was designed with one baggage sort area for domestic baggage and a second sort area for U.S. departure baggage. T2 uses a semi-

automatic sorting method. Baggage on the main conveyor track leading from the check-in counters to the sort room is separated automatically by destination onto the appropriate jet (conveyor belt leading off of main belt) where baggage is then sorted manually onto carts destined for the aircraft. Baggage tags that cannot be read by the computer scanner are rejected and the baggage is 'pushed' onto a designated conveyor belt, where someone reads the destination tag manually and returns it to the system for sortation.

The six kilometres of conveyor belts in T2 are travelling at 37 metres/minute (220 feet/minute) and transport approximately 25,000 bags on an average day. An article of baggage takes, on average, between 2 and 4 minutes to travel from the check-in desk to the baggage handler waiting to place the bag onto a cart. This time depends on the distance between the check-in desk and the sort room, as different check-in counters are at different distances. The cut-off time for baggage is twenty minutes before the flight is scheduled to take off. This allows baggage handlers adequate time to transport the baggage to and load it into the aircraft.

Although the Air Canada baggage handlers could not provide any accurate statistics, they felt that the arrival baggage reached the conveyor belts within the specified standard "most of the time". According to the baggage handlers, on a good day 6 bags in 1000 would be mishandled, whereas on a bad day 10 bags in 1000 could be mishandled. This

data is consistent with other data gathered during discussions with Air Canada employees.

Located on the ground level of Terminal 2, are nine domestic conveyor belts, numbered 26 through 34, which are separated into two main areas. One area, for arrivals from Ottawa, Halifax, Quebec City and Montreal, includes 2 racetrack-style conveyor belts and 1 carousel-style conveyor belt (numbers 26, 27, and 28 respectively). The second area, used for all other Air Canada domestic flights, contains 3 racetrack-style conveyor belts (numbers 30, 31 and 34) and 3 carousel-style conveyor belts (numbers 29, 32, and 33). Both areas, attached by a narrow corridor are separated from the general public area by secure doors and security guards constantly patrol these areas. Electronic display boards, updated by the Air Canada baggage personnel, are suspended from the ceiling above each conveyor belt indicating the flight number for the baggage being circulated. The ceiling height in this reclaim area varies from approximately 3.6 to 4.3 metres (12 to 14 feet).

The U.S. customs and immigration area of T2 has six carousel-style conveyor belts (numbers 17 through 22) with different sizes and layout configurations. While conducting research at the airport, conveyor belts 17 and 18 were not functioning and the majority of flights were using reclaim conveyor belts 20, 21 and 22. Electronic display boards were in use in the U.S. customs and immigration area and the area appeared well lit and fairly

spacious, with ceiling heights varying from approximately 3.6 to 4.3 metres (12 to 14 feet).

5.4 Comparison of Airports

The airports evaluated varied between locale, size, and baggage handling system characteristics. Based on the annual passenger volume, Thunder Bay was considered a small airport, Toronto was considered a large airport and the remaining four were considered medium airports (Table 5-6). The three smaller airports have a completely manual baggage sortation system (Thunder Bay, Ottawa and Edmonton), while Calgary uses a combination of manual and semi-automatic systems. Terminal 1 in Toronto, the original terminal, has a manual sortation system. Montreal and Terminal 2 in Toronto use semi-automated systems.

The three smaller airports have decentralized sorting rooms. In Thunder Bay and Ottawa each airline has a small room for sorting baggage located directly behind the check-in counters. In Edmonton, there are two main sort rooms in the old terminal that are for the exclusive use of two airlines. The new terminal has two main sort rooms (one domestic & international, one for pre-cleared transborder baggage) used by Air Canada. Calgary, Montreal and Toronto have centralized baggage sort rooms whereby one or more main

sort rooms are used for the entire terminal. (Toronto has one or more main sort rooms in each of the terminals.)

Table 5-6: Selected Variables for Comparison of Airports (Part One)

Airport Name	1999 Passenger Volume	Baggage Handling Sortation System	
		Sorting Method	Type of Sort Room
Thunder Bay	518,043 (small)	Manual	Decentralized
Ottawa	3,215,723 (medium)	Manual	Decentralized
Edmonton	3,651,155 (medium)	Manual	Decentralized/ Centralized
Calgary	7,800,362 (medium)	Manual/ Semi- automatic	Centralized
Montreal	8,297,614 (medium)	Semi-automatic	Centralized
Toronto	27,779,675 (large)	T1: Manual T2: Semi-automatic	Centralized (by terminal)

Table 5-7 provides four variables for the purpose of comparing the six airports. Column one lists the airports in increasing order of number of passengers per year. It can be seen that, with the exception of Montreal, as the number of annual passengers increases, the

number of conveyors provided also increases. The overall space and number of conveyor belts provided in the international area at the Dorval airport were inadequate at peak periods for the volume of passengers. Edmonton and Calgary airports have both recently been renovated and thus additional conveyors are in place to accommodate the airport's needs in future years. Ottawa has almost six times the amount of passenger traffic that Thunder Bay has, yet only one more conveyor was provided. At the Ottawa airport, baggage from numerous flights was frequently placed simultaneously on the same conveyor belt. Increasing the amount of baggage conveyors at the Ottawa airport would certainly improve the service.

The average number of square metres of space provided in the reclaim area adjacent to the reclaim device is shown in column 3 of Table 5-7. This area is provided for the retrieval of baggage by the passengers and does not include the reclaim device (conveyor). One would expect that as the number of annual passengers increases, the size of the reclaim area adjacent to the reclaim device would increase accordingly. It can be seen that this occurs for the four smaller airports from Thunder Bay to Calgary. Montreal, with 6% more annual passengers than Calgary, provides an average reclaim area of 87% of that provided in Calgary. Toronto provides nearly the same average area (161 m^2) that Ottawa does (160 m^2), even though Ottawa has an annual passenger volume equal to approximately 12% of Toronto's volume. However, Toronto does not permit greeters in the reclaim area, and thus has less people to accommodate.

Table 5-7: Selected Variables for Comparison of Airports (Part Two)

Airport name	Number of conveyors: domestic + international	Average space in reclaim area, not including reclaim device (m ²)	Average perceived time spent waiting (minutes) Domestic/Int'l	Average perceived LOS Scale 0 (bad) to 10 (good) Domestic/Int'l
Thunder Bay	2 + 1 = 3	105	4.0 / *	8.3 / *
Ottawa	3 + 1 = 4	160	11.8 / *	6.3 / *
Edmonton	7 + 2 = 9	188	7.8 / 6.2	6.8 / 8.2
Calgary	6 + 3 = 9	229	10.4 / 10.5	7.3 / 7.8
Montreal	2 + 6 = 8	199	10.8 / 14.8	6.6 / 6.8
Toronto	8 + 11 = 19	161	8.3 / 11.8	6.7 / 6.4
Note: * indicates that no international flights were observed				

Columns 4 and 5 of Table 5-7 present data that was collected from the respondents with the questionnaire. The former column indicates the average waiting time as perceived by the respondents at each airport. Column 5 indicates the average level of service as perceived by the respondents, which was rated on a scale from 0 (unacceptable) to 10 (excellent). Due to the relatively low average perceived time spent waiting for baggage in Toronto, and the relatively high value in Ottawa, no relationship appeared to exist between the airport size, measured in terms of passenger volume, and the perceived

waiting time. However, when Ottawa and Toronto airports were removed from the analysis, a strong positive linear relationship existed for the remaining four airports (Figure 5-1). The research was undertaken at the Ottawa airport during extremely congested periods, while in Toronto much of the research was conducted during relatively non-congested periods. These time periods were not an indication of the *average* level of service and congestion experienced at these airports and instead represented *extreme* conditions. On the other hand, the research at the other four airports was conducted during average conditions. Removing these extremes from the comparison resulted in a strong relationship between the average perceived waiting time and the annual passenger volume, as expected.

Figure 5-1: Average Perceived Waiting Time versus Annual Passengers

A linear relationship was found between the perceived waiting time (in minutes) and the overall perceived LOS on a scale of 0 (bad) to 10 (good). Figure 5-2 shows the relationship for both domestic and international flights. It can be seen that international passengers were more tolerant, indicating the same LOS for a higher waiting time.

Thunder Bay airport, with the smallest passenger volume, observed an average perceived waiting time of just under four minutes and the highest average perceived LOS of 8.3 out of ten (Table 5-7). The Ottawa airport, second smallest in passenger volume, had an average perceived waiting time of just under 12 minutes. This lengthy perceived waiting time resulted in a poor perceived LOS rating in Ottawa of 6.3 out of ten. This waiting time is 4 minutes longer than the perceived waiting time for domestic flights in Edmonton, an airport with only a slightly larger number of annual passengers. This time difference is partially a result of the shorter passenger walking times observed in Ottawa, when compared with Edmonton. However, since the distance the baggage must travel is also shorter, baggage should be delivered more rapidly in Ottawa. This could be achieved through changes in the baggage handling operations. It is interesting to note that although the average perceived waiting time for domestic passengers in Calgary (10.4 minutes) was higher than in Edmonton (7.8 minutes), the perceived LOS in Calgary was slightly higher (7.3 out of 10) than in Edmonton (6.8 out of 10). This occurred because the LOS perceived by passengers was affected by more factors than just the perceived waiting time.

Figure 5-2: Average Perceived Waiting Time versus Overall LOS Evaluation

5.5 Summary and Recommendations

Due to recent renovations to the airport facilities in Thunder Bay, Edmonton, and Calgary, these airports are operating under capacity and passengers are generally pleased with the service provided. The Toronto and Ottawa airports are currently being modified to increase capacity, which should result in improved service levels. With lower

perceived waiting times, the domestic passengers in Montreal were more satisfied with the BHS than the international passengers were.

Based on the average perceived LOS in Thunder Bay, Edmonton, and Calgary, these airports provide a sufficient number of conveyors, adequate space for the retrieval of baggage and acceptable perceived waiting times. Based on the amount of baggage handling equipment available at the other airports, the Ottawa airport should increase the number of conveyor belts from four to approximately eight.

The number of conveyor belts *and* the space provided for international arriving passengers in the reclaim area was inadequate during peak periods at Montreal's Dorval airport. Either more space and more conveyors should be implemented, or an attempt should be made to make better use of the current facilities. Since additional space and BHS equipment are costly and sometimes not physically feasible, some options for more efficient use of the current facilities are as follows.

- ◆ A different physical arrangement for the customs area and reclaim conveyors which would provide better use of the space.
- ◆ A more uniform flight arrival schedule providing more time between flight arrivals and resulting in a lower peak number of passengers, and thus lower space and equipment requirements.

- ◆ Better placement of the single exit door to avoid cross flow of passenger traffic and reduce congestion.
- ◆ Better placement of the baggage carts, resulting in less cross flow.
- ◆ The implementation of a second exit door from the reclaim area. This would require additional customs staff, but would certainly reduce congestion and cross flow.

A positive linear relationship was found between the airport size, measured in terms of passenger volume, and the average perceived waiting time for Thunder Bay, Edmonton, Calgary and Montreal airports. The research in Ottawa and Toronto was conducted during *extreme* instead of *average* conditions, and thus a relationship was not evident for these two airports. A linear relationship was also found between the perceived waiting time and the perceived LOS. International passengers were found to be more tolerant of waiting times than domestic passengers. However, waiting times and annual passenger volumes alone are not adequate variables for measuring the overall level of service as perceived by the passengers and thus, subsequent chapters discuss additional factors.

Chapter Six

6 CLASSIFICATION OF PASSENGERS AND SUMMARY OF RESPONSES

The first two sections of the questionnaire were designed to categorize the respondents according to flight information and personal passenger information. The flight information included type of flight (domestic, transborder or international) and class of ticket (business or economy). The personal information collected included the respondent's gender, age range, trip purpose, the number of checked items of baggage, and the number of flights taken per year. The third section of the questionnaire solicited their opinion of various aspects of the baggage handling system. While the questionnaire was being distributed, every effort was made to randomly select the respondents, regardless of gender, age, or traveling situation (alone, in a group, with children, etc). The results obtained are discussed in the following sections.

6.1 Response Rate

Table 6-1 indicates the number of questionnaires that were completed at each airport (second column). The third column indicates the number of questionnaires where, although the phrase 'Please turn over' was written at the bottom of the first side, only the first side of the questionnaire was completed. The information from these one-sided questionnaires was not entered into SPSS. The fourth column indicates the number of

people that refused to complete the questionnaires. This number was recorded at the Ottawa, Montreal and Edmonton airports. The number of refusals at the other three airports was more than that in Ottawa, but less than in Edmonton. Other than the 137 people recorded as having completed surveys in Montreal, 6 additional people (from 2 different flights) also completed questionnaires. However, these 6 questionnaires were not entered into SPSS because the flight data (arrival time, number of passengers, number of bags, etc) were unavailable. This information is displayed graphically in Figure 6-1.

Table 6-1: Total Number of Questionnaires – Distributed and Refused

Airport	No. of completed questionnaires	No. of one-sided questionnaires	Number of refusals	Total by Airport
YQT - Thunder Bay	100	9	*	109
YOW- Ottawa	109	14	4	127
YEG- Edmonton	133	7	16	156
YYC – Calgary	128	3	*	131
YUL – Montreal	137	7	5	149
YYZ - Toronto	198	4	*	202
Total	805	44	25	874

Note: * indicates that a count of refusals was not recorded

The response rates varied from airport to airport. Only four people declined to fill in the questionnaire at the Ottawa airport (out of 127 passengers asked) resulting in a response rate of 97%, while 16 declined at the Edmonton International Airport (out of 156 passengers asked) resulting in a 90% response rate.

There were various reasons that people refused to fill in the questionnaire. Some people were uncomfortable in the airport environment and did not want anything to distract them from their goal of collecting baggage. Other individuals were too tired, lacked the interest or time, had young children to oversee, spoke neither English nor French, or were unable to read the questionnaire due to lack of reading glasses.

Note: A count of refusals was accomplished in YOW, YEG and YUL.

Figure 6-1: Breakdown of Questionnaires by Airport

6.2 Classification of Passengers

This section presents the responses given by passengers in the first two sections of the questionnaires regarding flight and passenger characteristics. Responses related to the perceived LOS are presented in the following section.

6.2.1 Gender of Respondents

The percent of respondents that indicated they were male varied from 47.0% in Thunder Bay to 72.2% in Edmonton (Figure 6-2). The female respondents ranged from 27.1% to 52.5%. A total of 10 respondents out of 805 failed to indicate their gender.

With the exception of Thunder Bay, the percent of male respondents in this study was greater than the Calgary airport study determined (Section 5.3.4). The Calgary study found that 54% of passengers at the Calgary airport were male. The percent of female respondents in Thunder Bay was quite high compared to the other five airports. Fifty-two percent of respondents in Thunder Bay were female, while the other five airports had female respondents ranging from 27% to 37%. Additionally, the percent of female respondents in Thunder Bay exceeded the percent of male respondents by 5%, whereas, at all other airports the percent of males exceeded the percent of female respondents. It is possible that due to the female gender of the interviewer, male respondents were more

likely to complete the questionnaire than female passengers. Additionally, female passengers at the medium and large airports were more nervous about travelling, more uncomfortable in the reclaim area, and possibly more unfamiliar with the airport surroundings than the male passengers. However, in Thunder Bay, where there was a greater percent of female respondents than male respondents, it is believed that the female passengers were more at ease in the smaller, less crowded airport environment.

Figure 6-2: Gender of Respondents

6.2.2 Age Range of Respondents

Questionnaire respondents were asked which age category they were classified in from a list of four categories of: under 25 years, between 25 and 39 years, between 40 and 60

years, and over 60 years of age. In total, four respondents did not complete this question (Figure 6-3). The percent of respondents under 25 years of age ranged from 4.5% in Toronto to 13.0% in Thunder Bay. The second category, between 25 and 39 years of age, represented between 32% in Thunder Bay to 46.6% in Edmonton. The respondents between 40 and 60 years of age represented 39.1% in Edmonton to 58.6% in Toronto. The respondents over the age of 60 represented from 3.0% in Thunder Bay to 8.8% in Montreal.

As expected, the majority of passengers were between the ages of 25 and 60. In Edmonton and Montreal, more respondents were between the ages of 25 and 39 than were between the ages of 40 and 60. At the other four airports, the age category from 40 to 60 years of age formed the largest percent.

During the data collection phase of this research, it was found that younger passengers (less than 60 years of age) were more likely to agree to complete the questionnaire than older travellers were. There were two major reasons for this. Firstly, older passengers seemed less familiar and less at ease with the airport environment. They wanted to watch constantly for their baggage without any distractions (even if baggage was not yet being displayed on the conveyor belt). Secondly, older passengers seemed more tired and, for this reason, did not want to fill in the questionnaire. A large portion of passengers

refusing to complete the questionnaire were in this age category. Thus, the *actual* percent of travellers that were older than 60 years of age was higher than the results indicated.

Note that the 'Missing' category percents are not shown.

Figure 6-3: Summary of Respondent Age Categories

6.2.3 Trip Purpose of Respondents

Passengers were asked to indicate whether the purpose of the trip was for 'business only', 'pleasure only', 'both business and pleasure', or for 'another' reason. The majority of

passengers at all airports, from 49.6% to 63.9%, were traveling on business only (Figure 6-4). The passengers traveling for pleasure only ranged from 27.1% to 41.6%. Passengers traveling for both pleasure and business ranged from 3.0% to 8.3%. Travel for 'other' reasons amounted to between 1.6% in Calgary to 5.5% in Ottawa. In Montreal, it can be seen that there is only an 8% difference between the percent of business travellers and pleasure travellers. Montreal had fewer business travellers than the other airports and more pleasure travelers. Note that the missing category percents are not shown.

Figure 6-4: Summary of Respondent's Trip Purpose

6.2.4 Number of Checked Items of Baggage per Respondent

Respondents were asked how many items of baggage they had checked (placed in the baggage hold area under the aircraft, not carry-on) for the current flight. There were five possible categories that included one, two, three, four, five or more checked items. The majority of passengers at each airport, from 57.7% in Montreal to 67.7% in Edmonton, checked only one item of baggage (Figure 6-5). As the number of checked items increased, the percent of respondents carrying this number of items decreased. Between 27.1% of the respondents in Edmonton and 33.8% of respondents in Toronto checked 2 items of baggage. Three items of baggage were checked by between 3.0% of the passengers in Edmonton and 7.3% of the passengers in Toronto. Between 0% of the respondents in Edmonton and 5.5% of respondents in Calgary checked 4 items of baggage. Finally, at most one person, or less than 1% of the respondents at each airport, checked 5 or more bags.

Figure 6-5: Summary of Number of Checked Bags

6.2.5 Number of Flights per Year

Respondents were asked to indicate the number of flights they took per year in one of four categories which included: one to two flights per year, three to five flights per year, 6 to nine flights per year, and 10 or more flights per year. The middle value of the category was entered into an SPSS variable called FLIGHTY2 to indicate the annual

number of flights taken. For example, if a respondent indicated that they took between 3 and 5 flights annually, a value of four was entered in the SPSS software. (Note that the name of SPSS variables will be typed in upper case letters.) For respondents that selected the 'more than 10' category for annual number of flights, a value of 15 was entered, since a number of respondents indicated that many more than 10 flights were taken annually. The largest portion of passengers at each airport, from 29% in Thunder Bay to 42.2% in Ottawa, take 10 or more flights per year (Figure 6-6). In fact, many of these respondents indicated that they took in excess of 50 flights per year.

Figure 6-6: Summary of Number of Flights Taken by Respondents per Year

6.2.6 Type of Flight

For each flight, it was recorded whether the flight was a domestic, transborder, or international flight. In Ottawa it was not possible to gain access to the customs area and therefore, no international (or transborder) flights were observed at this airport.

Additionally, no international flights were observed in Thunder Bay because the one daily international arriving flight would not create a good sample size. In both Toronto and Montreal, the flights observed were almost evenly split between domestic and non-domestic flights (Table 6-2). In Montreal, 50% of flights were domestic while in Toronto 52.4% of flights were domestic.

Table 6-2: Summary of Flight Type by Airport

Airport	Domestic		Transborder		International, not U.S.		Total
	Number	%	Number	%	Number	%	
Thunder Bay	12	100	0	0	0	0	12
Ottawa	13	100	0	0	0	0	13
Edmonton	20	87	3	13	0	0	23
Calgary	13	68.4	5	26.3	1	5.3	19
Montreal	10	50	6	30	4	20	20
Toronto	11	52.4	7	33.3	3	14.3	21

6.2.7 Passenger Ticket Class

Passengers were asked to record the type of ticket they had purchased as either a 'business' or 'economy' ticket. The percent of passengers with business tickets ranged from 9.8% in Edmonton to 18.3% in Ottawa (Figure 6-7). Alternatively, the percent of passengers with economy tickets ranged from 79.8% in Ottawa to 88% in Edmonton. It is interesting to note that in Thunder Bay 12% of passengers (12 passengers) and in Montreal 13.1% of passengers (18 passengers in total) did not provide their ticket class. The placement of this question for both the English and French questionnaires was the same and thus does not explain the high number of missing entries in Montreal. Some respondents may have considered ticket type to be a personal question and thus did not provide an answer.

Figure 6-7: Summary of Respondent's Ticket Type

6.3 Passenger Responses

The previous section presented information regarding passenger and flight characteristics from the first two sections of the questionnaire. This section presents passenger responses from the third section of the questionnaire and some discussion. Additional information regarding relationships that were found among variables are presented in the following chapter on regression analysis. Thus, more discussion of the variables presented in this section can be found in the following chapter.

6.3.1 Misplaced Baggage

Respondents were asked to indicate whether their personal baggage arrived on the conveyor belt following the arrival of their flight. The variable GETBAG01 was assigned a value of 0 if the baggage arrived on the same flight as the passenger and a value of 1 if at least one item of baggage did not arrive. Some passenger responses to questionnaire items were negatively affected when an item of baggage did not arrive on the conveyor. These items included the waiting time (TIMEWAIT), the rating of the waiting time (WAITTIME), and the overall user-perceived LOS.

(a) Total Amount of Misplaced Baggage

Table 6-3 lists the number of respondents that did not receive all their personal baggage and provides flight details for each case, including airline, flight origin and flight destination. Each case represents one respondent. The right most column indicates the number of items checked by each respondent, rather than the number of items misplaced. A total of 23 out of 805 respondents did not receive at least one item of their personal baggage. In some cases one item of baggage was misplaced, whereas in other cases all of a respondent's items were misplaced. Although the actual number of items of baggage (also referred to as baggage or bags) misplaced per person was not requested, these 23 respondents were carrying between 1 and 5 items each for a total of 38 items between them. Thus, between 23 and 38 items belonging to the respondents of this study were misplaced. Of the 805 total respondents, 796 respondents reported the number of items of baggage they were carrying, for a total of 1177 bags with a mean value of 1.48 bags per person.

Assuming that the nine respondents ($805 - 796 = 9$) that did not answer this question carried on average 1.48 bags per person, the total number of bags *not* reported was 13 bags. These numbers indicate that a total of 1190 bags were carried among the 805 respondents. Knowing that between 23 and 38 bags were misplaced, the percent of bags misplaced among the respondents varied between 1.9% and 3.2%. This is more

commonly referred to as between 19 and 32 items in 1000 were misplaced. Since the respondents were randomly selected for this research, this range of values represents the number of bags misplaced per 1000 bags handled during the period of time the study took place and at the six airports that participated in the research. This is a relatively high value compared to the 'target' values for misplaced baggage that Air Canada attempts to achieve (not available for publication).

(b) Breakdown by Airport

The aggravation caused by a misplaced item occurs at the flight destination and it is at this location that respondents completed the questionnaire. However, the initial problem that resulted in the misplaced baggage does not generally occur at the final destination, but rather at one of the points of origin. Figure 6-8 and Figure 6-9 show the percent of respondents where at least one item of baggage was misplaced, both by flight origin and flight destination. Table 6-4 and Table 6-5 indicate the number of total respondents by flight origin and destination, respectively. These figures indicate that 74% of the misplaced baggage respondents originated in Toronto, while only 24% of the total number of respondents originated in Toronto.

Table 6-3: Misplaced Baggage Flight Details

	Flight number	Airline	Flight Origin	Flight Destination	Number of Checked Bags
1	AC8392	Air Canada	Calgary	Edmonton	2
2	AC1872	Air Canada	Vancouver	Edmonton	2
3	AC1874	Air Canada	Vancouver	Edmonton	1
4	AC1874	Air Canada	Vancouver	Edmonton	1
5	AC8392	Air Canada	Calgary	Edmonton	1
6	AC456	Air Canada	Toronto	Ottawa	1
7	AC456	Air Canada	Toronto	Ottawa	1
8	AC456	Air Canada	Toronto	Ottawa	1
9	AC456	Air Canada	Toronto	Ottawa	2
10	AC456	Air Canada	Toronto	Ottawa	1
11	AC060	Canadian	Toronto	Ottawa	2
12	AC456	Air Canada	Toronto	Ottawa	2
13	AC456	Air Canada	Toronto	Ottawa	2
14	AC456	Air Canada	Toronto	Ottawa	1
15	AC456	Air Canada	Toronto	Ottawa	3
16	AC456	Air Canada	Toronto	Ottawa	1
17	AC440	Air Canada	Toronto	Ottawa	5
18	AC456	Air Canada	Toronto	Ottawa	2
19	AC456	Air Canada	Toronto	Ottawa	1
20	AC456	Air Canada	Toronto	Ottawa	2
21	AC3823	Air Canada	Toronto	Thunder Bay	1
22	AC3963	Canadian	Toronto	Calgary	1
23	AC3518	Canadian	LAX (LA)	Calgary	2
Total	N	23	23	23	38

Figure 6-8: Percent of Misplaced Baggage by Flight Origin

Figure 6-9: Percent of Misplaced Baggage by Flight Destination

Table 6-4: Breakdown of Total Respondents by Airport Origin

Airport	Number of Respondents	%	Airport	Number of Respondents	%
Abbotsford	5	0.6	Orlando	6	0.7
Bermuda	13	1.6	Ottawa	28	3.5
Calgary	38	4.7	Paris	27	3.4
Chicago	3	0.4	Portugal	3	0.4
Dallas	11	1.4	Prague	11	1.4
Denver	13	1.6	Quebec	7	0.9
Dryden	6	0.7	Regina	5	0.6
Edmonton	6	0.7	San Diego	12	1.5
Frankfurt	6	0.7	San Francisco	14	1.7
Grande Prairie	17	2.1	Saskatoon	20	2.5
Halifax	37	4.6	Seattle	7	0.9
Hamilton	18	2.2	Sioux Lookout	3	0.4
Honolulu	12	1.5	Sault Ste. Marie	17	2.1
Las Vegas	10	1.2	Thunder Bay	9	1.1
Los Angeles	12	1.5	Toronto Island	6	0.7
London	14	1.7	Toronto	193	24.0
Miami	14	1.7	Vancouver	57	7.1
Minneapolis	10	1.2	Winnipeg	27	3.4
Montreal	55	6.8	Yellowknife	2	0.2
Newark	5	0.6	Zurich	15	1.9
NY – JFK	4	0.5	Missing	3	0.4
NY – LGA	16	2.0	Total	805	100.0
NY (JFK or LGA)	8	1.0			

Table 6-5: Breakdown of Total Respondents by Airport Destination

Airport Destination	Number of Respondents	Percent
Thunder Bay	100	12.4
Ottawa	109	13.5
Edmonton	133	16.5
Calgary	128	15.9
Montreal	137	17.0
Toronto	198	24.6
Total	805	100.0

Interestingly, 13 of 17 respondents with misplaced baggage originating in Toronto were on the same flight (AC456). During the peak time period of that flight, airplanes were travelling from Toronto to Ottawa frequently (at least every hour). The reason for these misplaced items of baggage could simply be that passengers took an earlier flight and that there was insufficient time with which to transfer or load their baggage onto flight AC456. The misplaced items in all likelihood arrived on the subsequent flight. If these 13 respondents are ignored from the total calculation for misplaced baggage, only 10 respondents ($23 - 13 = 10$) had a total of 10 (one misplaced item each) to 20 (total number of items for the 10 respondents) misplaced bags. With the total number of items of baggage transported for the 805 respondents equal to 1190 (as before), the range of misplaced baggage becomes 0.84% to 1.68% or, more commonly, 8 to 17 misplaced items per 1000 items handled. Thus, if these 13 passengers changed flights suddenly, the

airlines should not be required to get baggage onto the flight with the passenger and these items should not be considered mishandled. (Actually, the passengers should not be *allowed* to travel if their baggage did not get onto the flight.) If on the other hand, these passengers were scheduled to be on this flight and their baggage did not arrive with them, then, as previously calculated, between 19 and 32 bags in 1000 were misplaced during this study.

Although 65% of the respondents with misplaced baggage were destined for Ottawa, Table 6-3 indicates that these respondents, and the 4% of respondents with misplaced baggage arriving in Thunder Bay, originated in Toronto. Other misplaced baggage originated in Calgary, Vancouver and Los Angeles (LAX). Calgary was the origin of 4.7% of the total number of respondents observed during this research while 9% of respondents with misplaced baggage originated in Calgary. None of the 3.5% of the total respondents originating in Ottawa, the 6.8% originating in Montreal, the 0.7% originating in Edmonton or the 1.1% originating in Thunder Bay resulted in misplaced baggage at the destinations.

(c) Breakdown By Airline

Another consideration when discussing the respondents with misplaced baggage is the airline that transported the baggage. The purchase of Canadian Airlines by Air Canada

occurred immediately prior to the site visits and the completion of any questionnaires. At that time, many Canadian flights were still numbered and referred to as Canadian flights and were therefore labeled as Canadian flights during the data analysis.

All 23 respondents with misplaced baggage, or 100%, were travelling on Air Canada (or Canadian) flights (Table 6-3). By combining the Air Canada and Canadian respondents together, only 69.2% of the 805 respondents were travelling with Air Canada (Figure 6-10). Other airlines that accounted for more than 2% of the total number of respondents included WestJet (8.9%), Canada 3000 (4.1%), Bearskin Airlines (3.5%), and American Airlines (2.1%). All respondents travelling with these airlines during the research retrieved their baggage.

6.3.2 Respondent Perceived Waiting Time at Conveyor Belt

Respondents were asked to indicate the amount of time (in minutes) that they waited for baggage around the conveyor belt in the reclaim area. This value, referred to as the *perceived waiting time* or TIMEWAIT in SPSS, was discussed previously in Section 5.4. Traditionally, waiting time has been important in determining the LOS of the reclaim area and thus, it is a significant variable to measure. For each of the six airports, Table 6-6 indicates the minimum, maximum and mean values obtained for the perceived waiting time around the conveyor in the reclaim area. Since the waiting time is affected,

Note: Airlines with less than 2% of the total number of flight observed throughout the research were grouped together for clarity as 'Other'.

Figure 6-10: Breakdown of Total Flights Observed by Airline

to some extent, by the size of the airport, it is reasonable that Thunder Bay airport had the lowest average perceived waiting time of 4.0 minutes. Ottawa displayed the second highest average perceived waiting time of 11.8 minutes, and Montreal had the highest average perceived waiting time of 13.0 minutes. At least one respondent at each of the six airports perceived the waiting time for baggage to be zero minutes. The longest perceived waiting time in Thunder Bay, the smallest airport, was 15 minutes. For the Ottawa, Edmonton, Calgary and Montreal airports, the longest perceived waiting time was between 40 and 55 minutes. Interestingly, the longest perceived waiting time in Toronto was only 30 minutes.

An interesting question to consider is ‘how well do people estimate their waiting time?’ The difference in time between the arrival of the first passenger in the reclaim area and the arrival of the last item of baggage on the conveyor belt indicated the maximum time that any person should wait for baggage. This variable was called MAXWAIT3 in the SPSS software and was measured in minutes. A negative value for this variable indicated that all baggage from a specific flight arrived before any passenger from that same flight arrived in the reclaim area. One flight resulted in a MAXWAIT3 value of negative three minutes, while two flights resulted in a value of negative two minutes (Figure 6-11). Six additional flights delivered the last item of baggage at the same time as the first passenger arrived, resulting in a value of zero for MAXWAIT3.

Table 6-6: Respondents Average Perceived Waiting Time (TIMEWAIT)

Airport	Average Perceived Waiting Time (Minutes)		
	Minimum	Maximum	Mean
Thunder Bay	0	15	4.0
Ottawa	0	45	11.8
Edmonton	0	40	7.5
Calgary	0	50	10.4
Montreal	0	55	13.0
Toronto	0	30	10.0

Figure 6-11: Histogram of the Maximum Possible Waiting Time per Flight

This variable was compared against the waiting time as perceived by the respondent, also in minutes (TIMEWAIT). The variable DIFDLAY3 was the difference between MAXWAIT3 and TIMEWAIT. A negative value for DIFDLAY3 indicated that the respondent perceived their waiting time to be more than the maximum possible waiting time. Thus, any DIFDLAY3 value of zero or more would be reasonable, indicating that respondents perceived their waiting time (TIMEWAIT) to be equal or less than the maximum possible wait time. From a frequency table (not shown) and a histogram of DIFDLAY3, 71.6% of the respondents perceived their waiting time to be less than or equal to the maximum possible waiting time (Figure 6-12). In other words, the value for DIFDLAY3 was equal to or more than zero for 71.6% of the respondents. Additionally, a respondent waiting at the farthest end of the conveyor (from where baggage first entered the reclaim area) would have to wait a few minutes to claim his/her baggage. Thus, it is possible that a respondent estimating their waiting time with accuracy would have a TIMEWAIT value of a few minutes more than the maximum value (or a value for DIFDLAY3 of a few negative minutes). From the histogram (and from the table that produced the histogram) it can be seen that 93.5% of the values of DIFDLAY3 are more than or equal to negative five minutes (98% are more than or equal to negative 10 minutes).

Figure 6-12: Histogram of Respondent's Ability to Estimate Waiting Time

This same information can be shown graphically in a scatter plot of TIMEWAIT versus MAXWAIT3 (Figure 6-13). An imaginary reference line for $DIFDLAY = 0$ would extend from the lower left corner to the upper right corner at a 45 degree angle. Any points above this line indicate respondents who estimated a waiting time *less* than the maximum possible waiting time. Data points below this imaginary reference line indicate respondents who perceived the waiting time to be greater than the maximum possible

value (i.e. they overestimated their waiting time). Note that each point on Figure 6-13 can represent more than one respondent and that the number of respondents below the imaginary reference line was considerably less than the number of respondents above the line. From these two figures, it was determined that the majority of respondents were able to estimate their waiting times with reasonable accuracy (i.e. within a couple of minutes of the actual waiting time).

Figure 6-13: Scatter Plot of Maximum Possible Waiting Times against Perceived Waiting Times.

6.3.3 Respondent Expected Waiting Time

Respondents were asked to indicate the amount of time (in minutes) that they *expected* to wait for baggage in the reclaim area. This waiting time expectation is not the same as the value of time that a passenger might *want* to wait. For example, on arriving at an airport, a passenger might expect to wait 10 minutes for baggage based on past experience.

However, regardless of this value, they might also *expect, think or desire* baggage to be delivered in under 5 minutes. This latter value, although not collected as part of this research, would be an indication of the waiting time that passengers think is reasonable.

The former value for expected waiting time, which was collected, was based on a passenger's past experience and was an estimation of the waiting time that they expected would occur following the trip in question. Therefore, the *average* value of the expected waiting time, calculated for each airport, is an indication of the average waiting time that passengers think they are going to wait at each airport.

For each respondent, this value is referred to as the *expected waiting time* or EXPECT in the computer software. This value has not been used previously for the evaluation of LOS, however, it was anticipated that the relationship between the perceived and expected waiting times would have significance in this study. The shortest average expected waiting time was 6.8 minutes and occurred in Thunder Bay (Table 6-7). The

longest average expected waiting time was just under 12 minutes and occurred in Montreal. The longest expected waiting time was indicated by a respondent in Calgary as 40 minutes, while the longest expected waiting time indicated in Thunder Bay was only 15 minutes. Referring to both Table 6-6 and Table 6-7, on average, respondents in Montreal *expected* lengthy waiting times and *actually perceived* lengthy waiting times.

Table 6-7: Respondents Average Expected Waiting Time

Airport	Expected Waiting Time (Minutes)		
	Minimum	Maximum	Mean
Thunder Bay	1.5	15	6.8
Ottawa	0	30	9.5
Edmonton	0	25	8.8
Calgary	0	40	10.2
Montreal	0	30	11.6
Toronto	0	30	9.5

As anticipated, the average expected waiting time was shortest at the smallest airport. Unexpectedly, the longest average expected waiting time occurred in Montreal and not at the largest airport, Toronto. The reason could be that, on average the passengers traveling to Montreal travel less frequently and thus have less experience with actual waiting times, leading them to inflate their expected waiting time. More than 50% of respondents in Montreal traveled five or less times per year, whereas in Toronto, only 35.4% of respondents traveled five or less times per year (Figure 6-6). People who travel more

often have more experience with actual waiting times. Additionally, a larger percent of Montreal respondents (41.6%), versus 35.4% of Toronto respondents, were travelling for pleasure (Figure 6-4). Two Kruskal-Wallis tests, comparing expected waiting times by trip purpose and by annual number of flights taken, were both rejected ($H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_n$, etc) indicating that the average expected waiting time for respondents when grouped separately by trip purpose and by annual number of flights were not equal. It was found that respondents travelling for pleasure expected larger waiting times than respondents traveling for business, and respondents travelling less frequently expected larger waiting times than frequent flyers (Table 6-8).

Table 6-8: Average Expected Waiting Times

Grouping Variable	Average Expected Waiting Time (minutes)
a) Trip Purpose	
Business only	8.7
Business and Pleasure	9.5
Pleasure only	10.5
Other	12.1
b) Number of Annual Flights	
5 or less	10.1
More than 5	9.0

6.3.4 Respondent Perception of Walking Distance

Respondents were asked to evaluate the walking *distance* between the aircraft arrival gate and the reclaim area, where passengers collect their checked baggage. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using 'excellent', 'high', 'good', 'adequate', 'inadequate', or 'unacceptable' (WALKDIST). The best response of 'excellent' was given a coding of '1' in the software, 'high' got a coding of '2', 'good' got a coding of '3', etc, while the worst response of 'unacceptable' was given a coding of '6'. Thus, a low numerical value was better than a high numerical value and a value of 2.5 indicated a rating between 'good' and 'high'.

The first goal of arriving passengers is to determine where the reclaim area is and to locate which conveyor belt their personal baggage will be displayed on. Thus, the walking distance between the arrival gate and the reclaim area forms part of the arrival baggage handling system. It was anticipated that this walking distance would affect a passenger's evaluation of the BHS.

Thunder Bay, with the shortest average walking distance of 97 metres, received the best rating of 2.1 for average walking distance, which is between 'good' and 'high' (Table 6-9). Edmonton, with an average walking distance of 218 metres and Toronto, with an

average walking distance of 216 metres, received the lowest two ratings of 3.1 and 3.1 respectively. Both these ratings are just less than 'good'.

Table 6-9: Evaluation of Walking Distance from Aircraft to Gate

Airport	Minimum Walking Distance (metres)	Maximum Walking Distance (metres)	Average Walking Distance (metres)	Average WALKDIST Rating from 1 (excellent) to 6 (unacceptable)
Thunder Bay	76	127	97	2.1
Ottawa	56	325	132	2.6
Edmonton	91	309	218	3.1
Calgary	56	240	154	2.6
Montreal	38	344	219	2.8
Toronto	87	415	216	3.1

The relationship between the actual walking distance, measured in metres, and the rating for the walking distance (WALKDIST) can be seen in Table 6-10. The table indicates the mean and median values associated with the six ratings for WALKDIST from excellent to unacceptable. The median was provided because if one extreme value for walking distance (in metres) is included in the mean calculation, the mean value is greatly affected, whereas the median is not as sensitive. Therefore, the median values are considered to be better indications of the LOS perceived by the passengers. However, the same trend is evident with both the mean and median: passengers were able to distinguish

between each level of service and rated the service increasingly worse for longer walking distances. Thus, if an airport provides a median walking distance of 165 metres, passengers would perceive this as a good LOS.

Table 6-10: Relationship between Actual Walking Distance and Evaluation of WALKDIST

WALKDIST Rating	Actual Walking Distance (metres)	
	Mean	Median
Excellent	130.0	114.1
High	158.5	145.5
Good	179.4	165.4
Adequate	228.3	236.9
Inadequate	267.3	279.2
Unacceptable	266.9	292.1

6.3.5 Respondent Perception of Walking Time

Respondents were asked to evaluate the walking *time* required to travel from the aircraft arrival gate to the reclaim area, where passengers collect their checked baggage.

Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using 'excellent', 'high', 'good', 'adequate', 'inadequate', or

‘unacceptable’ (WALKTIME). As with the walking *distance*, it was anticipated that this walking *time* would influence a passenger’s perception of the overall BHS. Table 6-11 indicates the average walking time between the arrival gate and the conveyor belt as measured by the author (column 2), the average perceived walking time as estimated by the respondents (column 3) and the average rating from excellent (value of 1) to unacceptable (value of 6) as evaluated by the respondent. Regardless of airport size, the walking time perceived by the respondents at each airport was approximately twice the actual value measured by the author. Although some respondents might have taken care of personal business as they walked from the gate to the reclaim area (thus increasing their perceived time), the majority of passengers went directly to the reclaim area. Thus, airport planners must be aware that the time perceived by the passenger and the actual time are related by a factor of two. This statistic should influence the location of reclaim areas vis-à-vis the arrival gates. Possibly more reclaim areas, associated with fewer or closer gates, are warranted to ensure that the perceived, rather than actual walking distance, is kept to a minimum value.

Figure 6-14 provides a comparison of the average perceived walking time (between the reclaim area and the conveyor belt) and the average rating for this same walking time.

With the exception of Montreal, it can be seen that as the perceived walking time increases, the evaluation of this walking time decreases. A possible explanation for this is that in Montreal there was a high proportion of international passengers (Table 6-2) and

these passengers expected longer walking times and thus were satisfied with longer walking times. As with the ratings for walking distance, Section 6.3.4, Thunder Bay received the best average rating of 2.0, which refers to a 'high' rating. Edmonton and Toronto received the worst two ratings of 3.1 and 3.0, respectively. Both these refer to 'good' ratings.

Table 6-11: Evaluation of Walking Time Between Arrival Gate and Conveyor

Airport	Walking Time Between Arrival Gate and Conveyor		
	Average	Average	Average WALKTIME
	Measured	Perceived	Rating from 1 (excellent)
	(minutes)	(minutes)	to 6 (unacceptable)
Thunder Bay	1.5	2.9	2.0
Ottawa	2.2	4.7	2.5
Edmonton	3.0	6.4	3.1
Calgary	2.7	5.2	2.6
Montreal	3.6	7.5	2.8
Toronto	3.2	6.1	3.0

Figure 6-14: Average Perceived Walking Time versus Average Rating

The relationship between the perceived walking time, in minutes, and the rating for the walking time (WALKTIME) can be seen in Table 6-12. Median and mean values were provided for each LOS and for both the perceived walking time and the author's measured walking time. As previously noted, the actual and perceived values differ by a factor of approximately two. For airport authorities and airlines, the authors measured walking time is more appropriate for evaluating the BHS within terminals. However, if passenger perceived walking times are collected in the future, they should be compared with the perceived walking times provided here. For both perceived and actual walking

times, the WALKTIME rating worsened as the walking time increased. In the case of the perceived walking times, a median value of 5.0 was found for the four LOS's from high to inadequate. Thus, when using perceived walking times to evaluate LOS, the mean provides a better value for indicating the prevalent LOS.

Table 6-12: Relationship between Actual Walking Time and Evaluation of WALKTIME

WALKTIME Rating	Perceived Walking Time (minutes)		Measured Walking Time (minutes)	
	Mean	Median	Mean	Median
Excellent	4.0	3.0	2.2	1.8
High	5.1	5.0	2.5	2.3
Good	5.8	5.0	2.8	2.8
Adequate	6.9	5.0	3.4	3.6
Inadequate	7.4	5.0	3.8	3.8
Unacceptable	10.7	10.0	4.1	4.4

6.3.6 Respondent Perception of Waiting Time

Respondents were asked to evaluate the time spent waiting to collect baggage in the reclaim area. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using 'excellent', 'high', 'good', 'adequate',

'inadequate', or 'unacceptable' (WAITTIME). Waiting time has traditionally been important in determining the prevailing LOS, however, the relationship between the waiting time and the rating of this aspect of the BHS is of interest. What length of waiting time do passengers associate with an excellent LOS? Table 6-13 provides various statistics associated with the rating of waiting time (WAITTIME). As expected, as the perceived waiting time increased (TIMEWAIT), the rating of waiting time decreased in value, or worsened. Additionally, the minimum, maximum and median values for TIMEWAIT increased as WAITTIME decreased from excellent to unacceptable (with the exception of the maximum value for LOS D). Clearly, passengers were able to distinguish between the six levels of service.

Table 6-13: Perceived Waiting Times for Respondents Grouped by Rating of Waiting Time

Descriptive Variable	Rating of Waiting Time (WAITTIME)					
	A	B	C	D	E	F
Number of Respondents	130	110	209	155	76	39
Waiting time in reclaim area (minutes):						
Minimum	0	0	0	1.0	5.0	5.0
Maximum	10.0	25.0	35.0	55.0	50.0	50.0
Mean	3.4	6.4	8.6	12.1	16.5	22.2
Median	3.0	5.0	8.0	10.0	15.0	20.0

In addition to this research, Ashford (1988) attempted to understand the relationship between waiting time and respondent perception. In order to compare this thesis research with the analysis carried out by Ashford (1988), a figure similar to that developed in his research is included here (Figure 6-15). With reference to Table 4-6, Ashford (1988) suggested ranges for waiting times for the perception response model using the service levels of good (<12.5 minutes waiting time), tolerable (between 12.5 & 22.5 minutes waiting time), and bad (> 22.5 minutes waiting time). By combining 'excellent' and 'high', 'good' and 'adequate', and 'inadequate' and 'unacceptable' the six levels of service were converted to three levels of service. The lowest two ratings were combined because both reflected negative service levels. 'Excellent' and 'high', and 'good' and 'adequate' were combined in this manner for two reasons. First of all, this division separated the six original groups into three groups of two levels each, instead of combining the three higher levels together and then leaving 'adequate' on its own. Secondly, although the term 'good' was used in both models, the three level model did not provide any level higher than 'good'. Thus, a respondent evaluating the service as better than 'good' would nonetheless have to indicate 'good' using the three level model. Any respondent evaluating the service as mediocre would select 'tolerable' in the three level model, but could select either 'good' or 'adequate' using the six level model. Thus, both 'excellent' and 'high' from the six-level model were combined to form the 'good' level from the perception response model.

For each value of perceived waiting time, Figure 6-15 shows the percent of respondents that evaluated the waiting time according to the three categories. The data is summarized in this manner to enable a comparison with the analysis conducted by Ashford (1988). Two points on the graph are of interest: when the percent of respondents that provided the middle rating exceeded those that provided the highest rating; and when the percent of respondents providing the lowest rating exceeded those providing the middle rating. From the figure, the waiting time associated with the change from the highest level to the middle level occurred at 5 minutes, while the change from the middle level to the lowest level occurred at 22.5 minutes. Ashford's research identified 12.5 minutes and 22.5 minutes for these points, respectively. Although the higher values were identical (22.5 minutes), the lower values differed by 7.5 minutes. This discrepancy was caused by the many differences in the two research strategies that included:

- ◆ the objectives of the research were not the same;
- ◆ this research used perceived waiting time, rather than actual waiting time;
- ◆ the different questions on the questionnaires could have caused passengers to provide different evaluations; and
- ◆ the six levels from this research were possibly not converted to the same three levels used by Ashford (the 'good' ratings from the six levels should have been split between the highest and middle ratings of the three level model).

Based on the responses received from the six airports that participated in this research, a waiting time of 5 minutes or less provided excellent or high service, a waiting time between 5 and 22.5 minutes provided good or adequate service and a waiting time of more than 22.5 minutes was perceived by passengers as inadequate or unacceptable.

Figure 6-15: Percent of Respondents Versus Perceived Waiting Time

Table 6-14 shows the average perceived waiting time and the average rating of the waiting time for each of the six airports. Thunder Bay received the lowest average perceived waiting time of just less than four minutes and received the best rating of 2.1

out of six. This is a rating of approximately 'high'. Interestingly, Montreal had the largest average perceived waiting time, but both Ottawa and Toronto received lower ratings of 3.5 and 3.6, respectively. These ratings are approximately halfway between 'adequate' and 'good'. Respondents in Montreal expected a longer waiting time than at other airports and thus were not disappointed when that occurred. Due to bad publicity, respondents in Toronto evaluated the waiting time poorly, even though the waiting time was not actually that long, relatively speaking. They had a preconceived notion that the baggage delivery times would be lengthy and thus evaluated the service based on this notion rather than on the actual delivery time. Positive news articles, stressing the *actual* waiting times occurring at the Toronto airport might change the negative opinions that Toronto passengers have.

Table 6-14: Evaluation of Waiting Time in Reclaim Area

Airport	Waiting Time in Reclaim Area	
	Average Perceived	Average WAITTIME
	Waiting Time (minutes)	Rating from 1 (excellent) to 6 (unacceptable)
Thunder Bay	4.0	2.1
Ottawa	11.8	3.5
Edmonton	7.5	2.9
Calgary	10.4	2.8
Montreal	13.0	3.2
Toronto	10.0	3.6

6.3.7 Respondent Perception of Accessible Conveyor Belt Perimeter

Respondents were asked to evaluate the length provided along the conveyor belt for the collection of baggage. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using ‘excellent’, ‘high’, ‘good’, ‘adequate’, ‘inadequate’, or ‘unacceptable’ (EDGSPACE). The total length along the conveyor available was constant for each reclaim conveyor belt, however, the number of people using the belt affected the length along the belt provided per person. As traditionally used for LOS determination, it was anticipated that the accessible length provided per person along the conveyor would affect the respondent’s evaluation of the overall BHS.

It can be seen from Table 6-15 that the lowest maximum number of passengers per metre was observed as 1.3 in Thunder Bay. The highest maximum number of passengers per metre was observed as 5.1 in Calgary. This value occurred during only one flight and the next highest value in Calgary was 3.7 passengers per metre, which is well below the 5 passenger per metre standard. The lowest (best) average value was 0.5 passengers per metre and occurred in Edmonton, while the highest (worst) average value was 1.8 passengers per metre and occurred in Ottawa. Corresponding to the highest average value occurring in Ottawa, was the worst rating of 3.4, which corresponds to a service level midway between ‘adequate’ and ‘good’.

Table 6-15: Evaluation of Conveyor Frontage

Airport	Accessible Conveyor Belt Perimeter			
	Minimum (people/ metre)	Maximum (people/ metre)	Mean (people/ metre)	Average Rating from 1 (excellent) to 6 (unacceptable)
Thunder Bay	0.1	1.3	0.6	2.3
Ottawa	0.2	3.8	1.8	3.4
Edmonton	0.025	1.7	0.5	2.6
Calgary	0.1	5.1	1.1	2.9
Montreal	0.1	2.0	0.8	3.1
Toronto	0.2	3.9	1.1	3.1

Table 6-16 indicates the relationship between the number of passengers along the reclaim conveyor belt and the rating provided by the respondent for this aspect of the BHS, EDGSPACE. As expected, the EDGSPACE rating worsens as the mean and median values for number of passengers per metre of length along the conveyor belt increase. Since both inadequate and unacceptable are negative ratings, passengers had trouble distinguishing between the two. Table 6-16 indicates that a mean value of 2.7 passengers per metre indicates both inadequate and unacceptable service. Additionally, a median value of 3.0 passengers per metre indicates both inadequate and unacceptable service. These standards, which were developed based on passenger *perceptions*, are very different from the design standard used by the Aeroports de Paris of five passengers per metre.

Table 6-16: Relationship between Length along Reclaim Conveyor and EDGSPACE**Rating**

EDGSPACE Rating	Length along Conveyor (passengers per metres)	
	Mean	Median
Excellent	0.6	0.6
High	0.9	0.7
Good	1.1	0.9
Adequate	1.5	1.2
Inadequate	2.7	3.0
Unacceptable	2.7	3.0

6.3.8 Respondent Perception of Overall Space in Reclaim Area

Respondents were asked to evaluate the overall amount of space in the reclaim area, where passengers collect their checked baggage. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using 'excellent', 'high', 'good', 'adequate', 'inadequate', or 'unacceptable' (OVRSPACE).

The overall amount of space provided in the reclaim area has traditionally been an important criterion for LOS evaluation. The strength of this relationship is of interest, as is the relationship between the space provided per person (M2PERPAS) and the rating of the space (OVRSPACE). Table 6-17 indicates the mean and median for the amount of

space provided per person that are associated with the six LOS from excellent to unacceptable. With the exception of the 'unacceptable' category, the mean value for meters squared per passenger decreases as the rating decreases. Passengers had difficulty distinguishing between the two negative LOS categories of inadequate and unacceptable. When considering means, respondents were unable to distinguish between inadequate and unacceptable for this aspect of the service. When considering the median value for meters squared per passenger that is associated with each LOS, passengers did not distinguish between the categories of excellent and high. However, a general trend can be seen between these two variables: as the amount of space provided per person in the reclaim area decreased, the rating of this aspect of the BHS decreased. A comparison of these passenger perception based standards with the operational standards used by either Transport Canada or IATA (Table 4-5), indicates that passengers desire more space per person in the reclaim area and that the traditional standards are inadequate.

Referring to Table 6-18, the *maximum* amount of area provided per passenger is not a good indication of the service level provided as it occurs when only one or two people from a flight are collecting baggage. Thus, the *minimum* area provided is a better indication of the service level. Toronto provided the worst scenario where only 0.9 m² was provided per passenger at the most congested time during a flight. Ottawa and Calgary followed closely behind with a minimum of 1.1 m² provided per passenger. Due to a recent renovation, the Edmonton airport provided an average of 23.8 m² per

passenger. Comparing the average rating received from the respondents at each airport (column 5), Thunder Bay received the best rating of 2.3, which refers to a service level between 'good' and 'high'. Ottawa received the worst rating of 3.4, which refers to a service level between 'adequate' and 'good'.

Table 6-17: Relationship between Space provided in the Reclaim Area and OVRSPACE Rating

Rating	Space Provided in Reclaim	
	Area (m ² per passenger)	
	Mean	Median
Excellent	10.8	6.0
High	9.7	6.0
Good	6.4	4.1
Adequate	4.7	3.1
Inadequate	2.5	2.0
Unacceptable	3.1	1.3

Table 6-18: Evaluation of Overall Space in Reclaim Area

Airport	Overall Space in Reclaim Area			
	Minimum	Maximum	Average	Average OVRSPACE
	Area	Area	Area	Rating from 1 (excellent)
	(metres ² /passenger)			to 6 (unacceptable)
Thunder Bay	2.1	21	7.4	2.3
Ottawa	1.1	18.9	7.3	3.4
Edmonton	2.9	189	23.8	2.5
Calgary	1.1	58.8	11.8	2.7
Montreal	1.7	73.5	11.2	3.0
Toronto	0.9	29.2	7.2	3.1

6.3.9 Respondent Perception of Seating Provided

Respondents were asked to evaluate the amount of seating provided in the reclaim area. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using 'excellent', 'high', 'good', 'adequate', 'inadequate', or 'unacceptable' (SEATING). When counting the number of seats provided, the author considered the seats in the immediate vicinity of the conveyor belt, or within

approximately four metres, and visible from the conveyor belt. Adjacent seats allowed a passenger to sit while watching the baggage circulate on the conveyor belt, provided no standing passengers were obstructing the seated passengers view. It was anticipated that different age categories would evaluate this aspect of the BHS differently, as older passengers were possibly more interested in obtaining a seat.

Ottawa was the only airport that provided seats adjacent to *all* conveyor belts that were observed in operation during this research. The remaining airports had at least one conveyor with no adjacent seats. Referring to the average rating evaluated by the respondents (SEATING), Edmonton received the best rating of 2.5, which refers to a service level between 'good' and high' (Table 6-19). The remaining five airports were rated between 4.6, which corresponds to a service level halfway between inadequate and adequate, and 3.8, which corresponds to a service level a bit better than 'adequate'. Interestingly, in Thunder Bay the rating was 4.0, a service level of approximately 'adequate', even though no seats were provided in the immediate vicinity of the conveyor belt. This occurred because many respondents did not desire seating and thus, they were content with the amount of seating provided, regardless of the fact that no seats were adjacent.

Table 6-19: Evaluation of Number of Seats Provided

Airport	Seating Provided in Reclaim Area			
	Minimum No. of Seats	Maximum No. of Seats	Average No. of Seats	Average SEATING Rating from 1 (excellent) to 6 (unacceptable)
Thunder Bay	0	0	0	4.0
Ottawa	20	22	21.8	4.3
Edmonton	0	36	7.0	2.5
Calgary	0	16	11.7	3.8
Montreal	0	10	2.7	4.4
Toronto	0	8	1.6	4.6

6.3.10 Respondent Perception of Personal Comfort

Respondents were asked to rate the reclaim area in terms of the level of personal comfort and safety. Respondents were asked to rate this aspect of the service by indicating which level of service was being provided using ‘excellent’, ‘high’, ‘good’, ‘adequate’, ‘inadequate’, or ‘unacceptable’ (COMFORT). This aspect of the service was of interest because it was expected that the level of comfort and safety felt by the respondent would influence the overall LOS perceived.

Respondents were the most at ease in Thunder Bay, providing an average rating of 2.4, corresponding to a rating between 'good' and 'high' (Figure 6-16). The worst two ratings were given by respondents in Montreal and Toronto, with an average rating of 3.3 and 3.2, respectively, which corresponds to a service level of between 'adequate' and 'good'. This could have been due to the fact that 50% of the respondents in Montreal and 47.6% of the respondents in Toronto were international travellers. These passengers had possibly never been to the Montreal or Toronto airports and thus, were unfamiliar with the surroundings. This is in contrast to business passengers, a high percentage being on domestic flights, that are familiar with the destination airport. Additionally, the three airports that have been renovated in the past decade (Thunder Bay, Edmonton, Calgary) received better ratings for comfort and safety than the three airports that are operating at or near capacity.

6.3.11 Respondent's Perception of Overall Level of Service

Respondents were asked to rate the overall service provided by the arrival baggage handling system, including the reclaim area space, the seating provided, the design of the conveyor belts, and the speed with which the baggage was delivered. The answer provided by the respondent for the overall LOS was used as the dependent variable for the regression analysis. The main objective of this research was to determine the independent factors that influenced this variable.

Figure 6-16: Evaluation of Comfort and Safety in Reclaim Area

Respondents were asked to rate this aspect of the service using two different scales.

Using the first method, passengers were asked to rate the service on a scale of 0 to 10, where '0' indicated 'unacceptable' service and '10' indicated 'excellent' service. Using the second scale, passengers were asked to indicate which level of service was being provided using 'excellent', 'high', 'good', 'adequate', 'inadequate', or 'unacceptable'.

The first scale is a widely used scale where a system is rated on a scale of zero to ten.

Due to the simple and common nature of this scale, it was easy for passengers to evaluate. The second scale referred to the six LOS ratings from A through F. The two different scales were used to ensure that passengers could distinguish between the six adjectives used to describe the service in terms of LOS A (excellent) to LOS F (unacceptable).

(a) Numeric Scale

The responses for the overall LOS rating question using the numeric scale were saved in a variable called LOS1. Using this scale (0 = unacceptable, 10 = excellent) it was found that respondents rated the Ottawa airport with the lowest mean value of 6.3 out of 10, while Thunder Bay was rated the best with a mean value of 8.3 out of 10 (Table 6-20). Calgary received the second highest rating (7.5 out of 10), followed by Edmonton (7.0), Montreal (6.7), and Toronto (6.6).

The lowest rating that Thunder Bay received from any respondent was 6 out of 10 and the lowest rating that Montreal received from any respondent was 2 out of 10. The other four airports (Edmonton, Ottawa, Calgary, and Toronto) received ratings encompassing the whole scale from 0 through to ten. In all comparisons discussed thus far, the respondents have rated Thunder Bay airport the highest.

Table 6-20: Level of Service Rating of Arrival Baggage Handling System (scale: unacceptable = 0, excellent = 10)

Airport	Level of Service Rating from 0 to 10		
	Minimum	Maximum	Mean
Thunder Bay	6	10	8.3
Ottawa	0	10	6.3
Edmonton	0	10	7.0
Calgary	0	10	7.5
Montreal	2	10	6.7
Toronto	0	10	6.6

(b) Subjective Non-Numeric Scale

The responses from the second overall LOS rating question using the non-numeric scale were stored in a variable called LOS2. Referring to this scale, which contained the descriptive adjectives of ‘excellent’, ‘high’, ‘good’, ‘adequate’, ‘inadequate’, and ‘unacceptable’, Thunder Bay did not receive any rating less than adequate (Table 6-21), while the other five airports received ratings as low as unacceptable. The best response of ‘excellent’ was given a coding of ‘1’ in the software, while the worst response of ‘unacceptable’ was given a coding of ‘6’. Comparing the mean values, Thunder Bay

received the best rating of 2.2 (between 'good' and 'high') while Ottawa received the worst rating of 3.3 (between 'adequate' and 'good').

Table 6-21: Level of Service Rating of Arrival Baggage Handling System (Excellent, High, Good, Adequate, Inadequate, Unacceptable)

Airport	Level of Service Rating from 1 to 6		
	Minimum	Maximum	Mean ¹
Thunder Bay	Adequate	Excellent	2.2 = Good to High
Ottawa	Unacceptable	Excellent	3.3 = Adequate to Good
Edmonton	Unacceptable	Excellent	2.9 = Good to High
Calgary	Unacceptable	Excellent	2.6 = Good to High
Montreal	Unacceptable	Excellent	3.1 = Adequate to Good
Toronto	Unacceptable	Excellent	3.2 = Adequate to Good

Note 1: In SPSS, the 6 responses were each given a numeric coding. A response of 'Excellent' was input with a value of 1, and a response of 'unacceptable' was given a value of 6. Thus, a mean rating value of 2.5 refers to a rating between the responses of 'high' and 'good'.

(c) Comparison of Scales

The responses obtained for the overall LOS evaluation using the numeric and non-numeric scales were compared (Figure 6-17) to ensure that passengers could distinguish between the adjectives used to describe LOS A to F. A scatter plot revealed a non-linear,

quadratic relationship between LOS1 and LOS2. From a non-linear regression analysis in SPSS a significant correlation, with $R^2 = 0.711$, was found between the responses obtained using the two different scales. The relationship between the two variables can be described by the following equation.

$$LOS2 = 5.605 - 0.216(LOS1) - 0.0223(LOS1)^2$$

Figure 6-17: Relationship between LOS1 and LOS2

Since a strong correlation was found between LOS1 and LOS2, either measurement was deemed appropriate for developing the UPLOS regression model. Since respondents used the non-numeric scale (from excellent to unacceptable) for classifying seven other aspects of the baggage handling system, LOS2 was used instead of LOS1 for the regression analysis, described in the following chapters. Based on this equation, Table 6-22 indicates how the numeric scale of LOS1 from 0 to 10 can be translated to indicate the LOS being perceived (LOS2). For example, if a respondent rated the service with a value anywhere between 6.0 and 7.9 on a scale of 0 to 10, this translated to a LOS rating of Good.

Table 6-22: Conversion between LOS1 (numeric) and LOS2 (non-numeric)

LOS1 Range	LOS2 Value	LOS2
0 to 0.5	5.5 to 6	Unacceptable
0.5 to 3.7	4.5 to 5.5	Inadequate
3.7 to 6.0	3.5 to 4.5	Adequate
6.0 to 7.9	2.5 to 3.5	Good
7.9 to 9.6	1.5 to 2.5	High
9.6 to 10	1 to 1.5	Excellent

6.4 Summary of Questionnaire Responses

Passenger characteristics, flight details and passenger responses vis-à-vis the perceived LOS provided by the BHS were discussed in this chapter. This section summarizes the

most important results obtained from the analyses and discussions included in this chapter.

Gender: Female passengers declined to complete the questionnaire more often than male passengers. Female passengers were uncomfortable filling out a questionnaire in the medium and large airports, but were at ease at the small airport.

Age: In Edmonton and Montreal, the majority of passengers were between the ages of 25 to 39. In Ottawa, Calgary, Thunder Bay and Toronto, the majority of passengers were between the ages of 40 to 60. Since passengers over 60 years of age declined to complete the survey more often than younger passengers, the actual percent of travellers greater than 60 years of age is higher than results indicate.

Trip Purpose: The largest portion of passengers at all six airports, from 49.6% to 63.9%, were traveling on business only.

Amount of Checked Baggage: The majority of passengers at each airport, from 57.7% in Montreal to 67.7% in Edmonton, checked only one item of baggage.

Number of Flights per Year: At each airport, from 29% in Thunder Bay to 42.2% in Ottawa, the mode for number of flights taken was 10 or more flights per year.

Type of Ticket: The percent of passengers with economy tickets ranged from 81.3% to 90%, forming the majority of travellers. Regression analysis results (discussed in a subsequent section) did not make any distinction between respondents travelling with a business class ticket and respondents with an economy class ticket.

Perceived Waiting Time: Thunder Bay airport had the lowest average perceived waiting time of 4.0 minutes. Montreal had the highest average perceived waiting time of 13.0 minutes.

Expected Waiting Time: The shortest average expected waiting time was 6.8 minutes and occurred in Thunder Bay. The longest average expected waiting time was just under 12 minutes and occurred in Montreal.

Perception of Walking Distance: Thunder Bay received the best rating of 2.1 for average walking distance, which corresponds to a service level just less than 'high'. Edmonton and Toronto received the lowest rating of 3.1, which is just less than 'good'.

Perception of Walking Time: Regardless of airport size, the walking time perceived by the respondents at each airport was approximately twice the actual value measured by the author. Thunder Bay received the best rating of 2.0, which is a 'high' rating. Edmonton

and Toronto received the worst two ratings of 3.1 and 3.0, respectively, which are 'good' ratings.

Perception of Waiting Time in Reclaim Area: Thunder Bay received the lowest average perceived waiting time and received the best rating of 2.1 out of 6, corresponding to a rating of just less than 'high'. Ottawa and Toronto received the lowest ratings of 3.5 and 3.6, respectively, corresponding to a service level approximately halfway between 'adequate' and 'good'.

Perception of Conveyor Belt Frontage: Thunder Bay received the best average rating of 2.3 out of 6, between 'good' and 'high', for the length of conveyor belt frontage provided. Ottawa received the worst rating of 3.4, which corresponds to a service level midway between 'adequate' and 'good'.

Perception of Overall Space in Reclaim Area: Thunder Bay received the best rating of 2.3, which refers to a service level between 'good' and 'high'. Ottawa received the worst rating of 3.4, which refers to a service level between 'adequate' and 'good'.

Perception of Amount of Seating Provided: Edmonton received the best rating of 2.5, which refers to a service level between 'good' and high'. Toronto received the worst

rating of 4.6, which corresponds to a service level halfway between 'inadequate' and 'adequate'.

Perception of Personal Safety and Comfort in Reclaim Area: Thunder Bay received the best average rating of 2.4, corresponding to a rating between 'good' and 'high'. The worst two ratings were given by respondents in Montreal and Toronto, with an average rating of 3.3 and 3.2, respectively, which corresponds to a service level of between 'adequate' and 'good'.

Perception of Overall Level of Service Provided by Baggage Handling System: Thunder Bay received the best average rating, followed by Calgary, Edmonton, Montreal, and Toronto. The Ottawa airport received the lowest average level of service rating. However, the majority of respondents with mishandled baggage arrived in Ottawa (Figure 6-9) and thus, negatively influenced the overall LOS rating.

6.5 Conclusions

Based on the discussions within this chapter, the following conclusions were reached:

- ◆ Overall, Thunder Bay consistently received the lowest waiting times and best ratings.
- ◆ Between 1.9 and 3.2% of baggage was misplaced.

- ◆ All misplaced bags were carried by Air Canada.
- ◆ 74% of respondents with misplaced baggage were travelling through Toronto, while only 24% of all respondents traveled through Toronto.
- ◆ Respondents were able to estimate their perceived waiting time in the reclaim area within a couple of minutes of the maximum waiting time.
- ◆ Respondents were not able to estimate walking distance between the arrival gate and the reclaim area. Respondents estimated twice the actual walking distance.
- ◆ Respondents travelling for pleasure expected larger waiting times than respondents traveling for business, and respondents travelling less frequently expected larger waiting times than frequent flyers.
- ◆ For the 'unacceptable' or 'bad' LOS only, this research agreed with Ashford's research regarding the passenger perception model: both studies determined that a waiting time of more than 22.5 minutes indicated 'bad' or 'unacceptable' service.
- ◆ Table 6-23 indicates the mean and median values for each LOS from A to F for each individual aspect of the BHS. These values indicate how passengers rated each aspect of the baggage handling system and can be used as design or operational standards for individual characteristics of the BHS. The variables that influence a passenger's perception of the LOS provided by the BHS as a *whole* are discussed in the next chapter. This table is further discussed in the concluding chapter.

Table 6-23: Summary of Passenger LOS Expectations

Criteria	Level of Service					
	A	B	C	D	E	F
a) WALKDIST between arrival gate and reclaim						
Actual walking distance between arrival gate and reclaim area (metres)						
Mean	130	158	179	228	267	267
Median	114	146	165	237	279	292
b) WALKTIME between arrival gate and reclaim area						
Actual walking time between arrival gate and reclaim area (minutes)						
Mean	2.2	2.5	2.8	3.4	3.8	4.1
Median	1.8	2.3	2.8	3.6	3.8	4.4
Perceived Walking time between arrival gate and reclaim area (minutes)						
Mean	4.0	5.1	5.8	6.9	7.4	10.7
Median	3.0	5.0	5.0	5.0	5.0	10.0
c) WAITTIME in reclaim area						
Perceived waiting time in reclaim area (minutes)						
Mean	3.4	6.4	8.6	12.1	16.5	22.2
Median	3.0	5.0	8.0	10.0	15.0	20.0
d) EDGSPACE along conveyor						
Accessible length along reclaim conveyor (passenger per metre)						
Mean	0.6	0.9	1.1	1.5	2.7	2.7
Median	0.6	0.7	0.9	1.2	3.0	3.0
e) OVRSPACE in reclaim area						
Space in reclaim area (m ² per passenger)						
Mean	10.8	9.7	6.4	4.7	2.5	3.1
Median	6.0	6.0	4.1	3.1	2.0	1.3

Chapter Seven

7 PREVAILING LEVEL OF SERVICE

The previous chapters described the physical characteristics of the BHS at each airport and the responses obtained from the questionnaire. This chapter analyzes specific flight details in terms of space and time standards and compares the user-perceived LOS with the LOS provided presently by the airlines, baggage handlers and authorities. The differences between the *provided* LOS and the *perceived* LOS are discussed.

7.1 Time Standards

Chapter 4 described different level of service measurements for highways, pedestrian walkways, queues and airports. Table 4-3 provided space and time standards used by the British Airport Authority (BAA), the International Air Transport Association (IATA), Schiphol Airport Authority, and Aeroports de Paris for the baggage check-in area and the baggage reclaim area. These organizations evaluated waiting time variables to provide standards for the service being provided. The BAA, IATA and Aeroports de Paris use a design standard of a maximum of 25 minutes between the arrival of the first passenger and the arrival of the last bag on the conveyor. IATA also stipulates that 90% of the passengers should wait less than 20 minutes for baggage.

The airlines, baggage handlers and airport authorities can all affect the successful provision of these standards. The airlines control the size of aircraft and thus, control the number of people and amount of baggage on board each aircraft. The more baggage on board, the longer it takes to deliver baggage to the reclaim area. Additionally, the airline oversees the operation of the baggage handlers and can therefore influence the operating procedures (including baggage delivery times and allocation of personal) of the baggage handlers. Since the airport authority owns the conveyor belts operating at the airport, it is in their power to improve the equipment of the BHS and to increase its capacity, if and when required. The airport authority dictates the use of the inbound baggage conveyor belts and arrival gates, and whether their use is exclusive or shared by all airlines. The physical separation between arrival gates and reclaim conveyors affects the speed of operation of the BHS and, thus influences the passenger waiting times. Therefore, the airlines, baggage handlers and airport authorities can improve the waiting times described in this section and ensure that the stipulated standards are successfully achieved.

For the purpose of comparison with the standards used by these organizations, average perceived waiting times were calculated for each flight observed during the research. The times calculated for each flight, separated by airport, can be found in Appendix D, while Table 7-1 summarizes this information. Column three indicates the average time in minutes (by airport) between the arrival of the first passenger in the reclaim area and the last bag on the conveyor belt. Column 4 indicates the shortest and longest duration

(minutes) between the arrival of the first passenger in the reclaim area and the last bag on the conveyor belt. Column five indicates the number of flights at each airport (and as a percent) where the time between the first passenger in the reclaim area and the last bag on the conveyor belt exceeded 25 minutes. Finally, column six indicates the number of flights (and the percent of flights) where the cutoff time when 90% of passengers had left the area was greater than 20 minutes. For example, if a flight served 90% of the passengers in 30 minutes, instead of in 20 minute cut off point, that flight would be recorded as not meeting the standard. Alternately, column six indicates the number of flights where more than 10% of the passengers remained to be served at the 20-minute mark.

In some instances the total number of flights considered varied between columns five and six. This was because it was not always possible to record the time that the last bag arrived on the conveyor belt. The flights where this time was not recorded were generally flights with a large amount of baggage or when more than one flight was simultaneously using the same reclaim conveyor. This was due to a slow arrival of passengers through immigration or because there were too many passengers to fit simultaneously around the conveyor belt. For these flights, the waiting times were generally higher and thus, had these times been recorded, the numbers and percents of flights indicated in columns five and six would have increased.

Table 7-1: Summary of Selected Waiting Times and Ranges

Airport	Average Perceived Waiting Time in minutes	Average time between arrival of 1 st passenger and arrival of last bag (minutes)	Range of time between arrival of 1 st passenger and last bag (minutes)	Number (%) of flights where time between 1 st passenger and last bag was more than 25 minutes.	Number (%) of flights where less than 90% of passengers were served at the 20 minute mark.
Thunder Bay	4.0	2.9	1 to 5	0 in 12 (0%)	0 in 12 (0%)
Ottawa	11.8	15.6	2 to 35	4 in 12 (33%)	3 in 13 (23%)
Edmonton	7.5	6.0	-2 to 24	0 in 23 (0%)	4 in 23 (17%)
Calgary	10.4	9.7	2 to 45	1 in 15 (6.7%)	2 in 19 (10%)
Montreal	13.0	19.2	5 to 44	1 in 5 (20%)	5 in 20 (25%)
Toronto	10.0	14.0	4 to 24	0 in 4 (0%)	4 in 21 (19%)

The average time spent waiting to collect baggage in the reclaim area was the lowest in Thunder Bay, the smallest airport, with a value of 4.0 minutes. The average time between the arrival of the first passenger and the arrival of the last bag was also lowest in Thunder Bay, with an average value of just under three minutes. The worst average waiting time was observed in Montreal, with a value of 13.0 minutes. Also in Montreal, the longest average time between the arrival of the first passenger and the arrival of the last bag was observed, with a value of just over 19 minutes. The three most recently renovated airports (Thunder Bay, Edmonton and Calgary) observed an average perceived waiting time that

was slightly greater than the average time between the arrival of the 1st passenger and the arrival of the last bag indicating that most passengers arrived simultaneously in the reclaim area and at approximately the same time as the first passenger. Additionally, the passengers slightly overestimated the waiting time. At the remaining three airports, the average waiting time was lower than the average time between the arrival of the 1st passenger and the arrival of the last bag indicating that the passenger arrivals were more spread out (occurring over a more lengthy period of time).

Considering the range of times (minimum and maximum values) between the arrival of the first passenger and the arrival of the last bag, Edmonton observed the shortest time of minus two minutes (where the last item of baggage arrived before the first passenger by two minutes). Thunder Bay observed the lowest maximum value of five minutes whereas Montreal and Calgary observed the greatest difference between the arrival of the first passenger and the arrival of the last bag with values of 44 minutes and 45 minutes respectively.

According to the time standards used by the BAA, the IATA, and Aeroports de Paris for the baggage reclaim area (Table 4-3), there should be a maximum of 25 minutes between the arrival of the first passenger and the arrival of the last bag on the conveyor. During the research, three of the six airports investigated exceeded this time limit at least once. Calgary exceeded the 25 minutes during one of the 15 flights observed or 6.7% of the

flights. Montreal exceeded the 25-minute limit during one of the 5 flights observed or 20% of the flights. Finally, Ottawa exceeded the 25 minutes, during 4 of 12 flights, or 33% of the flights. As noted above, these values should have been greater for Toronto and Montreal, where it was impossible to record the time of the last bag for many of the flights.

A second standard stipulated by IATA is that 90% of the passengers should wait less than 20 minutes for baggage. Referring to column six of Table 7-1, only Thunder Bay Airport provided service above this standard where all of the 12 flights resulted in 90% of the passengers being served in less than 20 minutes. From 10% (Calgary) to 25% (Montreal) of flights at the five other airports resulted in 90% of passengers being served at a time greater than 20 minutes. Details about the flights that did not meet the 20-minute time standard can be found in the tables of Appendix C and Appendix D. The three flights in Ottawa were Air Canada flights AC456 and AC619, and Canada 3000 flight MM707. Both AC456 and MM707 had a relatively large number of passengers (162 and 134 respectively), while flight AC619, with a large ratio of baggage to passengers, arrived during a very congested period. In Edmonton, Air Canada flights AC167 and AC8396 and WestJet flights WJ42 and WJ46 failed the 20-minute standard for no obvious reason. The domestic Air Transat flight 424 and the international Canada 3000 flight CMM692 failed the 20 minute standard in Calgary. They were the two largest flights observed in terms of passenger and baggage volumes, both carrying in excess of 200 passengers and

350 items of baggage. In Montreal, the four largest flights observed, in terms of baggage volume, were Air Canada flight AC871, Air France flight 344, Swiss Air flight 134, and CSA flight SR134. These international flights transported 335, 438, 204 and 434 items of baggage, respectively, and failed the 20-minute time standard. Additionally, Air Canada flight AC066 departing from Toronto with 120 passengers and 60 bags and arriving in Montreal during a peak period failed the time standard. The three largest flights observed in Toronto, in terms of passenger volume, failed the standard. Air Canada international flights AC3232, AC857 and AC947 carried in excess of 160 passengers. Additionally, Air Canada domestic flight AC3977, carrying 100 passengers, failed the standard.

In summary, Thunder Bay, the smallest airport, was the only airport that satisfied the time standards set by the BAA, the IATA, and the Aeroports de Paris. Montreal's Dorval airport and the Ottawa airport provided the lowest service levels according to these standards.

Two columns from the tables in Appendix D indicate whether each flight passed or failed the time standards used by the above authorities. Additionally, the final column of the tables in Appendix D indicates the median user-perceived LOS. Thus, 50% of the respondents evaluated the overall BHS service above and 50% below this value. Table 7-2 summarizes the number flights that passed and/or failed the time standards and provides the UPLOS range that corresponds to these flights. As two time standards were

used, a particular flight either received two passing grades, two failing grades or one of each. All 12 flights in Thunder Bay received two passing grades and the median UPLOS values corresponding to these flights were LOS B's and LOS C's. In Edmonton, the 19 flights that received two passing grades received median UPLOS values ranging from A E. The four Edmonton flights that received one passing and one failing grade received median UPLOS values ranging from B to F. Similarly with the other airports, a direct relationship between the median user-perceived LOS values and whether the two time standards were passed successfully was not evident. Thus, no direct relationship was found between the UPLOS and the LOS provided by the airlines, baggage handlers, and airport authorities in terms of time standards.

Table 7-2: Comparison of Grading of Time Standards and UPLOS by Flight

Airport	Number of Flights and Corresponding Median UPLOS					
	Range					
	Two Passing Grades		One Passing and One Failing Grade		Two Failing Grades	
Thunder Bay	12	B-C	0		0	
Ottawa	7	A-C	3	C-D	2	C-D
Edmonton	19	A-E	4	B-F	0	
Calgary	13	A-C	1	D	1	D
Montreal	3	B-C	1	B	1	C
Toronto	3	B-D	1	D	0	

7.2 Space Standards

As mentioned in section 7.1, the various organizations listed in Table 4-3 evaluate different aspects of the baggage handling system to provide standards for the service being provided. Two variables commonly used for space standards include square metres per passenger and conveyor belt frontage per passenger. The Aeroports de Paris consider that a reclaim frontage of 1.0 m for every 5 passengers is a reasonable design standard. The space standards used by the BAA state that 1.25 m² be provided in the reclaim area per domestic passenger, 2.0 m² per short haul international passenger, and 3.25 m² per long haul passenger. The IATA design standards state that 0.8 m² be provided in the reclaim area per domestic and short haul international passenger, and that 1.6 m² be provided per long haul passenger. The IATA operational space standards used to distinguish between levels of service A through F are in Table 4-5. The design standard suggested by IATA refers to a LOS of C. The space standards used by Transport Canada to determine which LOS from A to F is being provided are also listed in Table 4-5. Appendix E provides a table for each airport indicating the space and frontage provided to the passengers for each flight observed. A summary of this information is provided in Table 7-3, Table 7-4, and Table 7-5.

As with the time standards described in the previous section, both the airlines and airport authorities have control over the LOS imparted to the passengers, in terms of space standards. Although airlines control the number of passengers on board aircraft, authorities have control over the amount of space in the reclaim area and the allocation of specific conveyor belts (some conveyors have more area surrounding them than others do). The authority operates the conveyors and controls the number, length and layout of available conveyors. Additionally, whether greeters (non-passengers) are allowed to enter the reclaim area is a decision left to the airport authority.

Table 7-3: Summary of Selected Space Standards (Reclaim Frontage) from Appendix E

Airport	Passengers per metre			No. of flights with > 5 passengers per metre
	Minimum value	Maximum value	Mean value	
Thunder Bay	0.1	1.3	0.6	0 in 12
Ottawa	0.2	3.8	1.8	0 in 13
Edmonton	0.025	1.7	0.5	0 in 23
Calgary	0.1	5.1	1.1	1 in 19
Montreal	0.1	2.0	0.8	0 in 20
Toronto	0.2	3.9	1.1	0 in 21

In reference to Table 7-3, columns two, three and four indicate the minimum, maximum, and mean values, respectively, for the number of passengers per metre length of reclaim conveyor belt. The values were calculated using the maximum number of passengers observed in the reclaim area and the frontage of the conveyor belt used for that specific flight. The worst result for average number of passengers per metre was 1.8 and occurred in Ottawa where baggage from more than one flight was frequently placed simultaneously on one conveyor belt. As mentioned above, the Aeroports de Paris considers that a reclaim frontage of 1.0 m for every 5 passengers is a reasonable standard. Column five indicates the number of flights at each airport that did not meet this standard. The table indicates that for all the flights observed only one flight out of 19 flights in Calgary provided inadequate frontage. This flight (Air Transat flight number 424 from Montreal to Calgary via Toronto) provided one metre of conveyor belt frontage for every 5.1 passengers. This value barely exceeded the standard of 5 passengers per metre set by the Aeroports de Paris. All other flights in Calgary and at the remaining five airports meet the standard.

Table 7-4 lists the number of square metres per passenger in the reclaim area at each airport. These values are based on the maximum number of passengers in the reclaim area for each flight observed. Column 2 indicates the minimum and maximum values of square metres per passenger observed for domestic flights, while columns 3 and 4 display the minimum and maximum values for international short haul (to the United States) and

international long haul flights (outside the United States), respectively. Column five lists the mean value of square metres per passenger for each airport. The lowest (worst) value of 0.9 square metres per passenger was observed during an international – long haul flight in Toronto. The highest (best) value of 189 square metres per passenger was observed during a domestic flight in Edmonton. This occurred where only one passenger at a time was collecting baggage from a particular flight.

Table 7-4: Summary of Square Metres per Passengers by Airport and Flight Type (Summarized from Appendix E)

Airport	Domestic m ² /passenger		International Short Haul- m ² /passenger		International Long Haul – m ² /passenger		Mean m ² /pass.
	Min.	Max.	Min.	Max.	Min.	Max.	Mean
Thunder Bay	2.1	21	*	*	*	*	7.4
Ottawa	1.1	18.9	*	*	*	*	7.3
Edmonton	2.9	189	6	19.3	*	*	23.8
Calgary	1.1	58.8	1.4	7.9	3.5	3.5	11.8
Montreal	1.7	15.3	8.0	73.5	2.3	3.3	11.2
Toronto	3.3	29.2	1.7	9.6	0.9	20	7.2

Note: * indicates that no flights of this type were observed.

Table 7-5 indicates the number of fights at each airport, by flight type, that did not meet the design standards used by the BAA and IATA. (Recall from a few paragraphs earlier, that the space standards used by the BAA state that 1.25 m² be provided in the reclaim

area per domestic passenger, 2.0 m^2 per short haul international passenger, and 3.25 m^2 per long haul passenger. Similarly, the IATA standards state that 0.8 m^2 be provided in the reclaim area per domestic and short haul international passenger, and that 1.6 m^2 be provided per long haul passenger.) The standards used by the BAA require more space per passengers and thus some airports met the IATA standards, but provided less space than the BAA requires. It can be seen that all flights in Edmonton and Thunder Bay met the standards used by both the IATA and the BAA. Four in thirteen (31%) domestic flights in Ottawa did not meet the BAA standards. In Montreal, three out of four (75%) international long haul flights did not meet the BAA standards. In Calgary, one in 13 domestic (7.7%) and one in five (20%) short haul international flights did not meet the BAA standards. At the Toronto airport, one in seven (14%) short haul international flights and three out of three (100%) long haul international flights did not meet the BAA standards. Additionally, two of the three (67%) long haul international flights in Toronto did not even meet the less stringent IATA standards. These flights failed the space standards for a number of reasons including the following.

- ◆ The flight had a large volume of passengers and the overall space was inadequate.
- ◆ More than one flight arrived simultaneously and used the same reclaim conveyor, thus more than one flight of passengers and greeters were using the same area.
- ◆ Many greeters were present (some flights received more greeters than other flights).

Table 7-5: Summary of Number of Flights that did not meet the BAA and IATA Design Standards for m² per Passenger (from Appendix E)

Airport	Standard	Domestic	International	International
			Short Haul	Long Haul
Thunder Bay	BAA	0 in 12	*	*
	IATA	0 in 12	*	*
Ottawa	BAA	4 in 13	*	*
	IATA	0 in 13	*	*
Edmonton	BAA	0 in 20	0 in 3	*
	IATA	0 in 20	0 in 3	*
Calgary	BAA	1 in 13	1 in 5	0 in 1
	IATA	0 in 13	0 in 5	0 in 1
Montreal	BAA	0 in 10	0 in 6	3 in 4
	IATA	0 in 10	0 in 6	0 in 4
Toronto	BAA	0 in 11	1 in 7	3 in 3
	IATA	0 in 11	0 in 7	2 in 3

Note: * indicates that no flights of this type were observed.

With reference to the Transport Canada standards for the level of service provided in the baggage reclaim area, a LOS A corresponds with more than 1.6 m² per passenger and LOS F corresponds with less than 0.8 m² per passenger in the reclaim area (Table 4-5). Level of service B, C, D, and E have area requirements between these two extremes. For each of the six airports, Table 7-6 indicates the number of flights that provided a LOS from A to F.

According to these Transport Canada standards, the airports in Edmonton, Thunder Bay and Montreal provided a LOS of A for all of the flights observed during the course of this thesis research. The Ottawa airport provided a LOS A for 8 of the 13 (61.5%) flights observed. Two Ottawa flights (15.4%) provided a LOS C and three flights (23.1%) provided a LOS D. Calgary's airport provided a LOS of A for 17 out of 19 (89.5%) observed flights, one of the 19 (5.3%) flights provided LOS B, and one of 19 (5.3%) provided a LOS of D. Toronto's airport provided a LOS of A for 19 out of 21 (90.5%) observed flights, one of the 21 (4.8%) flights provided LOS D, and one of 21 (4.8%) provided a LOS of E.

From these results, it was evident that, with the exception of the Ottawa airport, a LOS of A was provided by more than 89% of the flights at each airport and in three instances, 100% of the flights provided a LOS A. However, the passenger responses, obtained through the use of the questionnaire, showed that the percent of people satisfied with the service was less than this value (Chapter 6 and Appendix E). Thus, the standards used by Transport Canada do not reflect the LOS *perceived* by the passengers.

Table 7-6: Number of Flights Providing LOS A Through F Based on Transport Canada Standards

Airport	Number of flights providing passengers with LOS A through F					
	A > 1.6 m ²	B 1.4-1.6 m ²	C 1.2-1.4 m ²	D 1.0-1.2 m ²	E 0.8-1.0 m ²	F < 0.8 m ²
Thunder Bay	12 of 12	0	0	0	0	0
Ottawa	8 of 13	0	2 of 13	3 of 13	0	0
Edmonton	23 of 23	0	0	0	0	0
Calgary	17 of 19	1 of 19	0	1 of 19	0	0
Montreal	20 of 20	0	0	0	0	0
Toronto	19 of 21	0	0	1 of 21	1 of 21	0

Similarly, the operational space standards suggested by IATA for the levels of service A through F were analyzed. Table 7-7 indicates the number of flights at each airport that provided each IATA LOS space standard. As with the operational space standards suggested by Transport Canada, Edmonton and Thunder Bay provided LOS A for 100% of observed flights. The major difference between the TC and IATA standards, was that with the TC standards, no flight provided LOS F. Whereas with the IATA standards, Ottawa had three flights operating at a LOS F, Calgary had one flight at LOS F and Toronto had two flights at LOS F. Since the LOS recommended by IATA is C, it is interesting to note that Ottawa had 5 flights (39%) operating below LOS C, while Calgary and Toronto had 2 flights each (11% and 10%, respectively) operating below LOS C.

Table 7-7: Number of Flights Providing LOS A Though F Based on IATA Standards

Airport	Number of flights providing passengers with LOS A through F					
	A > 2.0 m ²	B 1.8 m ²	C 1.6 m ²	D 1.4 m ²	E 1.2 m ²	F < 1.2 m ²
Edmonton	23 of 23	0	0	0	0	0
Ottawa	8 of 13	0	0	0	2 of 13	3 of 13
Thunder Bay	12 of 12	0	0	0	0	0
Montreal	18 of 20	0	2 of 20	0	0	0
Calgary	17 of 19	0	0	1 of 19	0	1 of 19
Toronto	18 of 21	0	1 of 21	0	0	2 of 21

The tables in Appendix E provide a comparison of whether the design space standards were passed or failed, which operational LOS was provided and a corresponding median UPLOS value for each flight. It can be seen that in Edmonton and Thunder Bay all flights received passing grades for the three design space standards and a LOS A for the operational standards. However, the median UPLOS values ranged from LOS A to LOS F demonstrating that a relationship between the LOS indicated by the space standards and the user's perception of LOS does not exist. Where a flight received at least one failing grade, the corresponding median UPLOS values ranged from LOS B to LOS D. Where a flight was operating at a LOS F according to IATA operational standards the corresponding UPLOS values ranged from LOS B to LOS C, and these UPLOS values

more closely resembled the LOS designated by the TC operational standards. Thus, it appears that the TC operational standards (rather than those stipulated by IATA) are more appropriate measures of the LOS as perceived by the passengers. However, for most cases, the median UPLOS was not equivalent to the LOS determined with either the IATA or TC operational space standards.

7.3 Baggage Delivery Standards

Chapter 3 described the baggage handling operations at the Montreal and Ottawa airports, and section 3.1.4 listed the standard delivery times used by Air Canada baggage handlers. In summary, the priority baggage must be on the conveyor belt between 12 and 15 minutes after the aircraft arrives in the gate and the regular baggage must be on the conveyor belt between 15 and 30 minutes after the aircraft arrives in the gate. This range of values provides times for different sizes of aircraft to deliver baggage to the reclaim area. Appendix F provides a table for each airport indicating, among other variables, the time between the arrival of the aircraft and the arrival of the first bag on each flight. Table 7-8, Table 7-9, and Table 7-10 summarize the delivery times.

As with the time and space standards, the baggage delivery times can be affected by both airline and airport authority operating procedures. While the airline controls the allocation of baggage handling personnel and their operating procedures, the authority

allocates arrival gates. The distance between the arrival gate and the reclaim area, as well as the efficiency of the BHS equipment, influence the delivery times. Thus, whether the standards provided in this section were met or not, can be influenced by both the airlines, baggage handlers and airport authorities.

Table 7-8 indicates the difference in time (in minutes) between the arrival of the aircraft and the arrival of the *first* item of baggage. The minimum, maximum and mean values, calculated for this time difference, are listed by airport. For Edmonton, Ottawa, Thunder Bay and Calgary airports, the first item of baggage arrived on the conveyor belt approximately ten minutes after the arrival of the aircraft, on average. For Toronto and Montreal, the two airports with greater passenger volumes, the average time for the arrival of the first item of baggage was 15 minutes or 50% more than the other four airports. Thus, in both Toronto and Montreal, many flights did not deliver the priority bags between 12 and 15 minutes after arrival of the aircraft.

Table 7-9 indicates the difference in time (in minutes) between the arrival of the aircraft and the arrival of the *last* item of baggage. The minimum, maximum and mean values, calculated for this time difference, are listed by airport. Also in Table 7-9, are the percentages of time that the last item of baggage was delivered before the 15 and 30 minute Air Canada time standards. As per the baggage delivery practices of the baggage

handlers at each airport, the *last* item of baggage to be placed on the conveyor was not a priority item, but rather an item of regular baggage.

Table 7-8: Summary of Time Difference Between Arrival of Aircraft and Arrival of First Items of Baggage

Airport	Time between aircraft arrival and arrival of 1 st bag on conveyor (minutes)		
	Minimum	Maximum	Mean
Thunder Bay	4	14	10.5
Ottawa	4	15	10.5
Edmonton	3	31	10.3
Calgary	2	31	10.6
Montreal	9	22	14.8
Toronto	9	25	15.1

Referring to column 4 of Table 7-9, the average time that the last item of baggage was placed on the conveyors at the Thunder Bay and Edmonton airports was 11.8 and 12.3 minutes, respectively. Both of these average times are less than the 15-minute standard time used for the delivery of priority baggage. Thus, on average, both regular and priority baggage arrived on the conveyor belt before the 15 minute priority limit, and therefore, before the 30-minute regular baggage limit as well. The average time of arrival of the last item of baggage for the Calgary, Ottawa and Toronto airports was between the 15-minute

priority baggage limit and the 30-minute regular baggage limit. Thus, on average, these three airports met the regular baggage delivery standards used by Air Canada. The average time of arrival of the last item of baggage at the Dorval airport was 35.2 minutes. This average was greater than the 30-minute regular baggage limit set by Air Canada, and thus, for many flights in Montreal the standards were not met.

Table 7-9: Summary of Time Difference between Arrival of Aircraft and Arrival of Last Item of Baggage

Airport	Time between arrival of aircraft and arrival of last item on conveyor (minutes)			Percent of flights where the last item was delivered in 15 minutes or less	Percent of flights where the last item delivered in 30 minutes or less
	Minimum	Maximum	Mean		
Thunder Bay	5	15	11.8	100% (12 of 12)	100% (12 of 12)
Ottawa	6	38	20.1	50% (6 of 12)	67% (8 of 12)
Edmonton	4	32	12.3	70% (16 of 23)	96% (22 of 23)
Calgary	2	56	15.4	67% (10 of 15)	93% (14 of 15)
Montreal	19	59	35.2	0% (0 of 5)	60% (3 of 5)
Toronto	12	35	22.5	25% (1 of 4)	75% (3 of 4)

Columns 5 and 6 of Table 7-9 indicate the percentage of time and the number of flights where the last item of baggage was delivered in 15 minutes or less (column 5) and in 30 minutes or less (column 6). It can be seen that in Thunder Bay the latest delivery time

recorded for the last item of baggage was 15 minutes after the arrival of the aircraft. Thus, 100% of flights achieved the Air Canada delivery standards. In Edmonton and Calgary only one flight at each airport took longer than 30 minutes to deliver the last item of baggage. Conversely, only 75% of flights in Toronto and only 67% of flights in Ottawa delivered the last item of baggage within the 30-minute standard. Considering the flights from these six airports, where the time of delivery for the last item was recorded, Montreal provided the poorest service. In Montreal, the quickest delivery time for the last item was 19 minutes; none of the 5 flights delivered the last item of baggage before the 15 minute mark and more importantly, only 60 percent of flights delivered the last item within the 30-minute standard. As noted earlier, for some flights it was not possible to record the time that the last item of baggage was delivered. In these instances, mainly in Montreal and Toronto, the recording of these times would have worsened, not improved, the results.

The difference in time between the arrival of the first passenger and the arrival of the first item of baggage, PXBGDLAY, for each flight separately is displayed in Appendix F. This data is summarized by airport in Table 7-10. It can be seen that in both Montreal and Edmonton, there were instances where some baggage arrived on the conveyor belt before the passengers arrived at the conveyor. In Edmonton, the baggage arrived 3 minutes earlier than the passengers following two domestic flights. This occurred for two flights originating in Yellowknife that arrived at one of the furthest gates (#62) where the time to

move baggage by cart was faster than the passenger walking time. In Montreal, the baggage off a New York flight arrived 4 minutes earlier than any passengers and the baggage off a flight from Zurich arrived 2 minutes before the first passengers. Both flights arrived in the afternoon as the peak period was beginning and thus the passengers experienced delays through customs and immigration.

Table 7-10: Summary of Time Difference between Arrival of First Passenger and Arrival of First Item of Baggage

Airport	Time between arrival of first passenger and arrival of 1 st bag in minutes (PXBGDLAY)		
	Minimum	Maximum	Average
Thunder Bay	0	3	1.6
Ottawa	1	12	6.0
Edmonton	-3	23	4.0
Calgary	1	20	5.2
Montreal	-4	12	3.1
Toronto	0	18	7.1

Column four of Table 7-10 indicates the average difference in time between the arrival of the first passenger and the arrival of the first item of baggage. As was expected, Thunder Bay airport, with the smallest amount of passenger traffic, the smallest airport (by size) and the simplest airport had the lowest difference of 1.6 minutes between the arrival of passengers and baggage. Meanwhile, the Toronto airport, with the largest amount of

passenger traffic, the largest airport by size and a complex terminal, observed the greatest difference of 7.1 minutes. Considering that the Ottawa airport is second smallest in terms of annual passengers, it observed a relatively large average time (6.0 minutes) between the arrival of the first passenger and the arrival of the first item of baggage. Montreal, on the other hand, observed a relatively short average amount of time of 3.1 minutes between the arrival of the first passenger and first baggage.

The tables in Appendix F contain two columns indicating, for each flight, whether the last item of baggage was delivered within 15 minutes of the aircraft's arrival and whether the last item of baggage was delivered within 30 minutes of the aircraft's arrival.

Additionally, the last column indicates the median value for the UPLOS. When both of these two delivery times were achieved, the flight received two passing grades and the median UPLOS value ranged from LOS A to LOS E. For those flights that achieved the 30 minute delivery time, but not the 15 minute time, the flights received one passing grade and the median UPLOS values ranged from B to D. This latter range is *within* the former range of LOS A to E, when one would expect this range to be worse (for example, to be from LOS C to LOS F) since only one passing grade was received. For the flights that did not meet either time standard, two failing grades were received and the median UPLOS values ranged from LOS B to LOS F. Although the lower extreme of this range (LOS F) is worse than the other two ranges provided, it is surprising that a flight that did not deliver the last item of baggage before the 30 minute mark could have been given a

median UPLOS of LOS B. This type of discrepancy occurred (as with the space and time standards), when the owner of the last item of baggage was not a respondent. For the majority of flights, most baggage was delivered continuously, while for some flights the baggage was placed on the conveyor in two groups. A first portion of the baggage was placed initially, followed by a period of inactivity, followed again by a second portion of baggage. While only the time of the final item of baggage was recorded, it is possible that when the baggage was delivered in two or more groups, all respondents could have received their baggage from the earlier group(s). Thus, in these cases, the final baggage arrival time was greater than occurred for the specific respondents. This led to failing grades according to baggage delivery standards, but UPLOS values that were higher than expected. Despite these higher than expected UPLOS values, a relationship was not evident between the UPLOS values and whether the delivery times were met.

7.4 Summary of Time, Space and Baggage Delivery Standards

This section summarizes the standard stipulated by each organization and then describes whether each airport met or did not meet these standards.

7.4.1 Time Standards

BAA, IATA and Aeroports de Paris standard - Maximum of 25 minutes between the arrival of the first passenger and the arrival of the last bag:

Thunder Bay, Edmonton, and Toronto met the standard for 100% of the flights. Calgary did not meet the standard for one in 15 flights. Montreal did not meet the standard for one in five flights. Ottawa did not meet the standard for 4 in 12 flights.

IATA standard – 90% of passengers should wait less than 20 minutes for baggage:

All Thunder Bay flights met the standard. The percent of flights that did not meet the standard were 10% in Calgary, 17.4% in Edmonton, 19% in Toronto, 23% in Ottawa, and 25% in Montreal.

7.4.2 Space Standards

Aeroports de Paris design standard – reclaim frontage of 1.0 m per 5 passengers:

Calgary did not meet this standard (5.1 passengers per metre) for one of 19 flights. All other flights at all other airports met the standard.

IATA design standard - 0.8 m² per domestic and short haul international passenger, and 1.6 m² per long haul passenger:

Thunder Bay, Ottawa, Edmonton, Calgary and Montreal met the IATA standards.

Toronto did not meet the long haul international standard for 2 of 3 flights.

BAA design standard – 1.25 m² per domestic passenger, 2.0 m² per short haul international passenger, and 3.25 m² per long haul passenger:

Thunder Bay and Edmonton met all BAA standards. Ottawa did not meet the domestic requirement for 4 of 13 flights. Montreal did not meet the long haul international standard for 3 of 4 flights. Calgary did not meet the domestic standard for one of 13 flights and the short haul international standard for one of five flights. Toronto did not meet the short haul international standard for one of seven flights and the long haul international standard for 3 of 3 flights.

Transport Canada operational standard – LOS A > 1.6 m² per passenger to LOS F < 0.8 m² per passenger:

Edmonton, Thunder Bay and Montreal provided a LOS of A for all flights. The majority of flights in Ottawa (62%), Calgary (89%) and Toronto (90%) provided LOS A.

IATA operational standard –LOS A > 2.0 m² per passenger to LOS F < 1.2 m² per passenger:

Edmonton and Thunder Bay provided a LOS of A for all flights. The number of flights operating below LOS C was 5 in Ottawa (39%), 2 in Calgary (11%) and 2 in Toronto (10%).

7.4.3 Baggage Delivery Standards

Air Canada standard – Priority bags between 12 and 15 minutes after aircraft arrival, regular bags between 15 and 30 minutes after aircraft arrival:

All Thunder Bay flights were within these standards. Percent of flights that met the 30 minute delivery time were 96% in Edmonton, 93% in Calgary, 75% in Toronto, 67% in Ottawa, and 60% in Montreal.

7.5 Conclusions

From the discussions in this chapter regarding space, time and baggage delivery standards, the conclusions reached are as follows.

- ◆ In terms of time standards, no relationship was found between the UPLOS and the LOS provided by the airlines and airport authorities.
- ◆ In terms of space standards, no relationship was found between the UPLOS and the LOS provided by the airlines and airport authorities.

- ◆ Although neither Transport Canada, nor IATA operational space standards provided a good indication of the overall LOS as perceived by the passengers, the less stringent Transport Canada standards were more accurate than the IATA standards at predicting the UPLOS.
- ◆ The delivery times for priority baggage in Montreal and Toronto need to be improved.
- ◆ The delivery times for regular baggage in Ottawa, Montreal and Toronto need to be improved.
- ◆ No relationship was found between the UPLOS and whether the 15 and 30 minute baggage delivery times were met.

Regardless of whether the space, time or baggage delivery standards are used to determine the LOS, the LOS provided by the airlines, airport authorities and baggage handlers does not correspond well with the LOS as perceived by the users. The evaluation of LOS with traditional space and time measures is not an accurate predictor of the UPLOS.

Chapter Eight

8 MODEL DEVELOPMENT AND VERIFICATION

8.1 Software Package

The Statistical Package for Social Sciences (SPSS) was the software package selected for the analysis of the data collected from the six airports. SPSS (version 10) is capable of performing a large number of statistical procedures, including regression analysis. Other than regression, SPSS was used for creating scatter plots and frequency distributions, and for calculating the mean and standard deviations of a number of variables. Appendix G contains a description of the statistics calculated during the analysis. More than 80 variables were used to describe the airport characteristics and the responses obtained from the passengers. The variables used in the analysis, identified with a *name*, *label*, *type*, *measure*, and *value* are described in Appendix G.

The data were initially screened and then regression analysis was carried out for both aggregate and disaggregate models. The aggregate model considered all six airports simultaneously, while the disaggregate models considered two groupings of airports. The first disaggregate model considered the airports by size (small, medium, and large). The second disaggregate model analyzed the six airports individually.

8.2 Preliminary Data Screening

Scatterplots, histograms, descriptive and frequency procedures and correlation procedures were used to determine various statistics. Bivariate plots were useful for assessing possible outliers. Boxplots and stem-and-leaf plots were also viewed to determine whether outliers existed in the distributions. Additionally, partial residual plots, leverage values, DfBeta values and DfFit values were used to identify outliers among the independent variables and cases that greatly influenced the regression model constant and coefficient values. These values are defined, and a typical bivariate scatterplot, partial residual plot, leverage value plot, DfFit plot and DfBeta plot are provided in Section B of Appendix G.

Once outliers were identified, the cases were reviewed to provide possible reasons why the case was noted as an outlier. In some cases the value for walking time between the arrival gate and the reclaim area was extremely large (i.e. the person stopped partway between the two points). In other cases, the individual had focused on one specific aspect of the BHS (such as walking distance or lack of security) and thus, evaluated every aspect poorly. Since these data values were not a good representation of the population being considered, they were considered outliers and ignored from further analysis.

8.3 Assumptions of Normality

Many statistics, whose calculations are based on the mean and variance of the data, assume that the data being analyzed are from a normal distribution. Parametric tests, such as the t-test and analysis of variance (ANOVA) are appropriate for data that are from a normal distribution and assume that the groups being analyzed have equal variances. Levene's test of homogeneous (or equal) variances can be used to detect violations of the assumption of equal variances across groups.

The statistics are robust enough to handle minor violations of the assumptions of normality. However, for data that do not have a normal distribution, non-parametric tests are available and compare ranks instead of means. Non-parametric tests do not assume that the data come from the specific distribution, however, they sometimes make other assumptions.

Residual plots, including plots of studentized deleted residuals versus standardized predicted values and versus the independent variables, were used to study the assumptions of normality.

The correlation procedure or simple regression in SPSS was used to measure the linear association of two variables. For quantitative data and variables with ordered codes that

do not come from a normal distribution, the Spearman rank correlation coefficient is available, whereby the data values are replaced by the rank orders. Many of the variables being considered were unordered (gender, age, etc) and ordered (Excellent = 1, Unacceptable = 6) categorical data. Thus, the Spearman rank correlation coefficients (for ordered data) were calculated instead of the Pearson coefficients (Table 8-1).

Table 8-1: Sample of Selected Non-Parametric Correlations

Spearman's rho	(1)	(2)	(3)	(4)	(5)	(6)
Rating of Walking Time (1)	1.0	0.439	0.126	0.349	0.383	0.411
Rating of Waiting Time (2)		1.0	0.648	0.594	0.462	0.672
Perceived Waiting Time (3)			1.0	0.424	0.287	0.447
Rating of Overall Space (4)				1.0	0.575	0.573
Rating of Comfort and Safety (5)					1.0	0.555
Overall User Perceived LOS (6)						1.0

Note:

- All correlation significant at the 0.01 level

From histograms of numerical variables (including the passenger's perceived and expected waiting times), the data were found to be highly skewed (Figure 8-1). From

histograms of ordered categorical data (including the ratings for the seven specific BHS aspects and the overall perceived BHS LOS, or UPLOS), where respondents provided a rating of excellent to unacceptable, the data were also found to be skewed (Figure 8-2). These variables had high ratios of kurtosis and skewness to their respective standard errors (these ratios should be between minus two and plus two). Thus, the data could not be considered normal.

Transformations were investigated, but for the ordered categorical data, the x values have such a small range (between 1 and 6) that transformations did not improve the distributions. Further analysis of numerical variables indicated that transforms did not improve the distributions, nor were the transformed variables more correlated to the overall user-perceived BHS LOS (UPLOS). For example, for the passenger's perceived waiting time variable, TIMEWAIT, shown in Figure 8-1, a Levene test rejected the null hypothesis (H_0 : population variances from each group are equal) indicating that the variances from each airport group were not equal (this is an assumption needed for ANOVA). The spread-versus-level plot, used when variances are unequal, was constructed to suggest a power transform that might produce homogeneity of variances among airport groups. Although the log transform was suggested, the transformed variable had high ratios of skewness and kurtosis (Figure 8-3), and a Levene test indicated that the variances were still unequal. Additional transformations did not improve the results. Thus, non-parametric tests were used to analyze the variables. The

correlation procedure and bivariate plots showed relationships among the variables and thus, regression was used to analyze the relationships. Non-linear relationships were not observed in any bivariate plots, and thus the linear regression procedure was used throughout the analysis.

Notes:

- Skewness ratio = 21.9
- Kurtosis ratio = 31.6

Figure 8-1: Typical Skewed, Non-Normal Histogram of Numerical Data

Notes:

- Skewness ratio = 2.72
- Kurtosis ratio = 2.61

Figure 8-2: Typical Skewed, Non-Normal Histogram of Ordered Categorical Data

Notes:

- Skewness ratio = 32.7
- Kurtosis ratio = 67.0

Figure 8-3: Histogram of Log of TIMEWAIT

8.4 Size of the Coefficient of Determination

The strength of the relationship between the independent and dependent variables can be explained in terms of the correlation coefficient (R) or the coefficient of determination (R^2). While R indicates the strength of the linear relationship between the dependent

variable and the independent variable, R^2 indicates the amount of variation in the dependent variable that can be explained by the independent variables in the regression model. Although the interpretations of the R and R^2 values are very subjective, it has been stated that an R^2 of 0.33 indicates a moderately strong relationship (Younger 1979). Since correlation values (R) range between -1 and $+1$, a value of zero would indicate no relationship, and a value of ± 0.5 would indicate a moderate relationship. Any R value of ± 0.75 would indicate a moderately strong relationship, while R values of ± 0.25 would indicate moderately weak relationships. Thus, for a simple regression model (one independent variable), an R^2 of 0.25 results when the correlation between the independent and dependent variables (R) is 0.5. From the discussion above, this would indicate a moderate relationship. Additionally, an R^2 of 0.33 results from a simple regression correlation coefficient of 0.5744 and since this value lies between 0.5 and 0.75, this R^2 would indicate a moderately strong relationship.

A second consideration when determining the strength of the relationship and evaluating the size of the R^2 coefficient is the type of data that are being regressed. For example, a strong relationship exists between the temperature of the asphalt and its strength. As the temperature decreases, the asphalt hardens and the strength increases. These two variables are easily measured quantitative data that are highly correlated. The same experiment can be conducted on numerous occasions and the results will remain the same. The perceptions of individuals are much more difficult to assess and their

perception can vary according to many variables. In the case of this research, the reasons for variability in the passengers perceptions include:

- ◆ personal mood,
- ◆ personal level of stress,
- ◆ time of day,
- ◆ whether they are on holiday or working,
- ◆ whether they are leaving for a holiday or returning from one,
- ◆ whether their flight was on time,
- ◆ whether they are travelling alone or in a group, and
- ◆ whether they are rushed for time.

Thus, if a respondent were asked to fill in the same questionnaire during slightly different personal conditions (maintaining the same flight conditions, the same level of congestion in the reclaim area, the same waiting times, etc) the passenger's perceptions could be different. Passengers perceptions are inherently unpredictable and the R^2 values resulting from regression using individual perception variables will, therefore, be lower. Simple and multiple regression analyses are frequently conducted during sociological research and the resulting R^2 values have been very low. In research studies involving individuals, Clark and Foy (2000) obtained an R^2 of 0.18, Greenfield et al. (2000) obtained R^2 values of 0.10 and 0.18, and Castenada (2000) obtained R^2 values between 0.17 and 0.33. Since this research involved the development of a LOS model based on the evaluation of

various aspects of the BHS from the passenger's perception, the R^2 values would not be as high as would normally be found in purely mathematical engineering studies.

8.5 Variables Influencing Rating of Specific Aspects of BHS

Currently, the LOS of baggage handling systems is evaluated using time and space standards, as discussed in previous sections. Specifically, three standards have been used to describe the LOS being provided. They include the amount of time a passenger waits for baggage in the reclaim area in minutes (TIMEWAIT), the amount of space available in the reclaim area for waiting passengers, greeters and well-wishers measured in metres squared per occupant (M2PERPAS), and the length along the conveyor belt to collect baggage measured in passengers per metre of length (PASPERM). Regression analysis was carried out to determine how these and other variables influenced the ratings provided by the respondents for specific aspects of the BHS (walking time, walking distance, waiting time, space, etc). Subsequently, regression analysis was used to develop aggregate and disaggregate models for predicting the overall LOS perceived by the respondent vis-à-vis the BHS. The following section describes the variables that influence the perception ratings provided by the passengers for walking time and distance between the arrival gate and the reclaim area, waiting time at the reclaim conveyor belt, length along the reclaim conveyor belt, overall space in the reclaim area, amount of

seating provided in the reclaim area, and their perception of comfort and safety in the reclaim area. The actual regression equations can be found in Section D of Appendix G

8.5.1 Factors Affecting the Rating for Walking Time

Respondents were asked to indicate the perceived amount of time spent walking from the arrival gate to the reclaim area (TIMEARR) and to provide a rating for this service on a scale of 'excellent' (one) to 'unacceptable' (six) (WALKTIME). The author recorded the actual length of time required to travel from the arrival gate to the reclaim area based on an uninterrupted average walking speed (TIMEGATE). Comparing the scatter plots of the respondent's TIMEARR against the author's TIMEGATE, one notes that numerous respondents rounded the perceived walking time (TIMEARR) either up or down to the nearest multiple of 5 minutes. Thus, the respondents indicated a walking time that varied by as much as 2.5 minutes (5 minutes divided by 2) from what they perceived initially. For example, if TIMEARR was perceived as seven and a half minutes, the results indicate that passengers rounded this value to either five or ten minutes, a difference of 2.5 minutes from their original perception. Also, some passengers stopped in between the arrival gate and the reclaim area, thus taking more time than necessary to get to the reclaim area.

Regression analysis indicated that two independent variables were significant in predicting the dependent variable rating of walking time (WALKTIME). The independent variables were the distance in metres between the arrival gate (DISTGATE) and the reclaim area (as measured by the author), and the walking time perceived by the respondents (TIMEARR).

Intuitively, these two variables should influence the rating of the walking time. The time required to walk from the arrival gate to the reclaim area (TIMEGATE), as measured by the author, did not appear in the regression equation. The primary reason for this is that DISTGATE and TIMEGATE are highly correlated and thus cannot both be part of the regression. An analysis of these two variables, found that DISTGATE was a better predictor for the WALKTIME than TIMEGATE was. This occurred because the walking distance was a fixed quantity, while the walking time varied with the walking speed. Although the author attempted to walk at a pace equivalent to that of a passenger's, it appears this was not accomplished with complete success. Also, the author's familiarity with the actual walking route between the gate and the reclaim area might have affected the measured walking time. Actual respondents might have been more disoriented than the author and thus, took a greater length of time.

The non-parametric tests (Kruskal-Wallis and Mann-Whitney) were used to determine whether the mean value for WALKTIME differed between sample groupings. The cases

were divided by gender, type of ticket purchased (class), trip purpose, number of checked bags, number of flights per year and age category. The tests indicated that only the age category had an effect on the mean value for WALKTIME. When analyzing the WALKTIME by age group, it was found that the independent variables used to predict the rating for the waiting time differed between the age category models. The model for the respondents under the age of 25 had TIMEGATE as the sole independent variable. Respondents between the age of 25 and 39 had DISTGATE as the sole predictor variable. Both DISTGATE and TIMEARR predicted WALKTIME for the 40 to 60 year old. The model to predict WALKTIME for the respondents over the age of 60 included TIMEARR as the sole predictor variable. Since DISTGATE and TIMEGATE are highly correlated, the two younger age groups used similar independent variables. However, the respondents in the two older age categories used the TIMEARR variable (their perceived walking time) to evaluate WALKTIME. This occurred because the older respondents were less able to evaluate the actual walking time. The correlation between TIMEARR and TIMEGATE was better for the younger age categories ($r = 0.432$ and $r = 0.340$), whereas, the older respondents perceived value differed markedly from the author's measured value ($r = 0.326$ and $r = 0.280$).

8.5.2 Factors Affecting the Rating for Walking Distance

As with the walking time, passengers were asked to rate the walking distance on a scale of 'excellent' to 'unacceptable' (WALKDIST). The author recorded the actual distance between the arrival gate and the reclaim area (DISTGATE). Since WALKDIST is an ordinal variable, Kendall's tau-b was used to investigate correlations. Three significant positive correlations were found between WALKDIST and DISTGATE, TIMEARR (the time to walk between arrival gate and reclaim area), and BUSYDLAY (the time, in minutes, between the arrival of the aircraft and the time when the reclaim area contained the greatest number of passengers for that flight). BUSYDLAY evaluates the time required for the majority of passengers to arrive in the reclaim area following the arrival of the aircraft. Analyzing the data by age group, trip purpose, gender, number of flights taken per year, type of ticket purchased, and number of checked bags did not change the significant independent variables.

8.5.3 Factors Affecting the Rating of Waiting Time

Respondents were asked to indicate the amount of time that they *expected* to wait to collect baggage in the reclaim area in minutes (EXPECT), the perceived amount of time spent waiting for baggage in the reclaim area in minutes (TIMEWAIT), and to provide a rating for this aspect of the BHS on a scale from excellent to unacceptable (WAITTIME).

The difference between the expected waiting time (EXPECT) and the perceived waiting time (TIMEWAIT) was calculated (EXPEDLAY). As anticipated, a regression analysis showed that the main independent variable associated with the rating for the waiting time (WAITTIME) was the perceived waiting time variable, TIMEWAIT. Other significant independent variables were EXPEDLAY, the time difference between the arrival of the first passenger and the arrival of the first item of baggage (PXBGDLAY), the number of annual flights that the respondent takes (FLIGHTY2), the respondent's gender (GENDER01) and whether the checked baggage was received from the reclaim conveyor or not (GETBAG01).

(a) Aggregate Model

The regression analysis for WAITTIME was first carried out for the aggregate model consisting of responses from all six airports simultaneously. There was a positive relationship between WAITTIME and TIMEWAIT, PXBGDLAY, GETBAG01 and FLIGHTY2. As the perceived waiting time increased (TIMEWAIT), the rating worsened, or increased in value from 1 (excellent) to 6 (unacceptable). PXBGDLAY was calculated by subtracting the arrival time of the first passenger from the arrival time of the first item of baggage, thus, a positive value indicated that the first passenger arrived before the first item of baggage. As PXBGDLAY increased, WAITTIME worsened, or increased in value from 1 to 6. The variable GETBAG01 was given a value of zero (0) if the bag was

received and a value of one (1) if the bag was not received. Thus, if the bag was not received, the rating worsened. As the number of flights taken annually increased, the rating worsened (FLIGHTY2). This indicated that frequent flyers were less tolerant than people who traveled infrequently.

A negative relationship was evident between WAITTIME and EXPEDLAY and GENDER01. EXPEDLAY was calculated by subtracting the perceived waiting time from the expected waiting time. Thus, a positive value for EXPEDLAY indicated that the expected waiting time exceeded the perceived waiting time, and the respondent's expectations were met. A positive value resulted in an improvement in the rating for waiting time, or a decrease in the value of the rating. The variable GENDER01 received a value of 0 for male respondents and a value of 1 for female respondents. Thus, holding other independent variables constant, female respondents tended to rate the waiting time better than male respondents did.

As expected, non-parametric tests for GENDER01, FLIGHTY2 and GETBAG01 confirmed that the mean value for WAITTIME differed between male and female respondents, between infrequent and frequent flyers, and differed between respondents that received their baggage and those respondents whose baggage was misplaced. These variables were evident in the regression model to predict WAITTIME, above.

(b) Disaggregate Model

Similar to the above analysis, the six airports were considered separately for determining the independent variables that influenced the rating for waiting time. At the small airport, Thunder Bay, a strong relationship existed between TIMEWAIT and WAITTIME. Thus, the perceived waiting time greatly influenced the rating for the waiting time.

Additionally, the coefficient for the TIMEWAIT variable (0.250) in the Thunder Bay model was more than 3.4 times greater than the TIMEWAIT coefficient at the four other airports that include TIMEWAIT in their models. In Ottawa, where 15 of the 23 individuals with misplaced baggage arrived, whether the baggage arrived or not was of importance. In Ottawa, the time between the arrival of the first passenger and the first item of baggage was relatively lengthy and thus, influenced the waiting time rating (Table 7-10). At the four larger airports, EXPEDLAY had a strong correlation with WAITTIME. (EXPEDLAY was previously discussed in 6.3.3.) Three of these airports (not Edmonton) experienced a negative average value for EXPEDLAY indicating that, on average, the perceived waiting time exceeded the expected waiting time, thus passengers expectations were not met. In Edmonton, the coefficient for the EXPEDLAY variable (0.141) was at least 2.6 times greater than the EXPEDLAY coefficient at the other airports, indicating that the discrepancy between expected and actual waiting times heavily influenced the WAITTIME variable. Edmonton airport was extensively renovated immediately prior to the research. It is possible that following the renovation

passengers were led to believe that a certain quality of service would be provided and they expected better service than what actually occurred. Thus, a 10 minutes difference between expected and perceived waiting time in Edmonton changed the WAITTIME variable by 1.4 units (almost one and a half levels of service), whereas the same 10 minutes in Toronto changed WAITTIME by only 0.4 units (not even half a level of service).

8.5.4 Factors Affecting the Rating of Accessible Conveyor Belt Length

Scatter plots showed that for the aggregate model, no relationship existed between the measured accessible length in metres along the conveyor belt in the reclaim area (LENGHTM) and the rating of this length from excellent to unacceptable (EDGSPACE). Factors, other than the actual length of conveyor provided, contributed to the evaluation of this aspect of the baggage handling system. A stepwise regression analysis showed that three independent variables influenced the respondent's rating of the length along the conveyor belt. The predictor variables included the number of passengers per metre of length along the conveyor belt at the most congested time (PASPERM), the perceived waiting time (TIMEWAIT) and the number of checked bags (CHEKBAGS).

A positive relationship existed between the rating of the length along the conveyor and PASPERM, TIMEWAIT and CHEKBAGS. This indicated that as any of these variables

increased in value, the value of the rating increased, or worsened. Thus, the more passengers per metre along the conveyor and the longer the waiting time, the worse the rating was. As the number of checked bags that the respondent collected increased, the rating worsened. This is intuitively correct since the more checked items you have, the more space you require to collect them. Additionally, the respondents with more checked bags were more likely to use baggage carts and thus, required space for themselves and their carts.

The non-parametric Kruskal-Wallis test indicated that the mean value for the rating of the space (EDGSPACE) along the conveyor belt varied between the six airports. Thus, the airports were considered separately for the analysis of variables influencing EDGSPACE. At all airports, except Ottawa, TIMEWAIT was an important variable when determining the rating for the space along the conveyor belt. In Ottawa, the only significant variable for determining EDGSPACE was the value of PASPERM. This is not surprising since Ottawa received the worst average value of 1.8 passengers per metre, and the worst average for the EDGSPACE rating of 3.4 on the scale of 1 = excellent to 6 = unacceptable. Respondents in Ottawa were able to rate the length along the conveyor by simply considering the number of passengers per metre. At four of the other airports, not Thunder Bay, PASPERM was also a significant variable. Thunder Bay observed the smallest maximum number of passengers per metre along the conveyor belt, with a value of only 1.3 passengers per metre. Thus, respondents in Thunder Bay felt that the value of

PASPERM was always acceptable and it did not influence the rating. In Thunder Bay, only 5% of the EDGSPACE response was significantly predicted by the value of TIMEWAIT. Thus, the respondents in Thunder Bay did not behave as a homogeneous population when determining EDGSPACE. It is unknown how each respondent in Thunder Bay rated this aspect of the service. However, throughout the analysis, the TIMEWAIT variable has been found to predict, to different degrees, many variables. Evident from individual questionnaires and correlation tables, some respondents used the value of TIMEWAIT to evaluate numerous aspects of the BHS, regardless of the actual aspect being considered. Many of these responses were identified as outliers during regression analysis.

In Calgary, the actual length along the conveyor belt influenced the rating. Calgary observed the second highest mean value of 46 metres (behind Montreal) for the length provided around the conveyor belt. In Toronto, the number of flights taken per year was found to influence the EDGSPACE rating. The more flights taken per year, the worse the respondent's rating. It appears that occasional travellers were more tolerant and less concerned with the space provided. Additionally, frequent travellers possibly provided worse rating because they were more aware of the amount of space provided per person along conveyor belt in other airports worldwide. Thus, they were using their experience to aid in evaluating the accessible length of the conveyor belt.

8.5.5 Factors Affecting the Perception of Overall Space

Respondents rated the overall space in the reclaim area (OVRSPACE) on a scale of excellent (1) to unacceptable (6). The actual amount of space in the reclaim area that was being used to collect baggage in square metres was recorded (AREA2M). Regardless of this space in the reclaim area, which ranged from 82 m² to 328 m², respondents provided ratings for OVRSPACE ranging from excellent through to unacceptable. The amount of space provided per occupant at the most congested point of time for each flight was calculated in square metres per occupant (M2PERPAS) and for the majority of flights (795 of 805) this value was under 40 m² per passenger (although it ranged from 0.9 m² to 189 m²).

A linear regression analysis to predict OVRSPACE resulted in a model with five independent variables. These variables included the number of passengers at the most congested period (BUSYPASS), whether renovations had recently been undertaken in the reclaim area at the airport (RENO01CO), the number of flights taken by the respondent per year (FLIGHTY2), the accessible length around the conveyor belt (LENGTHM), and the number of checked bags (CHEKBAGS).

The rating for overall space had a positive correlation with BUSYPASS, RENO01CO, FLIGHTY2 and CHEKBAGS. As the number of passengers in the reclaim area at the busiest time increased (BUSYPASS), the respondent's rating worsened. The variable RENO01CO had a value of zero (0) for the three airports that had been significantly renovated in the recent past (Thunder Bay, Edmonton and Calgary), while it had a value of one (1) for the three airports that had not been recently renovated at the time of the research. Additionally, at the three former airports, only flights arriving in recently renovated areas were assigned a value of zero. For flights arriving in older, non renovated areas within the terminal, a value of one was assigned to the RENO01CO variable. For airports and reclaim areas that had not recently been renovated, the respondent's rating for overall space was worse. Recently renovated reclaim areas had newer fixtures and materials, a more pleasing atmosphere, electronic display boards, greater ceiling heights, more floor space, and an open design concept. Clearly these modern design aspects were observed and appreciated by the respondents. As with the regression model to predict the rating for the length along the conveyor belt (EDGSPACE), the number of flights made by the respondent per year and the number of checked bags affected the rating for overall space. As the number of flights taken per year and the number of checked bags increased, the respondent's rating worsened. The same reasoning, mentioned in the previous section, is applicable.

OVRSPACE had a negative relationship with the length provided to collect baggage along the conveyor belt. This indicated that as the length provided along the conveyor belt increased, the value of the OVRSPACE rating decreased, or the rating improved.

8.5.6 Factors Affecting the Perception of Seating

The relationship between the number of seats provided adjacent to the conveyor belt in the reclaim area (SEATS#) and the respondent's rating for this aspect of the BHS from excellent to unacceptable (SEATING) was investigated. The number of seats provided per person at the most congested period in the reclaim area (SEATPERS) for each flight was also calculated and compared with the respondent's rating. Scatter plots for all cases together revealed that no relation existed between either SEATS# and SEATING, or between SEATPERS and SEATING. Comparing scatter plots of the data by age group neither a linear nor a non-linear relationship existed between either of these two sets of variables for any age group.

Respondents had difficulty determining their personal rating for the number of seats provided. When few or no seats were provided, some respondents decided that the service was poor, regardless of whether they needed the seats or not. Other respondents, when faced with few or no seats, rated the service excellent because they personally did not require any seats. Thus, some respondents actually answered the question on behalf

of the passengers whom they felt might require seats instead of based on their own interest in having seats provided.

A second problem was caused by the availability of *unoccupied* seats versus the total number of seats provided. The number of unoccupied seats available at the time the respondent actually looked for a seat varied for each person. For some respondents, a large number of seats may have been available at the time of interest, whereas for other respondents from the same flight this may not have been the case. Thus, the *availability of unoccupied* seats, rather than the *actual* number of seats provided in the reclaim area affected the respondent's rating. This explains why no significant and strong correlation was found between the number of seats provided and the rating for this aspect of the BHS.

8.5.7 Factors Affecting the Perception of Comfort and Safety

Respondents were asked to rate their personal comfort and safety on a scale of excellent (value = 1) to unacceptable (value = 6). A number of variables were recorded which the author considered important in determining a passenger's response to this question. These included:

- ◆ the total number of passengers on the flight (PASS.#),
- ◆ the amount of space in the reclaim area (AREA2M),

- ◆ the number of people in the reclaim area at the most congested point (BUSYPASS),
- ◆ a ratio of these two variables (M2PERPAS),
- ◆ the length along the conveyor belt (LENGTHM),
- ◆ the number of passenger per metre of this length (PASPERM),
- ◆ the type of flight (CHFLIGHT),
- ◆ the amount of time spent in the reclaim area (TIMEWAIT), and
- ◆ whether the reclaim area was recently renovated (RENO01CO).

It was anticipated that a combination of these independent variables would predict the respondent's rating for comfort and safety.

From the initial analysis of this rating and through the use of scatter plots, it was determined that comfort and safety should have been considered as separate questionnaire items. Some passengers indicated a response for their perception of safety, while others provided a response for their perception of comfort. Although the respondent's perception of safety could lead to a sense of comfort, other aspects of the BHS and reclaim area influenced a respondent's perception of comfort. The six significant independent variables included TIMEWAIT (perceived waiting time), RENO01CO (whether renovation has recently been undertaken in the reclaim area), SEATS# (number of seats in the reclaim area), CHFLIGHT (type of flight), BUSYPASS (maximum number of people in the reclaim area) and CHEKBAGS (number of checked bags per occupant).

Due to the lack of normality of the variable COMFORT, a non-parametric Kruskal-Wallis test was performed. It indicated that the mean values for the rating of comfort varied between airports. Non-parametric tests also indicated that the mean values for COMFORT were *not equal* when the number of checked bags was considered, as evident by the sixth independent variable, CHEKBAGS. Non-parametric tests indicated that the mean values for the rating of personal comfort and safety were *equal* when the number of flights taken per year, the respondent's gender, and the respondent's trip purpose were each considered. Disaggregate regression models for predicting COMFORT for each of the six airports considered separately were developed.

Whereas the aggregate model for COMFORT included six independent variables, the disaggregate models (by airport) included at most three independent models. Four of the airport models included only one independent variable. Although a total of seven different variables were used for the disaggregate models, many of them are similar. PASPERM, LENGHTM, PASS.#, AREA2M and M2PERPAS are all indications of the number of people in the area and the level of congestion. All five variables indicate the passenger's perception of comfort and/or safety in the reclaim area. CHEKBAGS (number of checked bags per occupant) and TIMEWAIT (amount of time spent waiting to collect baggage) are both reasonable indicators of the level of comfort and safety in the reclaim area. The use of seven independent variables to describe the six airports further

validate the conclusion reached previously that comfort and safety should have been considered as separate aspects of the BHS.

8.6 Regression Analysis Using Traditional Variables

As previously mentioned, the LOS of baggage handling systems has traditionally been determined through the use of time and space standards. Specifically, the three standards used to describe the LOS being provided are the amount of time a passenger waits for baggage in the reclaim area (TIMEWAIT), the amount of space available in the reclaim area for waiting passengers, greeters and well-wishers (M2PERPAS), and the amount of space along the conveyor belt to collect baggage (PASPERM).

Recalling the equation introduced in Section 4.2.2 for the user-perceived level of service:

$$UPLOS = a + \sum_{i=1}^k b_i f_i(X_i) .$$

For the multiple regression analysis using the three

independent variables noted above, this equation can be written as:

$$UPLOS = a + b(TIMEWAIT) + c(M2PERPAS) + d(PASPERM) .$$

This section investigates the relationship between these three commonly used independent variables and their ability to predict the overall LOS perceived by the passengers.

8.6.1 Aggregate Model

Using linear regression analysis, the three independent variables mentioned above were used to describe their relationship with the dependent variable, the overall LOS. In 6.3.11(c) the relationship between LOS1 and LOS2 was discussed and their high correlation yielded the conclusion that both were good indicators of the overall LOS. It was also concluded that since seven aspects of the BHS were rated using the same subjective scale as LOS2, it would be used for the regression analyses. Thus, all future reference to the overall LOS or UPLOS are references to LOS2 and not to LOS1. With an R^2 of only 0.211, the aggregate regression equation was as follows:

$$UPLOS = 2.181 + 0.0582(TIMEWAIT) + 0.00364(M2PERPAS) + 0.106(PASPERM)$$

This regression equation was found using the *enter* method of including variables. Thus, all three variables were forced into the model. This resulted in the coefficient for M2PERPAS having a significance of 0.335, which is greater than 0.05, and thus, not significant. Using the *stepwise* method of entering variables would have resulted in a two independent variable model, with M2PERPAS being omitted. However, since the traditional method has been to use these three variables as an indication of LOS, all three were forced into the model. The low R^2 value of 0.211 indicates that these three variables together only account for 21.1% of the variation in the dependent variable, UPLOS.

Thus, as hypothesized, these three variables alone are inadequate for determining the LOS perceived by the airport user.

8.6.2 Disaggregate Model

A similar regression was subsequently carried out using the same three independent variables and the same dependent variable. However, for this analysis, disaggregate models were created, with the six airports considered individually. Two methods of including variables were considered: the first analysis used the *enter* method for including variables to the model (thus, all three independent variables were included in the model) while the second analysis used the *stepwise* method of including only significant variables. Table 8-2 shows the coefficients and their significance for the linear disaggregate model that included the three traditional variables using the *enter* method. The R^2 values for the six airports were: 0.136 for Thunder Bay, 0.242 for Ottawa, 0.148 for Edmonton, 0.389 for Calgary, 0.207 for Montreal and 0.114 for Toronto. Based on the R^2 values, Calgary had the best model, however, the R^2 values were not very high and many coefficients were not significant (i.e. the significance was greater than 0.05). Also, the coefficient for PASPERM had both negative and positive values. Intuitively, as the number of passengers per metre worsens or increases (PASPERM increases), the evaluation of the dependent variable should also worsen (UPLOS should increase from 1 = excellent to 6 = unacceptable). Thus, there should be a positive relationship between

these two variables. These six regression equations would be considered poor models due to their poor significance levels and to poor correlations (not shown).

Table 8-2: Linear Disaggregate Regression Models – Coefficients and Significance

Airport	Constant		PASPERM		M2PERPAS		TIMEWAIT	
	Value	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Thunder Bay	1.912	0.000	-0.161	0.635	0.00307	0.732	0.101	0.000
Ottawa	2.195	0.000	0.309	0.069	0.00367	0.938	0.0312	0.074
Edmonton	2.125	0.000	0.164	0.496	0.00697	0.276	0.0731	0.000
Calgary	1.883	0.000	0.274	0.008	-0.00576	0.555	0.0296	0.037
Montreal	2.990	0.000	-0.460	0.016	-0.00839	0.527	0.0536	0.000
Toronto	2.536	0.000	-0.036	0.689	-0.00083	0.958	0.0678	0.000

A better model for predicting the overall LOS from these three independent variables was developed by using the *stepwise* method of entering variables into the regression model.

Although not all three variables were forced into the model, the variables with stronger correlations and thus, a better ability to predict the dependent variable were included.

With all significance values being less than 0.05, and only two values greater than 0.0005, the linear disaggregate models created by using only some of the three traditional

independent variables were much more significant models. The regression equations were as follows:

$$\text{Thunder Bay } (R^2 = 0.129): \quad UPLOS = 1.841 + 0.09565(TIMEWAIT)$$

$$\text{Ottawa } (R^2 = 0.216): \quad UPLOS = 2.370 + 0.403(PASPERM)$$

$$\text{Edmonton } (R^2 = 0.139): \quad UPLOS = 2.321 + 0.07442(TIMEWAIT)$$

$$\text{Calgary } (R^2 = 0.387):$$

$$UPLOS = 1.809 + 0.0289(TIMEWAIT) + 0.297(PASPERM)$$

$$\text{Montreal } (R^2 = 0.166): \quad UPLOS = 2.548 + 0.04338(TIMEWAIT)$$

$$\text{Toronto } (R^2 = 0.113): \quad UPLOS = 2.512 + 0.06508(TIMEWAIT)$$

The amount of space (m^2) provided per person (M2PERPAS) in the reclaim area was not highly correlated with the overall perceived LOS for any of the six airports. Interestingly, in Ottawa the number of passengers per metre of length along the conveyor belt (PASPERM) was correlated to the overall perceived LOS, while the waiting time (TIMEWAIT) was not. For respondents in Ottawa, having space to collect baggage played a greater role in determining their overall satisfaction level vis-à-vis the BHS, than the amount of time they spent waiting to collect their baggage. In Calgary, both the waiting time and the number of passengers per metre of length along the conveyor belt were important in determining the overall LOS. At the other four airports, only waiting time was highly correlated with the overall LOS.

As previously discussed the Aeroports de Paris maximum standard for conveyor frontage is 5 people per metre. This standard was exceeded only once and this occurred during flight 424 in Calgary when there were 5.1 passengers per metre of frontage. If these passengers are removed from the stepwise method of including variables, the R^2 reduces from 0.387 to 0.243 and the regression equation becomes:

$$UPLOS = 1.615 + 0.05635(TIMEWAIT) + 0.298(PASPERM) .$$

Without these cases, the independent variables predict only 24.3% of the dependent variable, which is more in line with the R^2 values at the other five airports. Without the flight 424 cases being considered, the range of values for PASPERM is quite limited, ranging from a minimum of 0.025 to 3.9 passengers per metre (Table 7-3). Reducing the range, by removing flight 424 cases, reduced the strength of the relationship between PASPERM and UPLOS. When comparing all cases, the Spearman's rho correlation coefficient was 0.435 with a significance of less than 0.0005. After removing the thirteen flight 424 cases, the Spearman's rho correlation coefficient reduced to 0.296 with a significance of 0.001. Thus, more flights with a greater range of passenger per metre values for frontage are required to better define the model.

However, regardless of the above discussion on flight 424, the conclusions for this section are the same. Although the significance levels for the disaggregate stepwise models were sufficient for the models to predict the overall LOS, the R^2 values indicate that the traditional independent variables, with the exception of Calgary, only predict between 11% -21% of the dependent variable. In Calgary, the model predicts 39% of the dependent variable (24% if you remove flight 424 cases). Thus, Calgary's model leaves 61% unpredictable (or 76% without flight 424 cases), while the other five airports leave 79% to 89% unpredictable. As with the aggregate model, these three traditional variables are insufficient to predict the overall LOS perceived by the passengers.

8.7 Regression Analysis of User-Perceived Aggregate Model

In order to achieve one of the main objectives of this research, this section is dedicated to developing a regression model to predict the user-perceived LOS. Both aggregate and disaggregate models were developed. The user-perceived disaggregate models consider first, the airports grouped by annual passenger volumes, and secondly, as individual airports.

8.7.1 Comparing Means of Subgroups

Parametric and non-parametric tests were available in SPSS to compare means of two or more groups. The passengers were classified according to their age, gender, ticket class, etc. to determine whether these factors influenced the overall LOS perceived by the passengers. These classification factors were used to divide the data into various groups and to determine whether these groups had different means when comparing the overall LOS perceived. As previously noted, the dependent variable for the regression model was the overall LOS rating, which was a numeric variable with ordered values (e.g. 1 = excellent to 6 = unacceptable). Through the use of histograms, and skewness and kurtosis ratios it was determined that UPLOS did not follow a normal distribution. Nor is UPLOS a quantitative variable, but rather has ordered categories. Thus, non-parametric tests were used to compare the means for the variable UPLOS for subgroups that included: gender, age range, ticket class, trip purpose, number of checked bags, number of annual flights. For example, was the mean UPLOS the same for male and female respondents?

The Mann-Whitney test, to compare two groups, was used to compare the UPLOS means of gender groups (male and female) and ticket class groups (economy and business). It was also used to compare the UPLOS means of a group based on whether any transfers were made (yes or no) and a group based on whether the checked bag was retrieved or not (yes or no). Table 8-3 indicates the results of the Mann-Whitney test. The null

hypothesis for the test was that the mean UPLOS values for the two groups were equal. If the significance was below 0.05 then the hypothesis was rejected and the UPLOS values were different and, thus, came from different populations. The Mann-Whitney tests showed that the subgroups of gender and 'whether the bag was received or not' had significance levels below 0.05 and thus the null hypothesis was rejected. This indicated that gender categories (male and female) and 'whether the bag was received (yes or no)' influenced the UPLOS. The null hypothesis was accepted for the ticket class and 'whether any transfers were made or not' groups, thus, the categories of these two groups came from the same populations. In other words, whether the respondent had an economy or business ticket, or whether any transfers were made or not during the course of the trip, the UPLOS remained the same.

The Kruskal-Wallis test, to compare more than two groups, was used to compare the UPLOS means for groups based on trip purpose, age, number of checked bags, and the number of annual flights taken by respondents. As with the Mann-Whitney test, the null hypothesis was that the UPLOS mean values for the two groups were equal. If the significance was below 0.05 then the hypothesis was rejected and the UPLOS values were not equal for the two groups and, thus, came from different populations. The significance for the trip purpose and age group variables were above 0.05 and thus, the null hypothesis was accepted (Table 8-4). For these two groups, the mean UPLOS values were equal. For the 'number of flights taken per year' and the 'number of checked bags'

groups, the significance levels were below 0.05 and thus, were highly significant. The null hypothesis was rejected indicating that the mean UPLOS values were not equal. Thus, the categories within each of these latter two groups were from different populations and must be considered in the regression analysis.

Table 8-3: Testing Means of Subgroups using the Mann-Whitney Test

Categories		Mean Rank	Mann-Whitney	Sig. (2-tailed)
a) Gender				
	Male	406	61917	0.005
	Female	361		
b) Ticket Class				
	Business	388	34014	0.299
	Economy	367		
c) Transfers				
	Yes	369	24824	0.291
	No	397		
d) Bag Retrieved				
	Yes	389	4868	0.000
	No	565		

Using the above non-parametric tests, the mean value for UPLOS was shown to differ according to four variables: GENDER01, GETBAG01, CHEKBAGS and FLIGHTY2. Although these variables were not directly in the linear aggregate regression model, these four variables influenced the independent variables of the regression equation. (For example, the independent variable WAITTIME was affected by the variables

GENDER01 and GETBAG01.) Thus, the results of the non-parametric tests were analyzed and included, although indirectly, in the regression model.

Table 8-4: Tests of Means of Subgroups using Kruskal-Wallis Test

Categories	Mean Rank	Chi-square	df	Sig.
a) Trip Purpose				
Business	400	2.7	3	0.436
Pleasure	381			
Both	420			
Other	353			
b) Age				
< 25 years	324	7.1	3	0.068
25 to 39	405			
40 to 60	396			
> 60 years	373			
c) Number of Checked Bags				
1	380	12.4	4	0.015
2	415			
3	324			
4	473			
5 or more	599			
e) Number of Flights Taken per Year				
1 - 2	353	15.1	3	0.002
3 -5	352			
6 - 9	347			
10 or more	412			

8.7.2 User-Perceived Aggregate Regression Model – All Cases

The linear aggregate regression analysis was conducted by including all subjective and quantitative variables (all cases) and by using the stepwise method for including the significant variables. Variables were entered into the model if the probability of F was less or equal to 0.05, and variables were removed from the model if the probability of F was more or equal to 0.10. Following the initial regression analysis, diagnostics (DfFits, DfBetas, Cook's distance, etc) were used to identify outliers that were removed from subsequent regression analyses.

The final user-perceived model included four variables and had an R^2 of 0.636. The variables, in order of entering the model were: the rating of waiting time (WAITTIME), the rating of comfort and safety (COMFORT), the rating of walking time between the arrival gate and the reclaim area (WALKTIME), and whether the bag was received (GETBAG01). The significance of the coefficients was less than 0.0005 and the condition indices for this model were all less than eight. A condition index of more than 15 indicates a possible problem with collinearity, while a condition index of greater than 30 indicates a serious problem. The regression equation for this model was:

$$UPLOS = 0.362 + 0.391(WAITTIME) + 0.330(COMFORT) + 0.126(WALKTIME) + 0.802(GETBAG01)$$

The perceived waiting time was accounted for by the WAITTIME variable in the new user-perceived model. The other two variables (WALKTIME and COMFORT) have qualitative values, however, they are affected by quantitative measures, as previously mentioned.

This four-variable user-perceived linear aggregate regression model, with an R^2 value of 0.636, is an improvement of 300% and can predict an additional 40% of the UPLOS when compared to the aggregate model developed using traditional time and space standards where $R^2 = 0.211$. Although at first glance, an R^2 of 0.636 might not appear to be very high for engineering applications, one must consider that both quantitative and subjective variables were involved in this passenger perception model. Other regression analyses conducted in the social sciences have produced significant models with R^2 values significantly less than 0.636 (Section 8.4). People and their perceptions are very unpredictable variables to control and model.

When comparing the coefficients for WAITTIME and WALKTIME, one might reach the erroneous conclusion that longer walking times result in a better UPLOS, as opposed to longer waiting times. Since these two variables are ratings, this conclusion cannot be drawn from the coefficients. Instead, the research indicated that approximately 4 minutes of waiting time decreased the WAITTIME variable by one LOS (e.g. from LOS A to B, or B to C) resulting in a change the UPLOS by 0.391 units. A 4 minute change in walking

time decreased the WALKTIME rating by approximately 3 LOS's, thus changing the UPLOS by 0.378 units ($3 * 0.126$). Therefore, this research does not validate the suggestion that lengthening the walking time and shortening the waiting time result in much better UPLOS. Time, whether spent walking or waiting, is regarded by passengers in the same manner.

8.7.3 User-Perceived Linear Regression Model – Random Sample of Cases

The previous regression analysis (Section 8.7.2) used all cases to create the aggregate regression model. Following this, a regression analysis was carried out using only 70% of the cases. This was done to verify whether a model similar to the aggregate regression model was reproduced using only a random sample of the cases. The equation, with the same four independent variables, was as follows.

$$UPLOS = 0.387 + 0.409(WAITTIME) + 0.316(COMFORT) + 0.109(WALKTIME) + 0.704(GETBAG01)$$

The aggregate model using only 70% of the cases had an R^2 of 0.628 (compared to the R^2 of 0.636 in the model with all cases) and significant at 0.0005 (same as previous model's significance). As with the previous model, the residual plots indicated normality. The greatest difference between the two models was in the GETBAG01 coefficient that changed from 0.802, when all cases were considered, to 0.704, when the random sample

was considered. This was expected, since only a small percentage of cases did not receive their baggage (i.e. GETBAG01 = 1). Thus, when the random sample of 70% of the cases was selected, the group of cases where GETBAG01 = 1 was reduced in number.

Although the percent of cases where GETBAG01 = 1 remained similar (2.5% for model with all cases versus 2.7% for model with 70% cases), the number of cases represented a very small sample. In the model with all cases considered, 17 cases did not receive baggage, whereas in the model with the random sample, only 13 cases did not receive baggage. This extremely low number (13 cases) formed a very small sample size and thus, decreasing the total sample from 17 to 13 cases, resulted in a change in the GETBAG01 coefficient. Apart from this difference, the random sample resulted in a very similar aggregate regression model.

8.8 Regression Analysis of User-Perceived Disaggregate Model - by Airport Size

The airports participating in this research were selected, in part, for their size in terms of annual passenger volume. One small size airport, four medium and one large airport were included in the study. As part of the analysis, the responses were separated into groups based on the size of the airport they were collected from. Thus, three groups were assembled: Thunder Bay responses formed the 'small' group, Toronto responses formed the 'large' group, and the remaining four airports formed the 'medium' group.

Scatter plots and correlations were reviewed prior to the analysis to investigate the relationships between the independent variables and the dependent variables. In no instance was a non-linear relationship observed. The stepwise method of entering variables into the model was used to develop a linear regression model. Following the regression analysis, residual plots indicated that the residuals were normally distributed and their variances were constant. No cases were identified from the partial residual plots as having a large influence on the independent variable coefficients. The linear regression equations developed for these three groups were as follows.

Small Airports: the constant and all coefficient significance values were less than 0.0005 and the R^2 value for this model was 0.550.

$$UPLOS = 0.802 + 0.387(WAITTIME) + 0.232(COMFORT) + 2.579(GETBAG01)$$

Medium Airports: the constant and all coefficient significance values were equal or less than 0.014 and the R^2 value for this model was 0.589.

$$UPLOS = 0.613 + 0.334(WAITTIME) + 0.307(COMFORT) - 0.0196(EXPEDLAY) + 0.123(WALKTIME) + 0.538(GETBAG01)$$

Large Airports: the constant and all coefficient significance values were less than or equal to 0.049 and the R^2 value for this model was 0.618.

$$UPLOS = 0.365 + 0.342(OVRSPACE) + 0.298(WAITTIME) + 0.223(WALKTIME)$$

Regardless of the airport size, the *rating* of the waiting time on a scale of excellent (value =1) to unacceptable (value = 6), as opposed to the perceived waiting time in minutes, was one of the independent variable to be included directly in the regression model. The positive relationship indicated that as the rating of waiting time worsened (increased in value), the UPLOS worsened.

For both small and medium airports, GETBAG01, the variable identifying whether the baggage was retrieved from the conveyor belt or not, entered into the regression model. A value of one (1) for GETBAG01 indicated that the baggage was not received from the conveyor belt. Thus, as expected, a value of one for the variable GETBAG01 worsened the rating for UPLOS. The difference in the value of the coefficient for GETBAG01 between small and medium airports is worth noting. At small airports, if the baggage was not received, the rating for UPLOS increased by 2.54 units, on a scale of only six increments. Thus, the expectation at small airports was that the baggage should arrive safely, due to the small size of the airport. Alternately, at medium airports, the rating worsened by only 0.729 for those respondents that did not received their baggage. Passengers realized that the chance of their baggage not arriving was greater at the medium airports than at the small airports and thus, placed less importance on that aspect of the BHS. Medium airport respondents were more tolerant when realizing that their baggage did not arrive on their flight, but that it would generally arrive on the next flight. Medium airports have more flights than smaller airports and thus, when an item of

baggage does not arrive on the correct flight, the time before the next flight arrives from the same destination is less. At a small airport, the passenger might have to wait numerous hours before the next flight arrives, versus possibly only one hour at a medium airport.

At small and medium airports, the COMFORT variable heavily influenced the UPLOS. Thus, by improving the level of comfort and safety, the UPLOS improves. The factors affecting this variable were previously discussed in Section 8.5.5 and include, among others, the total length provided around the conveyor belt to collect baggage, the total number of passengers in the reclaim area at the most congested time, and whether the reclaim area had been recently renovated.

Unlike the small and medium airport models, the large airport regression model included OVRSPACE, but not COMFORT. From Table 8-1, it can be seen that a strong correlation exists between these two variables. Additionally, the Toronto airport provided the lowest average value of space per passenger. Having 7.1 m² per passenger, on average, the UPLOS at the large airport was influenced by OVRSPACE more than COMFORT.

EXPEDLAY (difference between the expected and perceived waiting times) was found to influence the UPLOS at medium airports. Previously introduced in Section 8.5.3, the

greater the EXPEDLAY, the better the UPLOS rating. The average value of EXPEDLAY for the medium airports was both negative and greater than at either the small or large airports, indicating that on average the perceived waiting time *exceeded* the expected waiting time, and that it exceeded it by a larger amount at the medium airports than at other airports. Thus, if either the waiting time was reduced or if a passenger's expectations can be lowered, the UPLOS can be increased.

At medium and large airports the rating of walking time (WALKTIME) influenced the UPLOS. This variable was discussed in Sections 6.3.5 and 8.5.1. Whereas at the small airport, the average perceived walking time was only 2.9 minutes, the perceived walking time at the medium and large airports was from 62% to 159% greater (Table 6-11). Thus, an average walking time of 2.9 minutes was perceived by the passengers as reasonable and did not influence the UPLOS, whereas an average walking time of 4.7 minutes or greater did influence the UPLOS.

8.9 Regression Analysis of User-Perceived Disaggregate Model - by Airport

The non-parametric Kruskal -Wallis test indicated that the mean values the UPLOS differed between airports. Thus, this section is dedicated to developing a UPLOS model for each of the six airports individually.

As with previous regression analyses, scatter plots were used to determine whether linear relationships existed between independent variables and the dependent variable, UPLOS. (Non-linear relationships were not evident in bivariate scatter plots.) Once linear relationships were observed, outliers were identified and removed if warranted. A linear regression analysis was carried out for each airport separately. Following each analysis, residuals plots were reviewed to ensure they were normally distributed. In order to identify additional outliers the following plots were reviewed.

- ◆ Partial residual plots,
- ◆ Plots of leverage values versus studentized deleted residuals (labeled using Cook's values),
- ◆ DfFit values, and
- ◆ DfBeta values for each independent variable.

The six user-perceived disaggregate (by airport) linear regression models, with R^2 and significance values shown in Table 8-5, were as follows. Note that the model for Thunder Bay is identical to the model for small airports in the previous section, and the model for Toronto is identical to the model for large airports in the previous section, since only one airport formed the small and large airport sample groups.

Thunder Bay:

$$UPLOS = 0.802 + 0.387(WAITTIME) + 0.232(COMFORT) + 2.579(GETBAG01)$$

Ottawa:

$$UPLOS = 0.590 + 0.488(WAITTIME) + 0.313(COMFORT)$$

Edmonton:

$$UPLOS = 0.463 + 0.404(WAITTIME) + 0.383(WALKTIME)$$

Calgary:

$$UPLOS = 0.644 + 0.308(WAITTIME) + 0.286(COMFORT) + 0.002436(BAGS\#)$$

Montreal:

$$UPLOS = 0.993 + 0.442(WAITTIME) + 0.224(COMFORT) - 0.427(TRANSFR\#)$$

Toronto:

$$UPLOS = 0.365 + 0.342(OVRSPACE) + 0.298(WAITTIME) + 0.223(WALKTIME)$$

Table 8-5: Disaggregate User-Perceived Model Significance and R^2 – By Airport

Airport	Regression Model R^2	Coefficient Significance Range
Thunder Bay	0.550	0.000
Ottawa	0.652	0.000 – 0.011
Edmonton	0.581	0.000 – 0.021
Calgary	0.622	0.000 – 0.001
Montreal	0.465	0.000 – 0.003
Toronto	0.618	0.000 – 0.049

The independent variables of the four medium airport models above were similar to those in the regression model developed in the previous section for medium airports. (The Thunder Bay and Toronto models are identical.) The WAITTIME variable had the strongest correlation with UPLOS. For the Ottawa, Calgary and Montreal airports, COMFORT had a strong influence on the UPLOS. In Edmonton, where the second highest average walking times were observed, the UPLOS was greatly influenced by the WALKTIME variable (Section 6.3.5). Edmonton also received the worst average rating for the WALKTIME variable because of these long walking times. The largest average walking time was observed in Montreal, however, a larger percent of the respondents in Montreal were travelling on international flights (versus the percent of international travellers in Edmonton). Longer walking times were expected through customs and immigration, whereas the long walking times observed in Edmonton were following domestic flights. The passengers perceived the walking times in Edmonton to be excessive.

In Montreal, the third independent variable of the regression model represented the number of transfers made by the passenger during the trip. More importantly, this value indicated the number of transfers that the *baggage* made during the trip. The variable TRANSFR# was assigned a numerical value indicating the actual number of transfers made. Interestingly, the more transfers made, the better the UPLOS rating. For each additional transfer, the UPLOS improved by 0.427 units on the six-unit scale from

excellent to unacceptable. This is almost equivalent to half a LOS. This occurred because a passenger, whose trip involved numerous transfers, had lower expectations. The passenger was more interested in simply *receiving* the baggage, rather than just the *speed* with which the baggage arrived on the reclaim device.

As previously discussed, although these linear regression models were significant, the R^2 values were not as high as one would have found with a relationship involving, for example, material properties rather than people. The unpredictability of individuals was evident in the models, however, the R^2 values obtained in this research were higher than those achieved with numerous other studies involving individuals and their preferences. Additionally, these aggregate and disaggregate UPLOS models obtained better R^2 values than ones developed using only the three traditional time and space variables (Table 8-6). The user-perceived models were able to predict between 161% more of the UPLOS in Calgary to 547% more in Toronto as compared to the traditional variables.

8.10 Comparison of UPLOS Models

Three groups of models were developed to evaluate the UPLOS. The first model was an aggregate model, the second group included three disaggregate models for three different annual passenger volumes, and third, six disaggregate models were developed, one for each of the participating airports. For each airport, Table 8-7 provides the average value

of the independent variables needed for each of the three models and indicates both the average measured UPLOS and the UPLOS predicted by each model. For example, if we consider Toronto airport, the average UPLOS provided by the respondents was 3.16, which is a LOS between adequate and good. The aggregate model predicted an average UPLOS of 3.18, while the disaggregate models predicted the actual value of 3.16.

Likewise at the other five airports, the UPLOS values predicted by the aggregate and disaggregate models were very close to the actual average UPLOS value. Thus, any of the models are good indicators of the average UPLOS provided at each airport. At any airport, the average UPLOS can be predicted per flight, per conveyor belt, or per airport.

Table 8-6: Improvement in R^2 Values from Traditional to User-Perceived Variables

Model	R^2 with Traditional Model Variables	R^2 with User Perceived Model Variables	Improvement in R^2 (%)
a) Aggregate			
	0.211	0.636	0.425 (301%)
b) Disaggregate			
Thunder Bay	0.129	0.550	0.421 (426%)
Ottawa	0.216	0.652	0.436 (302%)
Edmonton	0.139	0.581	0.442 (418%)
Calgary	0.387	0.622	0.235 (161%)
Montreal	0.166	0.465	0.299 (280%)
Toronto	0.113	0.618	0.505 (547%)

Table 8-7: Verification of UPLOS Models

	Airport					
	Thunder Bay	Ottawa	Edmonton	Calgary	Montreal	Toronto
Independent Variables:	Average value for each independent variable:					
WAITTIME	2.09	3.46	2.9	2.83	3.24	3.57
COMFORT	2.39	3.13	2.75	2.56	3.27	3.15
EXPEDLAY		-2.267	1.274	-0.299	-1.464	
WALKTIME	2.04	2.5	3.09	2.56	2.78	3.04
GETBAG01	0.01	0.14	0.0376	0.0156	0	0
OVRSPACE						3.07
BAGS#				130.75		
TRANSFR#					0.26	
Actual Average	2.23	3.26	2.88	2.6	3.12	3.16
UPLOS:						
Predicted						
UPLOS:						
Aggregate Model	2.23	3.18	2.82	2.65	3.06	3.18
Disaggregate	2.19	3.16	2.80	2.67	3.07	3.16
Model by Annual						
Passenger						
Volume						
Disaggregate	2.19	3.26	2.82	2.57	3.05	3.16
Model by						
Specific Airport						

8.11 Discussion of Airport Groupings

In the previous discussions, the airports were compared individually and then grouped according to airport size (annual passenger volumes) and as one aggregate model.

However, tests have indicated that these groupings are possibly not the most appropriate.

The non-parametric Mann -Whitney test indicated that the small airport, Thunder Bay, had a different mean value for UPLOS than any other airport. Additionally, Edmonton and Calgary airports had the same UPLOS means, and Ottawa, Montreal and Toronto had the same means for UPLOS. Throughout the research it was noted that passengers in Thunder Bay provided very different responses than passengers at other airports. Thus, the non-parametric test result above was not surprising, but rather validated the analysis and models developed to date that involved Thunder Bay. Respondents at the small airport were more unpredictable than respondents at the medium and large airports. The respondents appeared to be more relaxed and more tolerant than respondents at the other five airports. Thunder Bay respondents did, however, place a great importance on whether the bag arrived on the same flight as the respondent.

Edmonton and Calgary were both medium airports that had recently been renovated, thus, they produced similar results throughout the preceding analyses. Their similar size and terminal design style coupled with the fact that they are currently operating well below capacity resulted in similar responses and preferences from the passengers.

The airports in Ottawa, Montreal and Toronto (at the time of the research) had not undergone complete renovations recently and thus, responses collected from these airports displayed similarities. Although they have very different annual passenger volumes, the fact that they are operating near or above capacity caused passenger responses from these airports to be quite similar.

8.12 Summary of Independent Variables and Method of Use

The previous chapter essentially developed two sets of models. The first group, developed in Section 8.5, determined the independent variables that influenced the rating of *individual* aspects of the BHS. For example, the factors that influenced the passengers perception of comfort and safety were presented in Section 8.5.7. The second group of models, presented in sections 8.7, 8.8 and 8.9 indicated the UPLOS for the BHS as a *whole*. Section 8.7 presented one general aggregate model for use at any airport, while section 8.8 provided disaggregate models based on annual passenger volumes. Section 8.9 presented a UPLOS model for each of the six airports that participated in this research. A number of independent variables, summarized in Table 8-8, Table 8-9, and Table 8-10, were determined to predict the UPLOS.

To evaluate the LOS of a *single* aspect of the BHS, the models described in section 8.5.7 can be used. Additionally, Table 6-23 presented standards for five aspects of the BHS that are considered by the passengers as an indication of the LOS A through F. Airport authorities and airlines can use either the models from section 8.5.7 or Table 6-23 to evaluate the LOS provided to the passengers by a single specific aspect of the BHS and to determine appropriate strategies for increasing the LOS.

To evaluate the LOS of the *overall* BHS as a whole, the regression models from sections 8.7, 8.8 and 8.9 should be used. A UPLOS model was presented for each of the six airports that participated in this research and thus, should be used by these six airports to determine the prevalent UPLOS. If an airport (other than the six participating ones) can be considered similar to one of these six airports (in terms of BHS, size, atmosphere, etc.), then the model for the similar airport should be used to evaluate the UPLOS. If the airport that requires an evaluation is not similar to any of the six participating airports, then the appropriate disaggregate model by annual passenger volume should be selected. Additionally, the aggregate model from section 8.7 can be used by any airport to evaluate and analyze the user-perceived BHS LOS.

To use these UPLOS models, the independent variables must be evaluated. The independent variables can be separated into two distinct types: those that can be measured without user interference, and those that are perceived by the passengers. Those

that can be measured directly are GENDER01 (percent of male respondents), RENO01CO, DISTGATE, GETBAG01 (percent of mishandled baggage), PXBGDLAY, PASPERM, LENGTHM, M2PERPAS, AREA2M, PASS.#, BUSYPASS, BAGS#. Depending on the objective of the UPLOS evaluation, these values can be calculated by flight or as an average for the airport.

Those variables that should be evaluated by the respondents are CHEKBAGS, FLIGHTY2, TIMEARR, TIMEWAIT, and EXPEDLAY. However, these variables can be evaluated from studies conducted at an airport in the past and from relationships developed during this study. From previous surveys, the average number of checked bags per passenger (CHEKBAGS) and the average number of flights taken per year (FLIGHTY2) might be known at the airport of interest. In terms of its ability to predict UPLOS, TIMEARR is approximately the same as TIMEGATE and thus, the latter could be used instead.

The average perceived waiting time, TIMEWAIT, can be easily evaluated without asking the passengers directly. An individual (hired by the airport authority or airline) can monitor passengers and keep records of their actual waiting time. Otherwise, the relationship between average perceived waiting time and annual passenger volume can be used to evaluate the TIMEWAIT (Figure 5-1). Although a more refined relationship can be developed in the future using a larger sample size, this figure indicates that average

perceived waiting time, *TIMEWAIT* (minutes), is related to annual passenger volume, *P* (millions), with the following relationship.

$$TIMEWAIT = 3.5 + 1.02P$$

To evaluate *EXPEDLAY*, both the perceived waiting time (*TIMEWAIT*) and the expected waiting time must be known. The latter value can be controlled by the airlines by using electronic display boards and/or announcements (broadcast onboard the aircraft or within the terminal) to tell passengers what the expected waiting time for baggage is for each flight. Otherwise, a passenger survey can be conducted to evaluate the expected waiting time. The average *UPLOS* provided at an airport can be determined by evaluating the preceding variables, either by flight or for the airport as a whole.

Table 8-8: Summary of Independent Variables in Aggregate UPLOS Model

Independent Variable	Variables that predict these Independent Variables
Rating of Waiting Time	Perceived waiting time, Difference between expected and perceived waiting time, Gender, Time between arrival of first passenger and first bag in reclaim area, Whether bag was received, Number of flights taken by passenger per year
Rating for Comfort and Safety	Perceived waiting time, Whether renovation recently undertaken in reclaim area
Rating for walking time	Distance between arrival gate and reclaim area, Passenger's perceived time to walk from arrival gate to reclaim area
Whether bag was received	

Table 8-9: Summary of Independent Variables in Disaggregate UPLOS Model (by Size)

Independent Variable	Variables that predict these Independent Variables
a) Small Airports	
Rating of Waiting Time	Perceived waiting time
Rating for Comfort and Safety	Number of checked bags
Whether bag was received	
b) Medium Airports	
Rating of Waiting Time	Perceived waiting time, Difference between expected and perceived waiting time, Gender, Time between arrival of first passenger and first bag in reclaim area, Whether bag was received, Number of flights taken by passenger per year
Rating for Comfort and Safety	Passengers per metre along conveyor belt, Total length along conveyor belt, Metres squared per passenger in reclaim area, Area in which passengers were standing around the conveyor – not including the conveyor belt itself, Total number of passengers on the flight, Perceived waiting time
Difference between expected and perceived waiting time	
Rating for walking time	Distance between arrival gate and reclaim area, Passenger's perceived time to walk from arrival gate to reclaim area

Whether bag was
received

c) Large Airports

Rating for Overall Space	Maximum number of passengers in reclaim area, Whether renovation recently undertaken in reclaim area, Number of flights taken by passenger per year, Number of checked bags, Total length along conveyor belt
Rating of Waiting Time	Difference between expected and perceived waiting time, perceived waiting time, Number of flights taken by passenger per year
Rating for walking time	Distance between arrival gate and reclaim area, Passenger's perceived time to walk from arrival gate to reclaim area

Table 8-10: Summary of Independent Variables in Disaggregate UPLOS Model (by Individual Airport)

Independent Variable	Variables that predict these Independent Variables
a) Thunder Bay	
Rating of Waiting Time	Perceived waiting time
Rating for Comfort and Safety	Number of checked bags
Whether bag was received	
b) Ottawa	
Rating of Waiting Time	Time between arrival of first passenger and first bag in reclaim area, perceived waiting time, Whether bag was received
Rating for Comfort and Safety	Passengers per metre along conveyor belt
c) Edmonton	
Rating of Waiting Time	Difference between expected and perceived waiting time, Gender, Time between arrival of first passenger and first bag in reclaim area
Rating for walking time	Distance between arrival gate and reclaim area, Passenger's perceived time to walk from arrival gate to reclaim area
d) Calgary	

Rating of Waiting Time	Difference between expected and perceived waiting time, Perceived waiting time
Rating for Comfort and Safety	Total number of passengers on the flight, Area in which passengers were standing around the conveyor – not including the conveyor belt itself, Perceived waiting time
Total number of bags unloaded from aircraft	

e) Montreal

Rating of Waiting Time	Difference between expected and perceived waiting time, Perceived waiting time, Number of flights taken by passenger per year
Rating for Comfort and Safety	Metres squared per passenger in reclaim area
Number of transfers made by passenger	

f) Toronto

Rating for Overall Space	Maximum number of passengers in reclaim area, Whether renovation recently undertaken in reclaim area, Number of flights taken by passenger per year, Number of checked bags, Total length along conveyor belt
Rating of Waiting Time	Difference between expected and perceived waiting time, Perceived waiting time, Number of flights taken by passenger per year
Rating for walking time	Distance between arrival gate and reclaim area, Passenger's perceived time to walk from arrival gate to reclaim area

Chapter Nine

9 CONCLUSIONS, RECOMMENDATIONS AND FUTURE AREAS OF RESEARCH

9.1 Conclusions and Recommendations

The research objectives, discussed in Section 4.3.1, were accomplished throughout this research. The BHS facilities at six Canadian airports were assessed and their features were discussed in Chapter 5. The LOS perceived by the passengers and the standards that passengers associated with each LOS from A to F were presented in Chapter 6. The service provided by the airport authorities, airlines and baggage handlers according to various standards were evaluated in Chapter 7. Additionally, chapters 6 and 7 addressed the discrepancies between the LOS provided by the airport facilities and the airlines and the LOS as perceived by the passenger. The inadequacy of the traditional measures for evaluating the LOS of BHS as perceived by the users was determined. Finally, Chapter 8 presented the developed aggregate and disaggregate models for predicting the UPLOS and determining how altering various aspects of the BHS would alter the UPLOS. The aggregate model, created from all collected data, is a comprehensive tool for the preliminary evaluation and analysis of the perceived LOS of BHS's and should be used as part of the overall LOS evaluation of airport systems. The disaggregate model, based on annual airport volumes, allows for a more detailed evaluation of the perceived LOS of

the BHS and provides an additional tool for overall terminal analysis and design. Finally, a disaggregate model was developed for each of the six participating airports for future evaluation of these specific airports. The main findings of this research are provided in the following sections.

9.1.1 Inadequacy of Traditional Variables

The three traditional variables used to determine the LOS provided by the baggage handling system are the waiting time in the reclaim area, the square metres provided per occupant in the reclaim area, and the number of passengers per metre along the reclaim conveyor belt. This research has shown that these three traditional variables alone are not adequate predictors of the LOS as perceived by the passengers. This has been demonstrated through

- 1) a comparison between the LOS provided by the airport authorities, airlines and baggage handlers and the rating perceived by the passengers for specific aspects of the BHS,
- 2) a comparison between the LOS provided by the airport authorities, airlines and baggage handlers and the overall user-perceived LOS, and
- 3) the development of aggregate regression models.

It was concluded that the standards used by the organizations mentioned in this thesis (IATA, TC, etc.) to determine LOS do not reflect user perceptions. Results indicate that, based on these standards, the LOS provided by the airport authorities, airlines and baggage handlers in terms of waiting times, baggage delivery times, reclaim area, and conveyor frontage do not agree with the LOS that was perceived by the passengers.

9.1.2 Prevailing User-Perceived LOS

The average user-perceived LOS at the six airports investigated ranged between a good to adequate LOS and a high to good LOS. The lower average LOS (good to adequate) indicates a LOS between C and D, while the higher LOS indicates a LOS between B and C. Overall, Thunder Bay International Airport received the best ratings for all aspects of the baggage handling system and the average perceived LOS was between good and high (LOS B to C). The average perceived LOS at the Calgary International Airport was between good and high (LOS B to C) and was slightly better than good (LOS C) at the Edmonton International Airport. The Ottawa, Dorval (Montreal) and Toronto international airports all provided an average perceived LOS between adequate and good (LOS C to D).

Since transportation systems are traditionally designed for a LOS C, any airport that received an evaluation less than LOS C can be considered below standard and in need of

improvements. Therefore, it was found that the Ottawa, Montreal, and Toronto airports should improve the user-perceived LOS of the BHS.

9.1.3 User Preferences for Specific Aspects of BHS

Due to the lack of agreement between the user-perceived LOS and that evaluated with traditional variables, research was conducted to determine how passengers perceive specific aspects of the BHS (e.g. walking distance, waiting time, etc.) and the overall BHS. Table 6-23 demonstrates that passengers can distinguish between the LOS ratings from excellent to unacceptable. Additionally, this table indicates what passengers perceive to be a reasonable standard for each LOS for five specific aspects of the baggage handling system. For example, when considering walking distance, passengers perceived that a walking distance of 130 metres indicated an excellent LOS, while a walking distance of 270 metres was perceived as unacceptable. When considering waiting times, passengers perceived a waiting time of up to 3.4 minutes to be an excellent LOS, while a waiting time of 22.2 minutes was perceived as an unacceptable LOS. Airport authorities and airlines can use this table when designing new terminals or modifying existing ones, and when deciding which arrival gate and reclaim conveyor will be used for a particular flight.

Comparing the standards for overall space (OVRSPACE) as perceived by users (Table 6-23) with the operational standards suggested by IATA and TC (Table 4-5), a significant discrepancy exists. While, for a LOS C, TC suggests that a minimum of 1.2 m^2 per occupant be provided and IATA suggests a minimum of 1.6 m^2 per occupant be provided, passengers consider that a mean value of 6.4 m^2 per occupant should be provided for the same LOS. While the cost of providing this amount of space per occupant would be exorbitant, some compromise should be made between the standards suggested by TC and IATA, and the standards perceived by passengers. Clearly, the passengers perceptions were never considered when these standards were developed. Additionally, one must recall that the standards presented in Table 6-23 indicate a passengers perception of a reasonable standard for five specific aspects of the BHS considered *individually*. Thus, if an airport authority or airline wants to improve one single aspect of the BHS, these standards are appropriate. Meanwhile, the aggregate and disaggregate models were developed as a tool for evaluating and analyzing the user-perceived LOS of the overall BHS and can be used as part of a comprehensive airport terminal evaluation.

Reviewing the passengers perceptions for standards related to the frontage provided per person, it is evident that the 5 passengers per metre used as a design standard by the Aeroports de Paris is well below unacceptable, or LOS F. Passengers perceived any value greater than 2.7 passengers per metre as unacceptable. Thus, the length of conveyor belt provided per person must be increased if the airports wish to satisfy passengers.

9.1.4 Aggregate Model

From regression analysis, the traditional BHS evaluation variables were found to predict only 21.1% of the UPLOS, whereas the independent variables included in the developed user-perceived LOS model can predict 63.6% of the UPLOS, an improvement of 300%. The linear aggregate and disaggregate UPLOS models developed during this research were presented and discussed in Chapter 8. The linear aggregate UPLOS model (P-value = 0.005, $R^2 = 0.636$) is as follows:

$$UPLOS = 0.362 + 0.391(WAITTIME) + 0.330(COMFORT) + 0.126(WALKTIME) + 0.802(GETBAG01)$$

This model indicates that the independent variables capable of predicting 63.6% of the UPLOS are the passengers rating of waiting time in the reclaim area, the passengers rating of comfort and safety in the reclaim area, the passengers rating of walking time between the arrival gate and the reclaim area, and whether or not the passenger received his/her baggage from the reclaim device. These independent variables are, in turn, influenced by other variables as discussed in the following paragraphs.

The results indicate that the rating for waiting time is influenced by the perceived waiting time (minutes), the difference in time between the perceived and expected waiting times

(minutes), the gender of the respondent, the difference in time between the arrival of the first item of baggage and the first passenger, whether or not the bag was received, and the annual number of flights taken by the respondent. The passengers perception of waiting time (WAITTIME), and therefore the UPLOS, can be improved by:

- ◆ improving the waiting time or the baggage delivery time,
- ◆ ensuring that the time difference between the arrival of passengers and baggage is minimized (or baggage arrives first),
- ◆ ensuring that the expected and perceived waiting times are similar, and
- ◆ minimizing the amount of mishandled baggage.

The results of this thesis show that the variables affecting the rating for comfort and safety include whether or not renovations have recently been undertaken, the number of seats in the reclaim area, the type of flight (domestic or international), the maximum number of passengers in the reclaim area, and the number of checked bags. Measures that the airlines and airport authorities can take to improve the passenger's perception of comfort and safety in the reclaim area (COMFORT), and therefore, improve the UPLOS include:

- ◆ modernizing the reclaim area (adding washroom facilities and telephones, implementing an open design concept, modernizing features and colours),
- ◆ increasing the reclaim area ceiling height (more spacious and brighter),
- ◆ increasing the number of seats adjacent to the reclaim conveyor, and

- ◆ reducing the occurrence of more than one flight simultaneously using the same reclaim conveyor belt.

Results indicate that three variables significantly influence the passengers rating for walking distance. They include the actual walking distance and the passenger's perceived time to walk between the arrival gate and the reclaim area (metres and minutes, respectively) and the time between the arrival of the aircraft and the most congested period in the reclaim area (minutes). This latter variable is an indication of the time required for the average passenger to reach the reclaim area, which includes not only the walking time, but also the time required to exit the aircraft. The passengers perception of walking distance (WALKDIST), and therefore the UPLOS, can be improved by:

- ◆ reducing the physical distance between the arrival gate and the reclaim area,
- ◆ reducing the time required to travel between these two locations (e.g. shorter distance or use of automated people movers), and
- ◆ increasing the speed with which the aircraft is unloaded following arrival.

This third variable can be improved by having more than one exit door on all aircraft and restricting carry-on baggage. The former recommendation would be costly since both aircraft and arrival gates must be redesigned, however, it would result in a shorter passenger unloading time and thus, faster aircraft turnover. The latter recommendation would result in a faster exit time because people without carry-on baggage can exit an

aircraft faster than passengers with such baggage as purses, computers, coats, suits, books, knapsacks, etc.

Finally, reducing the amount of mishandled baggage can improve the UPLOS. Thus, if any of the measures recommended above are implemented, the user-perceived LOS can be improved. Whether it be for the design of a new terminal or for evaluating an existing one, airport authorities and airlines can use this regression model to determine what changes will improve the level of service as perceived by the passengers.

9.1.5 Disaggregate Model by Annual Passenger Volume

Additionally, disaggregate regression models, by annual passenger volumes, were developed to fine-tune the aggregate models and can be used to evaluate the user-perceived LOS. Three models were developed for small (less than one million annual passengers), medium (between one and 10 million passengers), and large (more than 10 million annual passengers) airports. The three disaggregate models are as follows.

Small Airports: $P\text{-value} = 0.0005$, $R^2 = 0.550$

$$UPLOS = 0.802 + 0.387(WAITTIME) + 0.232(COMFORT) + 2.579(GETBAG01)$$

Medium Airports: P-value = 0.014, $R^2 = 0.589$

$$UPLOS = 0.613 + 0.334(WAITTIME) + 0.307(COMFORT) - 0.0196(EXPEDLAY) + 0.123(WALKTIME) + 0.538(GETBAG01)$$

Large Airports: P-value = 0.049, $R^2 = 0.618$

$$UPLOS = 0.365 + 0.342(OVRSPACE) + 0.298(WAITTIME) + 0.223(WALKTIME)$$

In addition to the independent variables included in the aggregate regression model discussed above, the passenger's rating for overall space in the reclaim area (OVRSPACE) was an important independent variable for the large airport model. Since a strong correlation exists between the OVRSPACE and the rating for comfort and safety, the inclusion of this variable is reasonable. Also, the time difference between the expected and perceived waiting time (EXPEDLAY) was included in the medium-sized airport model. If the perceived waiting time equals or exceeds the expected waiting time, the UPLOS can be improved. Thus, altering expectations or improving the perceived waiting time is beneficial. This can be accomplished by:

- ◆ Improving actual waiting times,
- ◆ Providing distractions in the reclaim area (e.g. televisions, information display boards, artwork by local artist or other themes, etc.)
- ◆ Reducing passengers expectations, and
- ◆ Notifying passengers of the expected baggage delivery time (e.g. electronic display boards could indicate the expected baggage arrival time and/or provide updates at

each conveyor based on the arrival gate used, the number of baggage handlers working, weather conditions, airside congestion, etc.)

9.1.6 Disaggregate Model for Six Participating Airports

In addition to the disaggregate models developed based on annual passenger volumes, disaggregate models were developed for each participating airport individually. These models are to be used for future evaluation of the user-perceived LOS of the BHS at these six specific airports. Additionally, they are to be used for determining appropriate strategies for improving the LOS of the BHS when the model indicates that the UPLOS is below a LOS C. The developed models are as follows.

Thunder Bay: P-value = 0.0005, $R^2 = 0.550$

$$UPLOS = 0.802 + 0.387(WAITTIME) + 0.232(COMFORT) + 2.579(GETBAG01)$$

Ottawa: P-value = 0.011, $R^2 = 0.652$

$$UPLOS = 0.590 + 0.488(WAITTIME) + 0.313(COMFORT)$$

Edmonton: P-value = 0.021, $R^2 = 0.581$

$$UPLOS = 0.463 + 0.404(WAITTIME) + 0.383(WALKTIME)$$

Calgary: P-value = 0.001, $R^2 = 0.622$

$$UPLOS = 0.644 + 0.308(WAITTIME) + 0.286(COMFORT) + 0.002436(BAGS\#)$$

Montreal: P-value = 0.003, $R^2 = 0.465$

$$UPLOS = 0.993 + 0.442(WAITTIME) + 0.224(COMFORT) - 0.427(TRANSFR\#)$$

Toronto: P-value = 0.049, $R^2 = 0.618$

$$UPLOS = 0.365 + 0.342(OVRSPACE) + 0.298(WAITTIME) + 0.223(WALKTIME)$$

The independent variables included in the aggregate and disaggregate (by annual passenger volume) user-perceived models were included in these disaggregate models for the six participating airports. In addition, the Montreal airport included 'the number of transfers made' as an important variable. This variable indicates the number of transfers made by both the passenger *and* the baggage. A large number of Montreal respondents were travelling for pleasure and arriving on international flights, two variables that result in an increase in the number of transfers made. Results indicate that the user-perceived LOS improves as the number of transfers made increases and that passengers with many transfers have lower expectations.

In summary, the inadequacy of the traditional BHS evaluation variables was discussed. Subsequently, for five specific BHS aspects, standards were presented which passenger's

consider represent the six LOS's from A to F. In addition, three groups of regression models were presented: aggregate, disaggregate by size and disaggregate by specific airport. These developed models can predict the user-perceived BHS LOS 300% better than with traditional variables. The independent variables and means of improving the UPLOS were addressed and recommendations were provided. Airport authorities and airlines can use these models to evaluate and analyze the LOS perceived by the passengers. Together, with evaluation methods used for other airport terminal systems, these models provide a framework for determining the overall prevailing LOS as perceived by passengers.

9.1.7 Airport Specific Recommendations

Throughout the preceding chapters, some airport specific recommendations were suggested. They are summarized as follows:

- ◆ **Ottawa International Airport:** The Ottawa airport should provide additional conveyors in the reclaim area, which would result in a lower density of people collecting baggage from each conveyor in the reclaim area. Additionally, Ottawa should improve the baggage delivery times, which would reduce passenger waiting times. Since renovations are currently underway at the Ottawa airport, these alterations are being addressed.

- ◆ **Edmonton International Airport:** Passengers at the Edmonton airport perceived the walking distance to be excessive. Flights arriving at gates in the old terminal should not have to retrieve baggage from reclaim conveyors in the new terminal.

- ◆ **Dorval International Airport (Montreal):** The international reclaim area in Montreal was very congested during many observed flights. Recommendations, considering cost, security, delay and available space, were suggested in Section 5.5 that would improve traffic flow and the perceived LOS in that area. The delivery times for both regular and priority baggage should be shortened, as the Air Canada standards were not met for a large percent of flights.

- ◆ **Toronto Lester B. Pearson International Airport:** As with Montreal, the delivery times for both priority and regular baggage need to be improved, since the Air Canada delivery standards were not met for a large portion of the flights.

9.1.8 General Recommendations

Since this research included only one small and one large airport, the disaggregate UPLOS regression models for small and large airports were each developed using only

one airport sample. More small and large airports should be studied to verify the disaggregate models.

During the research, data about the sorting method (manual, semi-automatic, automatic) and sorting areas used (remote, centralized, decentralized) were collected at each airport. However, since this research involved the *arrival* baggage distribution system, these two characteristics of the BHS did not affect the regression models. It is recommended that future research efforts investigate the sorting method and sorting area used at the airport where the flight *originated*.

9.2 Future Research Work

Clearly, the research work carried out and presented in this thesis identified a number of new areas worth investigating. Some topics are as follows.

Topics that are an extension of this research:

- 1) A comparison of Canadian and non-Canadian airports to verify the UPLOS models.
- 2) Including additional small and large airports to verify the UPLOS models.
- 3) Investigating characteristics associated with the flight origin (i.e. location, attitude of respondents, cultural differences, etc.)

- 4) September 11th ramifications (i.e. safety, comfort, security, reasonable waiting times). Do the increased security measures affect the arrival baggage handling system? Has there been an increase in the amount of checked baggage within the system? If so, have delivery times worsened and has this decreased the UPLOS?
- 5) Economic implications of this new UPLOS model versus the traditional evaluation measures.
- 6) Is it worth checking that the passenger leaving the airport has a claim ticket for the baggage that he/she is carrying? How much delay would this cause the passengers? Would this reduction in mishandled baggage increase or decrease the UPLOS?
- 7) Investigate further the relationship between waiting time in the reclaim area and the walking time/distance between the arrival gate and the reclaim area.
- 8) Other airport terminal systems (e.g. processing and hold areas) should investigate whether or not discrepancies exist between the LOS perceived by passengers and traditional evaluation techniques.

Additional research and potential growth of airline industry:

- 1) Radio frequency tags and tracking devices - Investigate new technology of baggage tags and their effect on the current situation. Tracking devices for RF tags could be placed in a number of locations including check-in, within the terminal building, when baggage enters and exits the aircraft, when baggage arrives on the reclaim conveyor, and at terminal exit doors. Tracking of the RF tags could be accomplished

using fixed equipment that baggage passes through or using hand held scanners.

Using RF tracking devices can provide an indication of baggage waiting times, baggage delivery times, whether delivery standards are being met, and where and how much baggage is being mishandled. The use of RF tags can assist in setting and improving baggage delivery standards. In addition, tracking devices would indicate where mishandled bags were being mishandled initially so that system problems can be solved efficiently, resulting in a BHS with zero misplaced baggage. RF tags would assist in provided 100% baggage match (a possible result of the September 11th, 2001 terror attacks.

By using RF tags, we would have answers for the following questions:

Are all bags on/off aircraft?

Are all bags on reclaim conveyor?

Which bags, if any, are missing?

Where did a bag get 'mishandled'?

What time did the first/last/each bag enter aircraft, exit aircraft, arrive on conveyor belt?

In addition, will the number of mishandled bags be reduced considerably?

Reducing lost and damaged bags would improve the UPLOS since GETBAG01 was an independent variable. What will the cost savings be?

There could be a special location for placement of an RF tag within baggage so that it could never be damaged, decreasing the number of misread tickets. Could the RF tags be read and write (like transponders for automobiles) and be inserted *into* the baggage instead of *on* the baggage.

- 2) Is it worth having a company that *rents* baggage to the passengers? The baggage would then be a standard size and standard quality. This would reduce damage costs to the airline. Additionally, people would not have to store baggage in their homes for infrequent use.

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APPENDICES

Appendix A – English and French Questionnaires

ARRIVING PASSENGER SURVEY OF AIRPORT BAGGAGE HANDLING SYSTEMS

Hello! My name is Joanne Pagani and I am conducting research in the area of baggage handling and passenger satisfaction as part of a Ph.D. thesis at Carleton University, Ottawa. I would greatly appreciate a few minutes of your time to complete this questionnaire. Please fill in this information as accurately as possible.

Flight Information:

Flight No.: _____
 Arrival Time: ____:____ ☐ a.m. ☐ p.m.
 Airline: ☐ Air Canada, ☐ Other—please specify _____
 Route including all transfers: _____

Did you transfer from a different airline? ☐ Yes ☐ No

If yes, which airline: ☐ Air Canada, ☐ Other _____

Which class of ticket did you purchase? ☐ Business ☐ Economy

Personal information:

Trip purpose: ☐ business, ☐ pleasure, ☐ both, ☐ other
 Gender: ☐ Male ☐ Female
 Age range: ☐ under 25, ☐ 25-39, ☐ 40-60, ☐ over 60
 Number of *checked* bags today? ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more
 How often do you fly per year? ☐ 1-2 ☐ 3-5 ☐ 6-9 ☐ 10 or more

Please answer the following questions.

- 1) How long did it take you to arrive at the conveyor belt from the time you exited the aircraft? _____ minutes
- 2) Was some baggage (not necessarily yours) already on the conveyor belt when you arrived at the conveyor belt? ☐ Yes ☐ No

Please answer the following questions after collecting your checked baggage.

- 3) How long did you have to wait at the conveyor belt until your baggage arrived? _____ minutes
- 4) Before arriving at your destination, how long did you *expect* to wait at the conveyor belt to collect your baggage? _____ minutes

Please turn over →→

Please rate the following items using excellent, high, good, adequate, inadequate or unacceptable service by checking the appropriate box.

Items	Excellent	High	Good	Adequate	Inadequate	Unacceptabl
5) The walking distance from the aircraft gate to the reclaim area.	☐	☐	☐	☐	☐	☐
6) The time to walk from the aircraft gate to the baggage reclaim area.	☐	☐	☐	☐	☐	☐
7) The wait for baggage at the reclaim area.	☐	☐	☐	☐	☐	☐
8) The space to collect baggage along the conveyor belt.	☐	☐	☐	☐	☐	☐
9) The overall space in the baggage reclaim area.	☐	☐	☐	☐	☐	☐
10) The amount of seating in the reclaim area:	☐	☐	☐	☐	☐	☐
11) Your personal comfort and safety in the reclaim area.	☐	☐	☐	☐	☐	☐

The area you are now located in is part of the arrival baggage handling system. It includes the available space, the amount of seating provided, the speed with which the baggage arrived on the conveyor belt, and the design of the conveyor belt for retrieving your baggage.

13) On a scale of 0 (unacceptable) to 10 (excellent), how do you perceive the overall service provided by the arrival baggage handling system? _____

14) Using a different scale, what level best describes the service provided by the baggage handling system?

☐ Excellent

☐ High

☐ Good

☐ Adequate

☐ Inadequate

☐ Unacceptable

Comments: _____

Thank you very much for your time and cooperation. Please return the questionnaire and clipboard to me in the baggage handling area.

SONDAGE DES PASSAGERS AU POINT D'ARRIVER A PROPOS LE SERVICE DE MANUTENTION DES BAGAGES

Bonjour! Mon nom est Joanne Pagani et je suis à rédiger mon doctorat en génie civil a l'Université de Carleton, à Ottawa. Je vais utiliser l'information de ce sondage pour mes recherches, qui sont a propos des services de manutention des bagages et la satisfaction des passagers. J'apprecie votre support pour m'aider a completer ce sondage.

Information du vol:

No. de vol: _____

Temps d'arrivée: ____:____ ☐ a.m. ☐ p.m.

Compagnie Aérienne: ☐ Air Canada, ☐ Autre _____

Route incluant les transferts: _____

Pendant votre transfert, avez-vous changé de compagnie aérienne? ☐ Oui ☐ Non

Si oui, laquelle?: ☐ Air Canada, ☐ Autre _____

Quelle catégorie de billet avez-vous acheté? ☐ Affaires ☐ Economie

Information personnelle:

Raison de voyage?: ☐ affaires, ☐ plaisir, ☐ les deux, ☐ autre

Sexe?: ☐ Masculin ☐ Féminin

Catégories d'âge?: ☐ moins de 25, ☐ 25 - 39, ☐ 40 - 60, ☐ plus de 60

Nombre de bagages à retirer aujourd'hui? ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ou plus

Combien de vols prenez-vous par année? ☐ 1-2 ☐ 3-5 ☐ 6-9 ☐ 10 ou plus

S'il vous plait, répondez aux questions suivantes.

- 1) Combien de temps avez-vous mis après avoir quitté l'avion jusqu'à votre arrivée au tapis roulant? _____ minutes
- 2) Avez-vous vu des bagages (pas nécessairement les vôtres) sur le tapis roulant dès votre arrivée? ☐ Oui ☐ Non

S'il vous plait, répondre aux questions suivantes APRES avoir retiré vos bagages.

- 3) Combien de temps avez-vous attendu vos bagages au tapis roulant? _____ minutes
- 4) Combien de minutes aviez-vous estimé d'attendre vos bagages au tapis roulant? _____ minutes

S.V.P. au verso →

S'il vous plaît, assignez à chacun des points suivants une valeur utilisant: excellent, très bon, bon, suffisant, insuffisant, ou inacceptable. (Cochez une boîte pour chaque point.)

Points	Excellent	Très Bon	Bon	Suffisant	Insuffisant	Inacceptable
5) La distance à pied entre l'avion et la salle de réclamation des bagages.	☐	☐	☐	☐	☐	☐
6) Le temps nécessaire pour marcher entre l'avion et la salle de réclamation des bagages.	☐	☐	☐	☐	☐	☐
7) La durée de l'attente pour vos bagages au tapis roulant.	☐	☐	☐	☐	☐	☐
8) L'espace autour du tapis roulant pour retirer vos bagages.	☐	☐	☐	☐	☐	☐
9) L'espace globale dans la salle de réclamation des bagages.	☐	☐	☐	☐	☐	☐
10) Le nombre de sièges disponible aux passagers dans la salle de réclamation des bagages.	☐	☐	☐	☐	☐	☐
11) Votre niveau de confort et de sécurité dans la salle de réclamation des bagages.	☐	☐	☐	☐	☐	☐

La salle où vous vous trouvez présentement fait partie du système de manutention de bagages. Ce système comprend l'espace global, le nombre de sièges disponibles aux passagers, la durée de l'attente de vos bagages au tapis roulant, et votre habileté de retirer vos bagages.

13) Sur une échelle de 0 (inacceptable) à 10 (excellent) comment évaluez-vous le système de manutention de bagages dans sa totalité? _____

14) Utilisant une deuxième échelle, quel niveau accordez-vous au service fourni par le système de manutention de bagages?

☐ Excellent

☐ Très Bon

☐ Bon

☐ Suffisant

☐ Insuffisant

☐ Inacceptable

Commentaires: _____

Merci pour votre co-opération. S.V.P. laisser moi votre sondage.

Appendix B – Data Collection Sheets for Airport Visit

To be completed by the baggage handling company:

Name: _____

Position: _____

Company: _____

Airport Location: _____

Do you have information about the reclaim devices (make, model, capacity, speed, etc)? ☐ Yes ☐ No.

If yes, please provide as much information as possible. If no, who has that information? _____

On average, how many bags do you handle per day?

What are the standard unloading rates (i.e. how many minutes do you have to unload the aircraft)? Please provide the rates for priority bags and regular bags. Is there a different standard for different sizes of aircraft?

How well/ how often do you achieve these targets? Are there any available statistics indicating your average unloading times?

How many passengers and bags were unloaded from the following flights?

[illegible]**Comments:**

To be completed by researcher:

Airport: _____

Baggage handling companies: _____

Type of sorting area (centralized, decentralized, remote): _____

Type of sorting method (manual, semi automatic, automatic): _____

Total number of gates? _____

Total number of conveyor belts? _____

No.	Style (R-racetrack, C-carousel)	I-int'l D-domestic	Paces Around belt	Surrounding Area	# Seats	Paces door to belt	Time door to belt
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

[illegible]

To be completed by the researcher:

Conveyor belt number: _____

Flight number: _____

Arrival time of first bag: _____

Arrival time of last bag (if possible): _____

Arrival time of first passenger: _____

Time after arrival of 1 st passenger	No. of passengers in reclaim area

For later use:

Actual arrival time _____

of passengers _____

of bags _____

gate number _____

distance to gate _____

time to gate _____

Appendix C – Description of Flights Observed

Flights Observed in Edmonton

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	AC167	Air Canada	Toronto	Domestic	66	69
2	AC1812	Air Canada	Denver	International	68	90
3	AC1868	Air Canada	Vancouver	Domestic	51	30
4	AC1872	Air Canada	Vancouver	Domestic	26	30
5	AC1874	Air Canada	Vancouver	Domestic	43	40
6	AC1878	Air Canada	Vancouver	Domestic	71	15
7	AC3953	Air Canada	Toronto	Domestic	75	94
8	AC3973	Air Canada	Winnipeg	Domestic	79	95
9	AC8319	Air Canada	Grande Prairie	Domestic	41	15
10	AC8348	Air Canada	Vancouver	Domestic	3	3
11	AC8376	Air Canada	Vancouver	Domestic	30	35
12	AC8390	Air Canada	Calgary	Domestic	19	25
13	AC8392	Air Canada	Calgary	Domestic	13	5
14	AC8396	Air Canada	Calgary	Domestic	44	15
15	AC8454	Air Canada	Calgary	Domestic	40	20
16	AC8456	Air Canada	Calgary	Domestic	42	15
17	AC8460	Air Canada	Calgary	Domestic	35	20
18	AC8952	Air Canada	Yellowknife	Domestic	23	10
19	CMM654	Canada 3000	Los Angeles	International	36	70
20	CO6019	NorthWest	Minneapolis	International	61	62
21	NV952	First Air	Yellowknife	Domestic	23	10
22	WJ42	WestJet	Saskatoon	Domestic	25	43
23	WJ46	WestJet	Grande Prairie	Domestic	33	40

a. Name of Airport = YEG

Flights Observed in Ottawa

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	AC054	Air Canada	Toronto	Domestic	52	34
2	AC060	Canadian	Toronto	Domestic	59	15
3	AC1360	Air Ontario	Toronto Island	Domestic	37	20
4	AC440	Air Canada	Toronto	Domestic	134	11
5	AC456	Air Canada	Toronto	Domestic	162	61
6	AC458	Air Canada	Toronto	Domestic	155	123
7	AC613	Air Canada	Halifax	Domestic	40	45
8	AC619	Air Canada	Toronto	Domestic	71	91
9	AC8861	Air Canada	Montreal	Domestic	29	13
10	MM707	Canada 3000	Vancouver	Domestic	134	167
11	QN849	Royal	Toronto	Domestic	26	33
12	WJ072	WestJet	Hamilton	Domestic	115	123
13	WJ110	WestJet	Hamilton	Domestic	61	25

a. Name of Airport = YOW

Flights Observed in Thunder Bay

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	AC3704	Air Canada	Winnipeg	Domestic	21	20
2	AC3706	Air Canada	Winnipeg	Domestic	16	10
3	AC3823	Air Canada	Toronto	Domestic	54	30
4	AC3827	Air Canada	Toronto	Domestic	40	27
5	AC3835	Air Canada	Toronto	Domestic	33	38
6	AC505	Air Canada	Toronto	Domestic	45	41
7	AC8624	Air Canada	Toronto	Domestic	42	35
8	Bear30	Bearskin	Sault Ste Marie	Domestic	8	12
9	Bear34	Bearskin	Unknown	Domestic	7	11
10	Bear36	Bearskin	Sioux Lookout	Domestic	17	9
11	Bear37	Bearskin	Sault Ste Marie	Domestic	15	23
12	WJ85	WestJet	Calgary	Domestic	46	56

a. Name of Airport = YQT

Flights Observed in Montreal

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	AA5024	Air Canada	NY - JFK	International	23	11
2	AA5033	American	NY - JFK	International	26	25
3	AC066	Canadian	Toronto	Domestic	120	60
4	AC402	Air Canada	Toronto	Domestic	179	88
5	AC404	Air Canada	Toronto	Domestic	191	64
6	AC406	Air Canada	Toronto	Domestic	189	100
7	AC432	Air Canada	Toronto	Domestic	128	68
8	AC611	Air Canada	Halifax	Domestic	53	34
9	AC747	Air Canada	NY - LGA	International	49	29
10	AC795	Air Canada	Portland	International	14	9
11	AC8709	Air Nova	Quebec	Domestic	23	11
12	AC871	Air Canada	Paris	International	266	335
13	AF344	Air France	Paris	International	381	438
14	CO4148	Continental	Newark	International	50	40
15	DL6067	Delta	Unknown	International	27	12
16	GX1374	Air Nova	Toronto Island	Domestic	19	10
17	MM377	Canada 3000	Toronto	Domestic	.	.
18	OK108	CSA/Czech	Prague	International	143	204
19	QK8707	Air Canada	Quebec	Domestic	23	11
20	SR134	Swiss Air	Zurich	International	217	434

a. Name of Airport = YUL

Flights Observed in Calgary

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	424	AirTransat	Toronto	Domestic	222	444
2	AA2081	American	Dallas	International	64	68
3	AA829	American	Chicago	International	45	50
4	AC107	Air Canada	Toronto	Domestic	113	114
5	AC208	Air Canada	Vancouver	Domestic	76	73
6	AC3518	Canadian	Los Angeles	International	100	68
7	AC3664	Canadian	Vancouver	Domestic	52	49
8	AC3692	Canadian	Vancouver	Domestic	84	79
9	AC3901	Canadian	Ottawa	Domestic	60	51
10	AC3963	Canadian	Toronto	Domestic	52	37
11	AC8383	Canadian	Edmonton	Domestic	18	13
12	AC845	Air Canada	Frankfurt	International	156	182
13	AC8455	Canadian	Edmonton	Domestic	39	35
14	AC8457	Canadian	Winnipeg	Domestic	29	29
15	CMM692	Canada 3000	Las Vegas	International	200	360
16	UA1648	United	SFO	International	64	68
17	WJ15	WestJet	Saskatoon	Domestic	95	102
18	WJ23	WestJet	Regina	Domestic	39	42
19	WJ81	WestJet	Abbotsford	Domestic	82	91

a. Name of Airport = YYC

Flights Observed in Toronto

Description of Observed Flights

	Flight Number	Airline	Flight Origin	Type of Flight	Number of Passengers	Number of Checked Bags Removed
1	AC125	Air Canada	Halifax	Domestic	59	23
2	AC3128	Air Canada	Honolulu	International	161	199
3	AC3232	Air Canada	Miami	International	162	87
4	AC3805	Air Canada	Ottawa	Domestic	100	20
5	AC3809	Air Canada	Ottawa	Domestic	100	20
6	AC3845	Air Canada	Ottawa	Domestic	100	18
7	AC3977	Air Canada	Halifax	Domestic	100	20
8	AC405	Air Canada	Montreal	Domestic	115	33
9	AC407	Air Canada	Montreal	Domestic	104	28
10	AC409	Air Canada	Montreal	Domestic	95	37
11	AC411	Air Canada	Montreal	Domestic	100	14
12	AC413	Air Canada	Montreal	Domestic	148	38
13	AC506	Air Canada	Thunder Bay	Domestic	59	41
14	AC544	Air Canada	San Diego	International	57	52
15	AC698	Air Canada	Seattle	International	66	33
16	AC717	Air Canada	NY (JFK or LGA)	International	72	15
17	AC758	Air Canada	San Francisco	International	108	40
18	AC827	Air Canada	NY - LGA	International	46	26
19	AC857	Air Canada	London	International	258	332
20	AC907	Air Canada	Orlando	International	141	139
21	AC947	Air Canada	Bermuda	International	172	207

a. Name of Airport = YYZ

Appendix D – Evaluation of Time Standards

Evaluation of Time Standards for Edmonton

Comparison of Design Time Standards and UPLOS

	Flight Number	Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1	AC167	7.0	Pass	30.000	Fail	C
2	AC1812	12.0	Pass	11.200	Pass	B
3	AC1868	5.0	Pass	5.000	Pass	B-C
4	AC1872	6.0	Pass	8.000	Pass	B
5	AC1874	8.0	Pass	15.000	Pass	D
6	AC1878	3.0	Pass	5.000	Pass	C
7	AC3953	12.0	Pass	15.000	Pass	B
8	AC3973	10.0	Pass	14.500	Pass	C
9	AC8319	6.0	Pass	5.000	Pass	C-D
10	AC8348	5.0	Pass	5.000	Pass	C
11	AC8376	4.0	Pass	6.000	Pass	B
12	AC8390	5.0	Pass	8.000	Pass	B
13	AC8392	1.0	Pass	20.000	Pass	E
14	AC8396	24.0	Pass	40.000	Fail	F
15	AC8454	1.0	Pass	10.000	Pass	B-C
16	AC8456	1.0	Pass	2.000	Pass	C
17	AC8460	4.0	Pass	20.000	Pass	C
18	AC8952	-2.0	Pass	1.000	Pass	D
19	CMM654	3.0	Pass	10.000	Pass	B
20	CO6019	7.0	Pass	6.800	Pass	A
21	NV952	-2.0	Pass	.000	Pass	B
22	WJ42	12.0	Pass	22.100	Fail	D
23	WJ46	7.0	Pass	23.000	Fail	B
Total	Minimum	-2.0		.000		A
	Maximum	24.0		40.000		F
	Mean	6.043		12.28696		

a. Name of Airport = YEG

Evaluation of Time Standards for Ottawa

Comparison of Design Time Standards and UPLOS

		Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1		AC054	30.0	Fail	15.000	C
2		AC060	7.0	Pass	10.000	B-C
3		AC1360	2.0	Pass	1.000	C
4		AC440	4.0	Pass	20.000	B
5		AC456	17.0	Pass	29.500	D
6		AC458	34.0	Fail	17.250	C-D
7		AC613	16.0	Pass	14.600	C
8		AC619	35.0	Fail	25.000	D
9		AC8861	5.0	Pass	.500	B
10		MM707	29.0	Fail	27.000	C
11		QN849	4.0	Pass	2.000	B
12		WJ072	.	*	19.800	C
13		WJ110	4.0	Pass	4.500	A
Total	Minimum	2.0		.500		A
	Maximum	35.0		29.500		D
	Mean	15.583		14.31923		

a. Name of Airport = YOW

* - Indicates that the time of arrival of the last item of baggage could not be recorded

Evaluation of Time Standards for Thunder Bay

Comparison of Design Time Standards and UPLOS

		Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1	AC3704	4.0	Pass	7.500	Pass	B-C
2	AC3706	1.0	Pass	10.000	Pass	C
3	AC3823	4.0	Pass	8.600	Pass	B
4	AC3827	1.0	Pass	10.000	Pass	B
5	AC3835	5.0	Pass	5.000	Pass	B
6	AC505	5.0	Pass	6.800	Pass	B
7	AC8624	3.0	Pass	3.000	Pass	B-C
8	Bear30	1.0	Pass	2.000	Pass	C
9	Bear34	2.0	Pass	2.000	Pass	B
10	Bear36	2.0	Pass	5.000	Pass	B
11	Bear37	2.0	Pass	14.000	Pass	B-C
12	WJ85	5.0	Pass	8.000	Pass	B
Total	Minimum	1.0		2.000		B
	Maximum	5.0		14.000		C
	Mean	2.917		6.82500		

a. Name of Airport = YQT

Evaluation of Time Standards for Montreal

Comparison of Design Time Standards and UPLOS

		Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1		AA5024	.	7.500	Pass	C
2		AA5033	.	10.000	Pass	B
3		AC066	.	45.000	Fail	D
4		AC402	.	20.000	Pass	C
5		AC404	.	19.500	Pass	C
6		AC406	18.0	15.000	Pass	C
7		AC432	5.0	10.000	Pass	C
8		AC611	.	8.000	Pass	D
9		AC747	.	15.000	Pass	C
10		AC795	.	5.000	Pass	C
11		AC8709	.	8.500	Pass	C
12		AC871	.	52.000	Fail	C
13		AF344	44.0	33.000	Fail	C
14		CO4148	.	15.000	Pass	D
15		DL6067	.	7.000	Pass	C
16		GX1374	.	5.000	Pass	B-C
17		MM377	6.0	5.000	Pass	B
18		OK108	.	25.000	Fail	C
19		QK8707	.	15.000	Pass	D
20		SR134	23.0	27.500	Fail	B
Total		Minimum	5.0	5.000		B
		Maximum	44.0	52.000		D
		Mean	19.200	17.40000		

a. Name of Airport = YUL

* - Indicates that the time of arrival of the last item of baggage could not be recorded

Evaluation of Time Standards for Calgary

Comparison of Design Time Standards and UPLOS

	Flight Number	Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1	424	45.0	Fail	50.000	Fail	D
2	AA2081	10.0	Pass	15.800	Pass	C
3	AA829	5.0	Pass	15.000	Pass	C
4	AC107	.	*	7.500	Pass	C
5	AC208	.	*	20.000	Pass	C
6	AC3518	7.0	Pass	15.000	Pass	B
7	AC3664	4.0	Pass	10.000	Pass	B
8	AC3692	10.0	Pass	10.000	Pass	B
9	AC3901	.	*	12.100	Pass	B
10	AC3963	4.0	Pass	10.000	Pass	B
11	AC8383	3.0	Pass	2.000	Pass	A-B
12	AC845	15.0	Pass	15.000	Pass	B-C
13	AC8455	4.0	Pass	10.000	Pass	A-B
14	AC8457	2.0	Pass	10.000	Pass	A-B
15	CMM692	20.0	Pass	24.500	Fail	D
16	UA1648	7.0	Pass	15.000	Pass	B
17	WJ15	.	*	15.000	Pass	C
18	WJ23	7.0	Pass	10.000	Pass	A
19	WJ81	3.0	Pass	5.000	Pass	B
Total	Minimum	2.0		2.000		A
	Maximum	45.0		50.000		D
	Mean	9.733		14.31053		

a. Name of Airport = YYC

* - Indicates that the time of arrival of the last item of baggage could not be recorded

Evaluation of Time Standards for Toronto

Comparison of Design Time Standards and UPLOS

	Flight Number	Time between Arrival of First Passenger and Last Bag (minutes)	Design Standard - Maximum 25 minutes	Time when 90% of Passengers were Served	IATA Design Standard (90% Passengers Served Within 20 minutes)	Median UPLOS Value
1	AC125	.	*	14.400	Pass	D
2	AC3128	.	*	20.000	Pass	C
3	AC3232	24.0	Pass	22.500	Fail	D
4	AC3805	.	*	5.000	Pass	C
5	AC3809	.	*	10.000	Pass	C-D
6	AC3845	4.0	Pass	5.000	Pass	B-C
7	AC3977	.	*	30.000	Fail	C
8	AC405	.	*	12.100	Pass	D
9	AC407	11.0	Pass	14.200	Pass	D
10	AC409	.	*	14.000	Pass	C
11	AC411	.	*	15.000	Pass	C
12	AC413	.	*	19.500	Pass	C
13	AC506	.	*	10.000	Pass	B
14	AC544	.	*	15.000	Pass	B
15	AC698	.	*	10.000	Pass	D
16	AC717	.	*	20.000	Pass	C-D
17	AC758	.	*	15.000	Pass	C
18	AC827	.	*	15.000	Pass	C
19	AC857	.	*	26.000	Fail	C
20	AC907	17.0	Pass	15.000	Pass	C
21	AC947	.	*	25.000	Fail	C
Total	Minimum	4.0		5.000		B
	Maximum	24.0		30.000		D
	Mean	14.000		15.84286		

a. Name of Airport = YYZ

* - Indicates that the time of arrival of the last item of baggage could not be recorded

Appendix E – Evaluation of Space Standards

Evaluation of Space Standards for Edmonton
Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aéroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	AC167	.9	Pass	5.4	Pass	Pass	A	A	C
2	AC1812	.6	Pass	6.0	Pass	Pass	A	A	B
3	AC1868	.3	Pass	15.8	Pass	Pass	A	A	B-C
4	AC1872	.5	Pass	9.5	Pass	Pass	A	A	B
5	AC1874	1.0	Pass	5.0	Pass	Pass	A	A	D
6	AC1878	.3	Pass	17.2	Pass	Pass	A	A	C
7	AC3953	1.4	Pass	3.1	Pass	Pass	A	A	B
8	AC3973	1.7	Pass	2.9	Pass	Pass	A	A	C
9	AC8319	.4	Pass	12.6	Pass	Pass	A	A	C-D
10	AC8348	.0	Pass	189.0	Pass	Pass	A	A	C
11	AC8376	.5	Pass	9.5	Pass	Pass	A	A	B
12	AC8390	.4	Pass	11.4	Pass	Pass	A	A	B
13	AC8392	.1	Pass	47.3	Pass	Pass	A	A	E
14	AC8396	.3	Pass	18.9	Pass	Pass	A	A	F
15	AC8454	.3	Pass	17.2	Pass	Pass	A	A	B-C
16	AC8456	.2	Pass	31.5	Pass	Pass	A	A	C
17	AC8460	.3	Pass	13.2	Pass	Pass	A	A	C
18	AC8952	.1	Pass	42.9	Pass	Pass	A	A	D
19	CMM654	.2	Pass	19.3	Pass	Pass	A	A	B
20	CO6019	.2	Pass	19.3	Pass	Pass	A	A	A
21	NV952	.1	Pass	42.9	Pass	Pass	A	A	B
22	WJ42	1.3	Pass	3.0	Pass	Pass	A	A	D
23	WJ46	1.3	Pass	3.5	Pass	Pass	A	A	B
Total		1.7		189.0			A	A	A
	Minimum	.0		2.9			A	A	F
	Maximum	1.7		189.0			A	A	
	Mean	.523		23.759			A	A	

a. Name of Airport = YEG

Evaluation of Space Standards for Ottawa

Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aeroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	AC054	3.8	Pass	1.1	Pass	Fail	F	D	C
2	AC060	.4	Pass	10.1	Pass	Pass	A	A	B-C
3	AC1360	.2	Pass	16.8	Pass	Pass	A	A	C
4	AC440	.3	Pass	12.6	Pass	Pass	A	A	B
5	AC456	3.2	Pass	1.3	Pass	Pass	E	C	D
6	AC458	3.8	Pass	1.1	Pass	Fail	F	D	C-D
7	AC613	.8	Pass	5.1	Pass	Pass	A	A	C
8	AC619	3.8	Pass	1.1	Pass	Fail	F	D	D
9	AC8861	.2	Pass	18.9	Pass	Pass	A	A	B
10	MM707	3.1	Pass	1.2	Pass	Fail	E	C	C
11	QN849	.3	Pass	11.5	Pass	Pass	A	A	B
12	WJ072	2.6	Pass	2.2	Pass	Pass	A	A	C
13	WJ110	.3	Pass	12.5	Pass	Pass	A	A	A
		.2		1.1			A	A	A
Total		3.8		18.9			F	D	D
Minimum									
Maximum									
Mean		1.756		7.348					

a. Name of Airport = YOW

Evaluation of Space Standards for Thunder Bay
Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aeroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	AC3704	.6	Pass	4.4	Pass	Pass	A	A	B-C
2	AC3706	.1	Pass	21.0	Pass	Pass	A	A	C
3	AC3823	.7	Pass	4.0	Pass	Pass	A	A	B
4	AC3827	.3	Pass	8.7	Pass	Pass	A	A	B
5	AC3835	.7	Pass	4.2	Pass	Pass	A	A	B
6	AC505	.9	Pass	3.3	Pass	Pass	A	A	B
7	AC8624	1.3	Pass	2.1	Pass	Pass	A	A	B-C
8	Bear30	.1	Pass	21.0	Pass	Pass	A	A	C
9	Bear34	.6	Pass	4.4	Pass	Pass	A	A	B
10	Bear36	.3	Pass	8.7	Pass	Pass	A	A	B
11	Bear37	.6	Pass	4.4	Pass	Pass	A	A	B-C
12	WJ85	1.1	Pass	2.6	Pass	Pass	A	A	B
Total		.1	Pass	2.1	Pass	Pass	A	A	B
Minimum		1.3		21.0			A	A	C
Maximum		.626		7.394					
Mean									

a. Name of Airport = YQT

Evaluation of Space Standards for Montreal
Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aeroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	AA5024	.1	Pass	73.5	Pass	Pass	A	A	C
2	AA5033	.3	Pass	14.7	Pass	Pass	A	A	B
3	AC066	1.0	Pass	2.4	Pass	Pass	A	A	D
4	AC402	1.3	Pass	1.7	Pass	Pass	C	A	C
5	AC404	1.1	Pass	2.2	Pass	Pass	A	A	C
6	AC406	1.4	Pass	1.7	Pass	Pass	C	A	C
7	AC432	.7	Pass	3.6	Pass	Pass	A	A	C
8	AC611	.5	Pass	4.7	Pass	Pass	A	A	D
9	AC747	.6	Pass	8.0	Pass	Pass	A	A	C
10	AC795	.6	Pass	8.0	Pass	Pass	A	A	C
11	AC8709	.2	Pass	15.3	Pass	Pass	A	A	C
12	AC871	1.8	Pass	2.5	Pass	Fail	A	A	C
13	AF344	2.0	Pass	2.3	Pass	Fail	A	A	C
14	CO4148	.3	Pass	14.7	Pass	Pass	A	A	D
15	DL6067	.1	Pass	37.3	Pass	Pass	A	A	C
16	GX1374	1.0	Pass	2.4	Pass	Pass	A	A	B-C
17	MM377	.3	Pass	10.5	Pass	Pass	A	A	B
18	OK108	1.4	Pass	3.3	Pass	Pass	A	A	C
19	QK8707	.2	Pass	12.2	Pass	Pass	A	A	D
20	SR134	1.5	Pass	3.0	Pass	Fail	A	A	B
Total		.813		73.5			A	A	B
	Minimum	2.0		1.7			C	A	D
	Maximum								
	Mean								

a. Name of Airport = YUL

Evaluation of Space Standards for Calgary
Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aéroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	424	5.1	Fail	1.1	Pass	Fail	F	D	D
2	AA2081	1.5	Pass	3.5	Pass	Pass	A	A	C
3	AA829	.7	Pass	7.9	Pass	Pass	A	A	C
4	AC107	.3	Pass	19.4	Pass	Pass	A	A	C
5	AC208	.5	Pass	9.8	Pass	Pass	A	A	C
6	AC3518	.9	Pass	6.0	Pass	Pass	A	A	B
7	AC3664	.3	Pass	15.7	Pass	Pass	A	A	B
8	AC3692	.9	Pass	5.9	Pass	Pass	A	A	B
9	AC3901	.6	Pass	8.7	Pass	Pass	A	A	B
10	AC3963	.4	Pass	12.3	Pass	Pass	A	A	B
11	AC8383	.1	Pass	58.8	Pass	Pass	A	A	A-B
12	AC845	1.5	Pass	3.5	Pass	Pass	A	A	B-C
13	AC8455	.2	Pass	21.4	Pass	Pass	A	A	A-B
14	AC8457	.1	Pass	33.9	Pass	Pass	A	A	A-B
15	CMM692	3.7	Pass	1.4	Pass	Fail	D	B	D
16	UA1648	.9	Pass	6.1	Pass	Pass	A	A	B
17	WJ15	1.4	Pass	2.4	Pass	Pass	A	A	C
18	WJ23	.8	Pass	4.3	Pass	Pass	A	A	A
19	WJ81	1.1	Pass	3.0	Pass	Pass	A	A	B
Total									
Minimum				1.1			A	A	A
Maximum				58.8			F	D	D
Mean		1.100		11.851					

a. Name of Airport = YYC

Evaluation of Space Standards for Toronto

Comparison of Design and Operational Space Standards to UPLOS

	Flight Number	Passengers/ metre of frontage	Aéroports de Paris Design Standard (passengers/ metre)	Square metres/ passenger	IATA Design Standard (square metres/ passenger)	BAA Design Standard (square metres/ passenger)	IATA Operational Standard (square metres/ passenger) LOS	TC Operational Standard (square metres/ passenger) LOS	Median UPLOS Value
1	AC125	.7	Pass	5.5	Pass	Pass	A	A	D
2	AC3128	2.2	Pass	2.0	Pass	Fail	A	A	C
3	AC3232	2.3	Pass	1.7	Pass	Fail	C	A	D
4	AC3805	.4	Pass	14.6	Pass	Pass	A	A	C
5	AC3809	.3	Pass	21.9	Pass	Pass	A	A	C-D
6	AC3845	.2	Pass	29.2	Pass	Pass	A	A	B-C
7	AC3977	1.2	Pass	3.3	Pass	Pass	A	A	C
8	AC405	.9	Pass	4.1	Pass	Pass	A	A	D
9	AC407	.8	Pass	4.7	Pass	Pass	A	A	D
10	AC409	.8	Pass	4.5	Pass	Pass	A	A	C
11	AC411	.5	Pass	7.2	Pass	Pass	A	A	C
12	AC413	.6	Pass	6.8	Pass	Pass	A	A	C
13	AC506	.9	Pass	5.5	Pass	Pass	A	A	C
14	AC544	.6	Pass	6.1	Pass	Pass	A	A	B
15	AC698	.5	Pass	8.3	Pass	Pass	A	A	B
16	AC717	.4	Pass	9.6	Pass	Pass	A	A	D
17	AC758	1.2	Pass	3.5	Pass	Pass	A	A	C-D
18	AC827	.6	Pass	7.0	Pass	Pass	A	A	C
19	AC857	3.9	Pass	.9	Fail	Fail	F	E	C
20	AC907	1.1	Pass	3.4	Pass	Pass	A	A	C
21	AC947	3.2	Pass	1.0	Fail	Fail	F	D	C
Total		.2		.9			A	A	C
Minimum		3.9		29.2			F	E	B
Maximum		1.117		7.169			F	E	D
Mean									

a. Name of Airport = YYZ

Appendix F – Baggage Delivery Times

Baggage Delivery Times for Edmonton Airport

Summary of Baggage Delivery Times and Standards

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	AC167	11	13	5	Pass	Pass	C
2	AC1812	14	16	10	Fail	Pass	B
3	AC1868	9	10	4	Pass	Pass	B-C
4	AC1872	5	9	2	Pass	Pass	B
5	AC1874	8	11	5	Pass	Pass	D
6	AC1878	3	4	2	Pass	Pass	C
7	AC3953	11	18	5	Fail	Pass	B
8	AC3973	10	16	4	Fail	Pass	C
9	AC8319	17	18	5	Fail	Pass	C-D
10	AC8348	10	11	4	Pass	Pass	C
11	AC8376	7	9	2	Pass	Pass	B
12	AC8390	9	10	4	Pass	Pass	B
13	AC8392	6	6	1	Pass	Pass	E
14	AC8396	31	32	23	Fail	Fail	F
15	AC8454	4	5	0	Pass	Pass	B-C
16	AC8456	6	7	0	Pass	Pass	C
17	AC8460	9	10	3	Pass	Pass	C
18	AC8952	8	9	-3	Pass	Pass	D
19	CMM654	12	16	-1	Fail	Pass	B
20	CO6019	9	11	5	Pass	Pass	A
21	NV952	8	9	-3	Pass	Pass	B
22	WJ42	17	18	11	Fail	Pass	D
23	WJ46	13	15	5	Pass	Pass	B
		3	4	-3			
		31	32	23			
Total		10.30	12.30	4.04			F
Minimum							
Maximum							
Mean							

* - Indicates that the time of arrival of the last item of baggage could not be recorded.

a. Name of Airport = YEG

Baggage Delivery Times for Ottawa Airport

Summary of Baggage Delivery Times and Standards

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	AC054	8	31	7	Fail	Fail	C
2	AC060	10	12	5	Pass	Pass	B-C
3	AC1360	6	7	1	Pass	Pass	C
4	AC440	10	11	3	Pass	Pass	B
5	AC456	11	23	5	Fail	Pass	D
6	AC458	15	38	11	Fail	Fail	C-D
7	AC613	14	19	11	Fail	Pass	C
8	AC619	14	37	12	Fail	Fail	D
9	AC8861	14	15	4	Pass	Pass	B
10	MM707	10	32	7	Fail	Fail	C
11	QN849	9	10	3	Pass	Pass	B
12	WJ072	12	6	7	Pass	Pass	C
13	WJ110	4	6	2	Pass	Pass	A
Total		10.54	20.08	6.00	Pass	Pass	A
	Minimum						A
	Maximum						A
	Mean						D

* - indicates that the time of arrival of the last item of baggage could not be recorded.

a. Name of Airport = YOW

Baggage Delivery Times for Thunder Bay Airport

Summary of Baggage Delivery Times and Standards

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	AC3704	14	15	3	Pass	Pass	B-C
2	AC3706	12	13	0	Pass	Pass	C
3	AC3823	10	12	2	Pass	Pass	B
4	AC3827	4	5	0	Pass	Pass	B
5	AC3835	12	14	3	Pass	Pass	B
6	AC505	11	13	3	Pass	Pass	B
7	AC8624	10	11	2	Pass	Pass	B-C
8	Bear30	10	10	1	Pass	Pass	C
9	Bear34	12	13	1	Pass	Pass	B
10	Bear36	10	11	1	Pass	Pass	B
11	Bear37	10	11	1	Pass	Pass	B-C
12	WJ85	11	14	2	Pass	Pass	B
Total		4	5	0	Pass	Pass	B
Minimum		14	15	3			C
Maximum		10.50	11.83	1.58			
Mean							

* - indicates that the time of arrival of the last item of baggage could not be recorded.

a. Name of Airport = YQT

Baggage Delivery Times for Montreal's Dorval Airport

Summary of Baggage Delivery Times and Standard

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	AA5024	12		-4	.	.	C
2	AA5033	12		3	.	.	B
3	AC066	22		12	.	.	D
4	AC402	20		7	.	.	C
5	AC404	22		2	.	.	C
6	AC406	13		5	Fail	Pass	C
7	AC432	15	26	1	Fail	Pass	C
8	AC611	14	19	7	.	.	D
9	AC747	12		0	.	.	C
10	AC795	14		0	.	.	C
11	AC8709	9		4	.	.	C
12	AC871	16		3	.	.	C
13	AF344	19	59	4	Fail	Fail	C
14	CO414B	11		1	.	.	D
15	DL6067	17		6	.	.	C
16	GX1374	20		10	.	.	B-C
17	MM377	13	19	0	Fail	Pass	B
18	OK108	16		1	.	.	C
19	QK8707	11		2	.	.	D
20	SR134	9	34	-2	Fail	Fail	B
Total		9	19	-4			B
Minimum		9	19	-4			B
Maximum		22	59	12			D
Mean		14.85	35.20	3.10			

* - Indicates that the time of arrival of the last item of baggage could not be recorded.

a. Name of Airport = YUL

Baggage Delivery Times for Calgary Airport

Summary of Baggage Delivery Times and Standards

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	424	31	56	20	Fail	Fail	D
2	AA2081	15	17	8	Fail	Pass	C
3	AA829	17	18	4	Fail	Pass	C
4	AC107	7		1	.	.	C
5	AC208	7		1	.	.	C
6	AC3518	11	13	5	Pass	Pass	B
7	AC3664	3	3	4	Pass	Pass	B
8	AC3692	12	15	7	Pass	Pass	B
9	AC3901	12		7	.	.	B
10	AC3963	6	8	2	Pass	Pass	B
11	AC8383	12	12	3	Pass	Pass	A-B
12	AC845	11	23	3	Fail	Pass	B-C
13	AC8455	13	13	4	Pass	Pass	A-B
14	AC8457	2	2	2	Pass	Pass	A-B
15	CMM692	17	23	14	Fail	Pass	D
16	UA1648	10	12	5	Pass	Pass	B
17	WJ15	5		3	.	.	C
18	WJ23	7	9	5	Pass	Pass	A
19	WJ81	5	7	1	Pass	Pass	B
		2	2	1			A
Total		31	56	20			D
Minimum		10.68	15.40	5.21			
Maximum							
Mean							

* - indicates that the time of arrival of the last item of baggage could not be recorded.

a. Name of Airport = YYC

Baggage Delivery Times for Toronto Airport **Summary of Baggage Delivery Times and Standards**

	Flight Number	Time between Arrival of Aircraft and Arrival of First Bag (minutes)	Time between Arrival of Aircraft and Arrival of Last Bag (minutes)	Time between Arrival of First Passenger and First Bag (minutes)	Baggage Delivery Standard - last bag less than 15 minutes	Baggage Delivery Standard - last bag less than 30 minutes	Median UPLOS Value
1	AC125	19		10	.	.	D
2	AC3128	15		8	.	.	C
3	AC3232	21	35	10	Pass	Fail	D
4	AC3805	12		4	.	.	C
5	AC3809	13		8	.	.	C-D
6	AC3845	12	12	4	Pass	Pass	B-C
7	AC3977	19		6	.	.	C
8	AC405	12		7	.	.	D
9	AC407	16	19	8	Fail	Pass	D
10	AC409	13		7	.	.	C
11	AC411	13		5	.	.	C
12	AC413	13		6	.	.	C
13	AC506	11		3	.	.	B
14	AC544	16		9	.	.	B
15	AC698	17		7	.	.	D
16	AC717	9		0	.	.	C-D
17	AC758	17		8	.	.	C
18	AC827	14		5	.	.	C
19	AC857	15		8	.	.	C
20	AC907	15	24	8	Fail	Pass	C
21	AC947	25		18	.	.	C
Total		9	12	0			B
Minimum		25	35	18			D
Maximum		15.10	22.50	7.10			
Mean							

* - Indicates that the time of arrival of the last item of baggage could not be recorded.
a. Name of Airport = YYZ

Appendix G – Supplementary Regression Analysis Details

Part:

**A - Description of Statistics Calculated During SPSS
Procedures**

B – Identifying Outliers

**C - Descriptions of Variables used for the SPSS
Software Analysis, and**

**D – Summary of Regression Equations for Specific
Aspects of BHS**

A - Description of Statistics Calculated During SPSS

Procedures

Correlation Procedure

The Bivariate Correlations procedure computes Pearson's correlation coefficient, Spearman's rho, and Kendall's tau-b with their significance levels. Correlations measure how variables or rank orders are related. Before calculating a correlation coefficient, the data should be screened for outliers (which can cause misleading results) and evidence of a linear relationship. Pearson's correlation coefficient is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson's correlation coefficient is not an appropriate statistic for measuring their association.

Significance (2-tailed): The probability of obtaining results as extreme as the one observed, and in either direction when the null hypothesis is true. A two-tailed significance level tests a null hypothesis in which the direction of an effect is not specified in advance.

Pearson's coefficient: A measure of linear association between two variables. Values of the correlation coefficient range from -1 to 1. The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships.

Kendall's tau-b coefficient: A non-parametric measure of association for ordinal (low, medium, high) or ranked variables that take ties into account. The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. Possible values range from -1 to 1.

Spearman's coefficient: A non-parametric version of the Pearson correlation coefficient, based on the ranks of the data rather than the actual values. It is appropriate for ordinal data, or for interval data that do not satisfy the normality assumption. Values of the coefficient range from -1 to +1. The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships.

Regression Procedure

Linear Regression

Estimation of the linear relationship between a dependent variable and one or more independent variables. Linear regression estimates the coefficients of the linear equation,

involving one or more independent variables that best predict the value of the dependent variable.

Non-linear Regression

Nonlinear regression is a method of finding a nonlinear model of the relationship between the dependent variable and a set of independent variables. Unlike traditional linear regression, which is restricted to estimating linear models, nonlinear regression can estimate models with arbitrary relationships between independent and dependent variables. This is accomplished using iterative estimation algorithms. Note that this procedure is not necessary for simple polynomial models of the form $Y = A + BX^2$. By defining $W = X^2$, we get a simple linear model, $Y = A + BW$, which can be estimated using traditional methods such as the Linear Regression procedure.

Regression Output: Model Summary

R: The correlation coefficient between the observed and predicted values of the dependent variable. It ranges in value from 0 to 1. A small value indicates that there is little or no linear relationship between the dependent variable and the independent variables. A value of 1 indicates a perfect relationship.

R Squared: Goodness-of-fit measure of a linear model, sometimes called the coefficient of determination. It is the proportion of variation in the dependent variable explained by the regression model. It ranges in value from 0 to 1. Small values indicate that the model does not fit the data well.

Adjusted R squared: The sample R squared tends to optimistically estimate how well the model fits the population. The model usually does not fit the population as well as it fits the sample from which it is derived. Adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model in the population.

Change statistics: Change statistics include R square change, F change, significance F change.

R square change: The change in the R squared statistic that is produced by adding or deleting an independent variable. If the R squared change associated with a variable is large, that means that the variable is a good predictor of the dependent variable.

F change: Statistic used for testing the null hypothesis that inclusion of an additional variable does not result in a significant increase in R squared.

df1, df2: The degrees of freedom associated with calculating F Change. df1 is the numerator degrees of freedom and df2 is the denominator degrees of freedom.

Significance F change: If the significance of F change is small (smaller than say 0.05) then the null hypothesis that inclusion of an additional variable does not result in a significant increase in R squared is rejected.

Regression Output: ANOVA – Analysis of variables

df: Value associated with a test statistic that is used in determining the observed significance level.

S_{xy} is the numerator of the sample covariance between two variables X and Y and measures the “extent to which the two variables act alike” (Younger 1979).

Mean squares: The sum of squares divided by the degrees of freedom.

F: The ratio of two mean squares. When the F value is large and the significance level is small (typically smaller than 0.05 or 0.01) the null hypothesis can be rejected. In other words, a small significance level indicates that the results probably are not due to random chance.

Sig.: The conditional probability that a relationship as strong as the one observed in the data would be present, if the null hypothesis were true. It is often called the p-value. Typically a value of less than 0.05 is considered significant.

Regression Output: Coefficients Table

Unstandardized coefficients: Displays the regression coefficients with their standard errors.

B: Regression coefficients used to compute the regression equation.

Std. Error: A measure of how much the value of a test statistic varies from sample to sample. It is the standard deviation of the sampling distribution for a statistic. For example, the standard error of the mean is the standard deviation of the sample means.

Standardized coefficients: Beta coefficients, sometimes called standardized regression coefficients, are the regression coefficients when all variables are expressed in standardized (z-score) form. Transforming the independent variables to standardized form makes the coefficients more comparable since they are all in the same units of measure.

t: Statistic used to test the null hypothesis that there is no linear relationship between a dependent variable and an independent variable or, in other words, that a regression coefficient is equal to 0. When the significance level is small (less than 0.10) the coefficient is considered significant.

B – Identifying Outliers

For boxplots and stem-and-leaf plots, outliers were defined as any point that was more than 1.5 times the interquartile range below the twenty-fifth percentile or above the seventy-fifth percentile. Following regression analysis, outliers were considered as any cases that resulted in a predicted dependent variable more than three standard deviations away from the mean.

Prior to the regression analysis, bivariate scatterplots of independent variables against the dependent variables were used to identify some outliers (Figure 1, which follows).

Following the initial regression analysis, outliers among the independent variables and cases that greatly influenced the regression model constant and coefficient values were identified with partial residual plots (Figure 2), leverage values, DfFit values and DfBeta values. Leverage values were used to identify independent variable outliers (Figure 3).

Their calculation was based on the distance between each case and the mean of all other cases. Only independent variables were considered, while the dependent variable was disregarded. Rules of thumb for leverage values suggest that values less than 0.2 are safe, values between 0.2 and 0.5 are risky, and values above 0.5 should be avoided. Measures of influence, such as Cook's distance and DfBeta and DfFit values, were used to identify cases that greatly influenced the constant and coefficients of the regression model.

Cook's distance is a measure of the change in the regression coefficients if the i^{th} case is ignored. DfFit values also measure the influence of each case on the estimates of the

regression coefficients, however, unlike Cook's distance, the DfFit values can be both positive and negative (Figure 4). DfBeta values measure the influence of the i^{th} case on the estimate of each regression coefficient (Figure 5). Thus, each case has one value for Cook's distance, one DfFit value, and n DfBeta values, where n indicates the number of independent variables in the regression model. Plots of Cook's distance, DfFit values and DfBeta values were used to identify values that stood apart from the others.

Figure 1: Typical Scatterplot - Perceived Waiting Time versus Rating of Waiting Time

Figure 2: Typical Partial Residual Plot

Figure 3: Typical Plot of Leverage Values Labeled by Cook's Distance

Figure 4: Typical Plot of DfFit Values

Figure 5: Typical Plot of DfBeta Values

C - Descriptions of Variables used for the SPSS Software

Analysis

The variables used in the analysis were each identified with a *name*, *label*, *type*, *measure*, and *value*. The variable *name* is used to identify the variable, must begin with a letter, cannot contain blanks and can contain a maximum of eight letters. The variable *label* is a description of the variable using up to 255 characters, since the 8 digit *name* is not always enough to identify what the variable actually is. The variable *type* can be defined as numeric, string or date. A *level of measurement* or *measure* is specified for all variables and is used to identify variables as either scale or categorical (includes nominal and ordinal) variables during some chart procedures. Thus, the *level of measurement* can be specified as scale, nominal, or ordinal. The measurement level of scale describes numeric data such as the number of conveyors or the annual passenger levels. The ordinal measurement describes numeric or string data that has an order such as low, medium and high. The numeric data would represent distinct value categories such as 1 = low, 2 = medium, and 3 = high. The nominal measurement level represents data with no specific order, such as 1 = male and 2 = female. Thus, variables of the numeric type can have a level of measurement of scale, ordinal or nominal. Variables of the string type can have a level of measurement of either nominal or ordinal. (Variables of the type 'date' define their measure as 'date' as well.) The *value* of a variable should be defined when the data entered for a variable represents distinct categories, such as described above by 1 = low,

2 = medium, and 3 = high. The user enters the numeric value (e.g. 1) and the SPSS software converts the numeric value to the appropriate category (e.g. low). A combination of the above data types were used to describe the questionnaire responses, the flight specific variables and the airport specific variables.

Variable Name	Variable Type	Variable Measure	Variable Label (Description)	Variable Value
AGERANGE	numeric	ordinal	Age range of passenger	1 = under 25 years, 2 = 25 to 39 years, 3 = 40 to 60 years, 4 = over 60 years
AIRLINE	string	nominal	Airline	
AIRPORT	string	nominal	Name of airport	
AREA2M	numeric	scale	Area (square metres) in which passengers were standing around the conveyor – not including the conveyor belt itself	
AREA2P	numeric	scale	Area (square paces) in which passengers were standing around the conveyor – not including the conveyor belt itself	
AREAM	numeric	scale	Area (square metres) in which passengers were standing around the conveyor – including the conveyor belt itself	
AREAP	numeric	scale	Area (square paces) in which passengers were standing around the conveyor – including the conveyor belt itself	
ARRGATE	string	nominal	Arrival gate number	

BAGDLAY1	numeric	scale	Time difference between arrival of aircraft and arrival of 1st bag
BAGDLAY2	numeric	scale	Time difference between arrival of aircraft and arrival of last bag
BAGONCON	numeric	nominal	Whether bags were already on the conveyor belt at time of arrival 1 = yes, 2 = no
BAGS#	numeric	scale	Total number of bags unloaded from the flight
BUSYDLAY	date	scale	Time between flight arrival and earliest most congested period (i.e. maximum number of occupants)
BUSYPASS	numeric	scale	Maximum number of passengers observed in the reclaim area at the earliest busy time (sec BUSYTIME variable)
BUSYTIME	date	scale	Earliest congested time, The earliest time when the greatest number of people were in the reclaim area.
BZBGDLAY	date	scale	Time between BUSYTIME and arrival of first bag
CHEKBAGS	numeric	ordinal	Number of checked bags
CHFLIGHT	numeric		Type of flight (International or Domestic)

A value of 5 indicates 5 or more bags.
0 = Domestic, 1 = International

CHTIMEWA	numeric	scale	TIMEWAIT with zero values changes to 0.01 so that a log would produce a normal distribution
COMFORT	numeric	ordinal	LOS rating of comfort and safety in baggage reclaim area
COMMENTS	string	nominal	Comments
CONBELT#	numeric	scale	Conveyor belt number
DATE	date	scale	Date
DIFDLAY2	date	scale	Difference between perceived wait and max possible wait (maxwait2-perctime)
DIFDLAY3	date	scale	Difference between perceived waiting time (TIMEWAIT) and maximum possible wait (MAXWAIT3) = MAXWAIT3 - TIMEWAIT.
DIFDLAY	date	scale	Difference between perceived wait and max possible wait (maxiwait-perctime) for YEG
DISTGATE	numeric	scale	Author's measured distance (metres) to walk from the arrival gate to the reclaim conveyor
DOMCONVE	numeric	scale	Number of domestic conveyors at airport
EDGSPACE	numeric	ordinal	LOS rating of space around edge of conveyor

1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable

1 = excellent, 2 = high, 3 = good, 4 =

				adequate, 5 = inadequate, 6 = unacceptable
ESCALATO	numeric	scale	Number of escalators used to travel from arrival gate to reclaim area	
EXPECT	numeric	scale	Time expected to spend waiting for bags at edge of conveyor	
EXPEDLAY	numeric	scale	Time between expected wait and perceived wait (EXPEDLAY = EXPECT - TIMEWAIT)	
FIRSTBAG	date	scale	Time of arrival of first item of baggage on conveyor belt	
FIRSTPAS	date	scale	Time of arrival of first passenger in reclaim area	
FLIGHT#	string	nominal	Flight Number	
FLIGHTY2	numeric	ordinal	Number of flights made by passenger per year	1.5 = 1 to 2 flights, 4 = 3 to 5 flights, 7.5 = 6 to 9 flights, 15 = 10 or more flights
FLIGHTYP	string	nominal	Type of flight (international, U.S., or domestic)	
FLIGHTYR	numeric	ordinal	Number of flights made by passenger per year	1 = 1 to 2 flights, 2 = 3 to 5 flights, 3 = 6 to 9 flights, 4 = 10 or more flights
GATES	numeric	scale	Number of gates	

GENDER01	numeric	nominal	Gender of passenger	0 = male, 1 = female
GETBAG01	numeric	nominal	Whether bag was received	0 = yes, 1 = no
INTLCONV	numeric	scale	Number of international conveyors at airport, includes U.S. conveyors	
LASTBAG	date	scale	Time of arrival of last item of baggage on conveyor belt	
LENGTHM	numeric	scale	Accessible length (in metres) around the conveyor belt	
LENGTHP	numeric	scale	Accessible length (in paces) around the conveyor belt	
LOGTIMEW	numeric	scale	Log of CHTIMEW to check for a linear relationship with LOS1	
LOS1	numeric	scale	Overall LOS rating of BHS scale 0 (U) to 10 (E)	
LOS1RESQ	numeric	scale	LOS1REVI squared for non-linear relation between LOS1 and LOS2	
LOS1REVI	numeric	scale	LOS1 revised by removing 11 outliers, used for the relation btw LOS1 and LOS2	
LOS2	numeric	ordinal	Overall LOS rating of BHS scale excellent, high, good, etc..., unacceptable	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 =

				unacceptable
M2PERPAS	numeric	scale	Meters squared per occupant at most congested period in reclaim area	
MAXIWAIT	date	scale	Time between first passenger arrival and last passenger departure for YEG	
MAXWAIT2	date	scale	Time between first passenger arrival and last bag arrival if lastbag>0	
MAXWAIT3	date	scale	Time between first passenger arrival and last bag arrival (minutes)	
MAXWT1	numeric	scale	Time between 1st passenger to arrive and last passenger to leave as numeric	
MAXWT2	numeric	scale	Time between first passenger arrival and last bag arrival as numeric	
MEANWAIT	numeric	scale	Average waiting time for each flight	
NUMBQUES	numeric	scale	Number of completed and valid questionnaires	
ORIGIN	string	nominal	Flight Origin	
OVRSPACE	numeric	ordinal	LOS rating of overall space in baggage reclaim area	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable

PACEGATE	numeric	scale	Distance in paces to walk from the arrival gate to the reclaim conveyor
PASPERM	numeric	scale	Passengers per metre of frontage along reclaim conveyor (BUSYPASS/AREA2M)
PASS.#	numeric	scale	Total number of passengers on the flight
PAXDLAY1	date	scale	Time between flight arrival and first passenger arrival
PAXPERYR	numeric	scale	1999 passenger levels
PERCTIME	date	scale	Perceived waiting time at conveyor belt as hour/minutes instead of numeric
PURPOSE	numeric	nominal	Trip purpose 1 = business, 2 = pleasure, 3 = pleasure and business, 4 = other
PXBGDLAY	date	scale	Time between arrival of first passenger and arrival of first bag
PXBGDLY2	numeric	scale	Time between arrival of first passenger and arrival of first bag in minutes (numeric)
RENO01AP	numeric	scale	Whether major renovations were undertaken at the airport in past decade 0 = Yes, 1 = No
RENO01CO	numeric	scale	Whether major renovations were undertaken 0 = Yes, 1 = No

around the specific reclaim conveyor in past decade			
RENOVATI	numeric	scale	Whether renovation was recently undertaken 1 = Yes, 2 = No
SEATING	numeric	ordinal	LOS rating of number of seats in baggage reclaim area 1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable
SEATPERS	numeric	scale	Number of seats per person in the immediate vicinity of the conveyor at the most congested period
SEATS#	numeric	scale	Number of seats in the immediate vicinity of the conveyor
SIZE	numeric	scale	Size of airport 1 = Small, 2 = Medium, 3 = Large
SQRTTIMW	numeric	scale	Square root of CHTIMEW to check for a linear relationship with LOS1
STDVWAIT	numeric	scale	Standard deviation for waiting time, by flight
TAIRLINE	string	nominal	Name of airline if passenger transferred from a different airline
TICCLASS	numeric	nominal	Ticket class 1 = business, 2 = economy
TIME	date	scale	Actual recorded flight arrival time, time when

				aircraft stopped at arrival gate, recorded by airline or traffic controller	
TIMEARR	numeric	scale		Perceived time to travel from the arrival gate to the conveyor belt (minutes)+E92	
TIMEDLAY	numeric	scale		Time between respondents perceived walking time and author's measured walking time	
TIMEGATE	numeric	scale		Author's measured time (minutes) to walk from the arrival gate to the reclaim conveyor	
TIMEWAIT	numeric	scale		Respondents perceived time spent waiting to collect bags at edge of conveyor (minutes)	
TLASTPAX	date	scale		Time that the last passenger left the reclaim area	
TRANSFER	numeric	nominal		Whether any transfers were made	1 = yes, 2 = no
TRANSFR#	numeric	scale		Number of transfers made by the passenger during the current trip	
UPLOS	numeric	ordinal		Overall User-Perceived LOS of BHS	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable
WAIT90	numeric	scale		Time with which 90% of the people waited less than (minutes)	

WAITTIME	numeric	ordinal	LOS rating of waiting time at conveyor	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable
WALKDIST	numeric	ordinal	LOS rating of walking distance between gate and conveyor	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable
WALKTIME	numeric	ordinal	LOS rating of walking time between gate and conveyor	1 = excellent, 2 = high, 3 = good, 4 = adequate, 5 = inadequate, 6 = unacceptable
WEEKDAY	string	nominal	Day of week	

D – Summary of Regression Equations for the Ratings of Specific Aspects of BHS

Rating for Walking Time (WALKTIME)

$$R^2 = 0.215$$

$$p\text{-value} = 0.0005$$

$$WALKTIME = 1.515 + 0.005233(DISTGATE) + 0.04693(TIMEARR)$$

When looking at WALKTIME by age group:

Age Category	R^2
Under 25 years of age	0.219
25 to 39	0.251
40 to 60	0.225
Over 60	0.102

Rating for Walking Distance (WALKDIST)

$$R^2 = 0.247$$

$$p\text{-value} = 0.016$$

$$WALKDIST = 0.955 + 0.006712(DISTGATE) + 0.04181(TIMEARR) + 0.03167(BUSYDLAY)$$

Table 1: Relationship between Measured Walking Distance (DISTGATE) and Perceived LOS of Walking Distance (WALKDIST)

Airport	R ² by airport	R ² by age group			
		Under 25	25 to 39	40 to 60	Over 60
Edmonton	0.176	0.618	0.169	0.242	0.181
Ottawa	0.146	0.168	0.151	0.184	0.029
Thunder Bay	0.178	0.212	0.125	0.164	
Montreal	0.171	0.598	0.205	0.283	0.001
Calgary	0.069	0.008	0.039	0.121	0.102
Toronto	0.162	0.025	0.180	0.167	0.134

Rating of Waiting Time (WAITTIME)

Aggregate Model:

R² of 0.467

P-value = 0.008

$$WAITTIME = 2.074 + 0.06087(TIMEWAIT) - 0.0448(EXPEDLAY) - 0.238(GENDER01) + 0.04914(PXBGDLAY) + 1.138(GETBAG01) + 0.02114(FLIGHTY2)$$

Disaggregate Model:

R² from 0.275 in Toronto to 0.640 in Ottawa (Table 2).

Thunder Bay:

$$WAITTIME = 0.954 + 0.250(TIMEWAIT)$$

Ottawa:

$$WAITTIME = 1.151 + 0.167(PXBGDLAY) + 0.07809(TIMEWAIT) + 2.202(GETBAG01)$$

Edmonton:

$$WAITTIME = 2.9 - 0.141(EXPEDLAY) - 0.523(GENDER01) + 0.07127(PXBGDLAY)$$

Calgary:

$$WAITTIME = 2.217 - 0.0536(EXPEDLAY) + 0.05664(TIMEWAIT)$$

Montreal:

$$WAITTIME = 2.081 - 0.0519(EXPEDLAY) + 0.05449(TIMEWAIT) + 0.0446(FLIGHTY2)$$

Toronto:

$$WAITTIME = 2.481 - 0.0444(EXPEDLAY) + 0.0733(TIMEWAIT) + 0.03165(FLIGHTY2)$$

Table 2: Significance of the Model Predicting the Rating for Waiting Time

Airport	R ²	Range of Significance for Coefficients
Thunder Bay	0.555	0.000
Ottawa	0.640	0.000
Edmonton	0.538	0.000 to 0.017
Calgary	0.499	0.000 to 0.036
Montreal	0.524	0.000 to 0.011
Toronto	0.275	0.000 to 0.034

Rating of Accessible Conveyor Belt Length

Aggregate:

R^2 of 0.299

$$EDGSPACE = 1.881 + 0.405(PASPERM) + 0.04042(TIMEWAIT) + 0.115(CHEKBAGS)$$

Table 3: Significance of Coefficients for Regression Model Predicting Rating for the Length Along the Conveyor Belt

Variable	Significance of Coefficients $R^2 = 0.299$
Constant	0.000
PASPERM	0.000
TIMEWAIT	0.000
CHEKBAGS	0.048

Disaggregate:

The regression models predicting the rating for the length along the conveyor belt are as follows.

Thunder Bay: $EDGSPACE = 1.881 + 0.07749(TIMEWAIT)$

Ottawa: $EDGSPACE = 1.935 + 0.648(PASPERM)$

Edmonton: $EDGSPACE = 1.779 + 0.665(PASPERM) + 0.04069(TIMEWAIT)$

Montreal: $EDGSPACE = 2.163 + 0.526(PASPERM) + 0.03116(TIMEWAIT)$

Calgary:

$EDGSPACE = 2.965 + 0.282(PASPERM) + 0.05334(TIMEWAIT) - 0.0212(LENGTHM)$

Toronto:

$EDGSPACE = 1.725 + 0.277(PASPERM) + 0.0561(TIMEWAIT) + 0.165(FLIGHTYR)$

Table 4: Significance and R^2 for Regression Model Predicting EDGSPACE

Airport	R^2	Significance of Coefficients
Thunder Bay	0.054	0.000 to 0.033
Ottawa	0.425	0.000
Edmonton	0.191	0.000 to 0.011
Calgary	0.445	0.000 to 0.042
Montreal	0.187	0.000 to 0.005
Toronto	0.184	0.000 to 0.028

Rating for Overall Space

The regression equation has an R^2 of 0.265 and the coefficients are significant at the 0.003 level.

$$OVERSPACE = 1.701 + 0.01059(BUSYPASS) + 0.456(RENO01CO) + 0.165(FLIGHTY2) + 0.164(CHEKBAGS) - 0.0098(LENGTHM)$$

Table 5: Regression Model Coefficient Significance for Rating of Overall Space

Variable	Significance for Coefficient $R^2 = 0.265$
Constant	0.000
BUSYPASS	0.000
RENO01CO	0.000
FLIGHTY2	0.000
CHEKBAGS	0.003
LENGTHM	0.003

Rating for Perception of Comfort and Safety

Aggregate:

P-value = 0.022

R^2 of only 0.166

$$COMFORT = 2.152 + 0.02219(TIMEWAIT) + 0.603(RENO01CO) - 0.0208(SEATS\#) - 0.445(CHFLIGHT) + 0.004271(BUSYPASS) + 0.121(CHEKBAGS)$$

Disaggregate:

Edmonton: $COMFORT = 3.709 - 0.0223(LENGTHM)$

Thunder Bay: $COMFORT = 1.915 + 0.298(CHEKBAGS)$

Ottawa: $COMFORT = 2.466 + 0.296(PASPERM)$

Calgary:

$$COMFORT = 2.540 + 0.006463(PASS\#) - 0.00399(AREA2M) + 0.03298(TIMEWAIT)$$

Montreal: $COMFORT = 3.419 - 0.0309(M2PERPAS)$

Toronto: $COMFORT = 2.288 + 0.241(CHEKBAGS) + 0.05093(TIMEWAIT)$

Table 6: Significance and R^2 for Regression Model Predicting COMFORT

Airport	R^2	Significance of Coefficients
Thunder Bay	0.043	0.000 to 0.050
Ottawa	0.119	0.000
Edmonton	0.133	0.000
Calgary	0.314	0.000 to 0.011
Montreal	0.06	0.000 to 0.007
Toronto	0.101	0.000 to 0.042