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Commuter Aircraft Video Landing Parameter Surveys, Summary Report—London City Airport, Philadelphia International Airport, and Atlantic City International Airport

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16. Abstract

The Federal Aviation Administration (FAA) William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-activity commercial airports. The intent of this research is to develop a better understanding of typical landing contact conditions for a wide variety of aircraft. This information is used to assess the validity of current aircraft certification criteria. This report documents survey results for commuter aircraft.

This report documents the commuter results from surveys conducted at London City Airport (LCY), Philadelphia International Airport (PHL), and Atlantic City International Airport (ACY). The LCY survey was performed in the summer of 1997 and the PHL survey in the summer of 1999. Additional data collected at the FAA ACY facility is also included in this report. Previous survey reports, focused on mainline jet operation, were issued for surveys conducted at John F. Kennedy International Airport (JFK) in June 1994, at Washington National Airport (DCA) in June 1995, and at Honolulu International Airport (HNL) in April 1996. Landing parameters presented herein include sink rate; approach speed; touchdown pitch, roll, and yaw angles and rates; off-center distance; and the touchdown distance from runway threshold. Wind and weather conditions were also recorded. All the data were processed and presented without regard to the airline or flight number.

The results from this survey and the prior landing parameter surveys at JFK, DCA, and HNL differ substantially from aircraft survey results reported 35 years ago during the National Aeronautics and Space Administration (NASA) surveys. No other efforts to collect operational landing data were performed by either the FAA or NASA in the interim.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ACY	Atlantic City International Airport
BAE	British Aerospace
CAA	Civil Aviation Authority
DCA	Washington National Airport
FAA	Federal Aviation Administration
HNL	Honolulu International Airport
ILS	Instrument Landing System
JFK	John F. Kennedy International Airport
LCY	London City Airport
NAALDAS	Naval Aircraft Approach and Landing Data Acquisition System
PHL	Philadelphia International Airport

EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-activity commercial airports. The intent of this research is to develop a better understanding of typical landing contact conditions for a wide variety of aircraft. This information is used to assess the validity of current aircraft certification criteria. This report documents survey results for commuter aircraft.

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1. INTRODUCTION.

The Federal Aviation Administration (FAA) William J. Hughes Technical Center has initiated a series of aircraft video landing parameter surveys at high-activity commercial airports. The purpose of this research was to better understand and document commercial transport aircraft landing impact conditions during actual operations. By collecting and analyzing large quantities of video data for a wide variety of aircraft, the original design criteria and fatigue-life estimates for aircraft landing gear and support structures can be assessed and verified. This operational data collection is also a valuable resource in developing design requirements for future transport aircraft.

The use of image data to characterize the landing performance of aircraft has been used since jet aircraft were introduced. In the late 1950, the U.S. Navy developed a system to characterize the typical aircraft carrier landing environment, which led to the development and implementation of procedures to make carrier-arrested landings safer. In 1967, the U.S. Navy enhanced its data acquisition system by replacing the original 16-mm film cameras with 70-mm film cameras. This provided considerably greater image resolution and consequently greater measurement accuracy [1]. Using these systems, the U.S. Navy conducted over 40 landing parameter surveys and still has an active carrier landing survey program. However, the data reduction phase of the research was labor-intensive and limited the number of surveys that could be conducted with available resources. The search for a new, improved system was concluded in 1992 when the U.S. Navy successfully developed and implemented a system using adaptive video imaging and tracking technology for their surveys. The performance and accuracy of this system is documented in references 2 and 3. Shortly thereafter, the FAA and the U.S. Navy established an interagency agreement to transition this newly developed video technology to characterize commercial operations. The procedures used to analyze commercial landings are documented in reference 4.

The objectives of the ongoing FAA landing parameter survey program were to acquire large amounts of typical transport operational data to (1) validate and update NASA TN D 4529, which was derived from usage data measured during the 1950; (2) provide detailed characterization of typical transport airplane landing touchdown velocities and angular displacements; and (3) determine if there is a trend towards higher sink rates for aircraft of higher gross weights.

The first of this series of commercial aircraft video landing surveys was conducted in 1994 at John F. Kennedy International Airport (JFK), runway 13L. The primary goal of the JFK survey was to confirm the feasibility of using the video system in commercial operation. The other goal of the JFK survey was to collect large quantities of wide-body jet aircraft data. Analysis of the data from JFK indicated the existence of a possible trend of increasing sink speed with increasing aircraft landing weight.

The second survey, performed in 1995 at Washington National Airport (DCA), collected landing parameters for flight operations using a shorter runway. The principle runway (runway 36) at DCA is 7000 ft long and cannot handle aircraft larger than the Airbus A320 and the Boeing 757. The third landing survey was conducted in 1996 at Honolulu International (HNL), runway 8L.

This survey, like the one done at JFK, collected a large number of wide-body aircraft landings for further video analysis. An additional survey, which targeted the collection of landing parameters from Airbus wide-body aircraft, was performed at London's Heathrow Airport in the summer of 2001.

Other surveys in this research program were conducted at London City Airport (LCY) and Philadelphia International Airport (PHL). These surveys were performed in an effort to collect landing data on runways more representative of commuter operations. A limited quantity of commuter data was collected during the initial series of airport surveys, but these small data samples on longer runways are not considered representative of typical commuter operations. LCY with its glide slope of 5.5° is considered an upper bound on the severity of these operations. The LCY survey was performed over a 2-week period in late June into early July 1997. In this survey both ends of the single 3800-foot-long runway (10/28) were used to acquire video image data. Data on more routine operations were collected at PHL from runway 17, which is a 5500-ft runway used primarily for commuter operations. The PHL survey was performed in July 1999. Additional commuter aircraft landing data were collected using the permanent video landing data collection facility at the Atlantic City International Airport (ACY). This facility records data on runway 13, a 10,000-ft runway and the only instrument landing system (ILS)-equipped runway at ACY. The ACY data, primarily Beech 1900 aircraft, was compared to the Beech 1900 aircraft recorded at PHL. Data were collected at ACY through the spring and summer of 2003.

Video images of aircraft landing at LCY were recorded by a series of three cameras temporarily installed on the edge of both ends of the runway. Four cameras were used to record the landings at PHL. Similarly, four cameras were used at ACY. These video images were stored on an optical disk recorder, processed, and analyzed at the Naval Air Warfare Center, and then the resulting landing parameter information was forwarded to the FAA William J. Hughes Technical Center.

Since the primary goal of these surveys was to collect statistical information on actual operations, the identity of individual aircraft, airlines, flight numbers, and dates were purposefully omitted from this report. Aircraft landing performance was analyzed only on the basis of aircraft category, model, type, and wind conditions.

2. SYSTEM DESCRIPTION.

Modern developments in image technology permitted the U.S. Navy to update its landing parameter analysis system from photographic film to video recording. The Navy video system is known as the Naval Aircraft Approach and Landing Data Acquisition System (NAALDAS). The data acquisition portion of the system consists of a high-resolution frame grab video camera, a laser disk recorder, and a computer control unit. The key to the NAALDAS system is a highly modified video camera. The camera's enhanced vertical resolution (double that of standard video formats) permits highly accurate measurement and tracking of aircraft position data. The camera is supported by an image analysis system incorporates image processing technology. Particular image features (landing gear wheels, wing tips, flaps, or engine inlets) are tracked in successive images, and this information is used to determine the relative motion of the aircraft.

The combination of camera resolution and image processing technology permits the location of image features to be determined within 0.1 pixel. This technique is as accurate, yet more efficient, as the U.S. Navy's previously used 70-mm film system.

NAALDAS was designed to cover the restricted touchdown area on an aircraft carrier using a single camera. To support research on commercial aircraft operations, the FAA funded the design and development of a modified, multiple-camera configuration of NAALDAS using a series of video cameras. The cameras are located along the edge of the runway, each covering a different overlapping segment of the expected touchdown area. The images from these cameras are recorded sequentially as the aircraft passes through their field of view. This modification permits the system to cover approximately 2000 ft along the anticipated touchdown region of the runway. Fiber-optic signal cables are used to eliminate interference and line losses between the cameras and the recording station. The modified configuration of NAALDAS was successfully tested in February 1994 at the William J. Hughes Technical Center. Figure 1 shows a camera in operation on a commercial runway.

FIGURE 1. VIDEO CAMERA IN OPERATION DURING COMMERCIAL LANDING PARAMETER SURVEY

At PHL four cameras were used to monitor the anticipated touchdown area. Only one end of the runway was instrumented. The video cameras were installed on the edge of the runway, facing toward the approaching aircraft. The cameras were placed near the runway edge lights. The first PHL camera was located 1000 feet from the threshold, and from that point, the cameras were spaced 400 feet apart. The cameras were aimed at the center of the targeted touchdown area. Figure 2 shows a schematic of the multiple-camera configurations.

The LCY airport survey used six cameras and recorded landings on both ends of the runway. LCY has a 3800-ft runway, and the aircraft followed a 5.5° glide slope to touchdown. These characteristics shorten the expected landing area, thus requiring only three cameras at each end of the runway. The cameras at LCY were located approximately 300 feet apart, starting 697 feet from the end of the runway and usually located in line with the runway edge lights. At LCY, the cameras were located approximately 53 ft off the runway centerline.

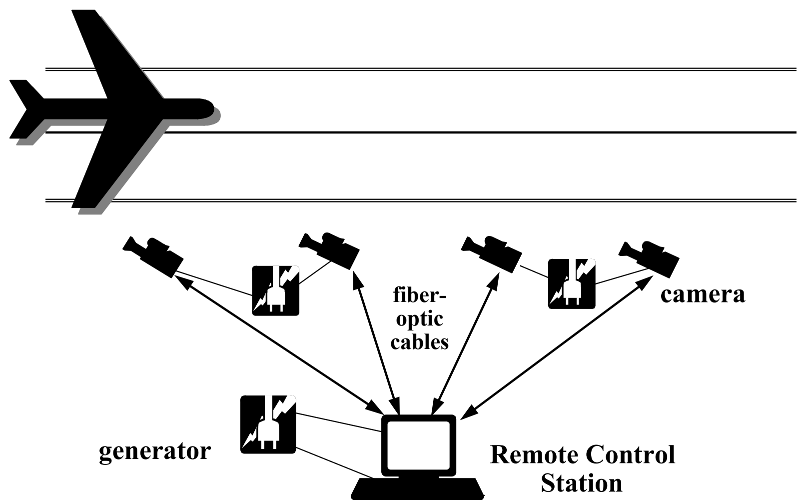


FIGURE 2. FEDERAL AVIATION ADMINISTRATION LANDING LOADS CAMERA SETUP

The NAALDAS video cameras have a fixed field of view. Each camera was aligned and calibrated against targets that were temporarily placed on the runway. The runway must be closed during this procedure. These targets were placed in surveyed locations and in the corners of the camera's field of view. The target images were recorded as a calibration sequence. This sequence was processed to generate a transformation matrix that relates image features to positions on the runway.

The aircraft image was captured on an optical laser disk recorder for subsequent analysis on the NAALDAS analysis system workstation. Approximately 60 landings can be stored on a video disk. An identity number was assigned to the disk, and event numbers were assigned to each video sequence. The use of video disks eliminated film-processing costs and time. The image data were recorded at a rate of 30 frames per second.

Image enhancement and automatic data point tracking were performed using the analysis workstation. This provided position time information of image features on the aircraft. Each individual airplane landing was also identified by model type and serial number so that the necessary physical dimensions and geometric locations could be correlated with the time-tracked video images. The software data reduction system then derived the landing impact parameters, i.e., sinking speed, horizontal velocity, bank angle, yaw angle, etc.

The analysis work station consists of a Sun computer workstation with an image-processing board, laser disk player, computer monitor, high-resolution monitor, and associated power regulator and cables. The station operator automatically tracks the video image features during the landing sequence. Once the image sequence is tracked, the pixel information is transformed, digitized, and entered into the landing parameter analysis software. This software takes image position information, determines the change in image feature position of successive frames, and generates position time curves for the feature.

The analysis of the image data provides the aircraft's closure speed with respect to the camera. The reported value of approach speed is the sum of the closure speed and the component of the wing parallel to the centerline of the runway. The wind speed and direction information, measured using an anemometer situated near the touchdown location, is used to calculate the approach speed.

3. DISCUSSION.

Each of the airports surveyed and reported herein (LCY, PHL, and ACY) have their own constraints and unique operating procedures. The following discussion provides both a flavor of the typical operational characteristics as well as the video landing survey results.

3.1 LONDON CITY AIRPORT.

3.1.1 London City Airport Operations.

LCY is located approximately 6 miles east of the center of London, the United Kingdom. The airport is located in the docklands, on the north side of the Thames river, near the Thames barrier. The airport, which has a single runway and no taxiways, is situated on the King George V dock. The primary activity at the airport is short takeoff and landing commuter operations. The airport connects London with the principle cities in continental Europe, Scotland, and Ireland.

LCY was originally built to accommodate short takeoff and landing aircraft such as the De Havilland Canada DASH 7. The runway at LCY was later extended, allowing the airport to serve more distant destinations with a broader range of aircraft. The runway is still only around 3800 feet in length and because of the surrounding area only aircraft certified to perform approaches at a 5.5° glide path are permitted to land there. There are also special training requirements for the pilots operating into LCY. This nonstandard glide path was one of the reasons LCY was chosen for a video landing parameter survey. It was viewed as representing an extreme operating condition for this category of aircraft. Figure 3 shows a diagram of LCY.

The data collected and analyzed will also be extremely useful in providing operational usage information for an anticipated joint FAA/Civil Aviation Authority (CAA) regulatory publication on performance for aircraft landing on airports requiring steep approaches. Results from this survey should help researchers fill gaps in the CAA and British Aerospace (BAE) technical database.

Video landing survey data acquisition equipment was installed on the north side of runway 10/28 at LCY in 1997. Three cameras were installed at each end of the runway and the data acquisition system was installed in an underground equipment facility located along the north side of the runway near the center point of the runways length. Because of this short runway, the centrally located facility allowed data to be collected from either set of cameras without moving the data acquisition system to accommodate changes in runway operational direction.

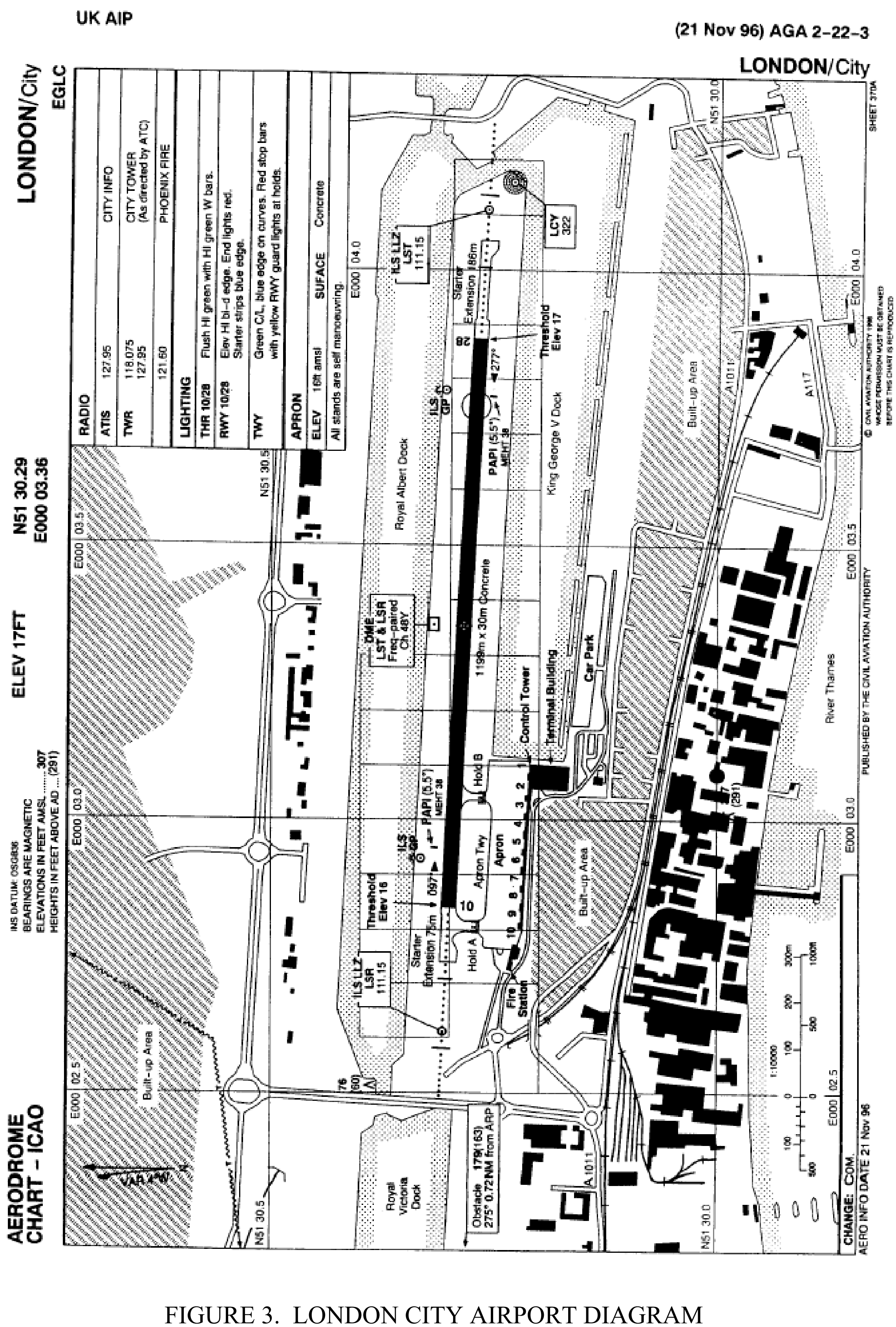


FIGURE 3. LONDON CITY AIRPORT DIAGRAM

Video images from a total of 254 landings at LCY were processed. A total of 144 BAe 146 landings were analyzed, along with 72 Fokker F-50, 23 DeHavilland Canada DHC-8, and 15 landings of other types of aircraft. Because of the unusually rainy weather during the survey, many additional video image recordings were of poor quality and could not be successfully processed.

3.1.2 London City Airport Survey Results.

Landing parameters for 254 commuter transport aircraft landings were calculated using the procedures described in references 1 and 4. Table 1 summarizes the primary landing parameters for the six commuter airplane models covered in this survey. The table provides the mean and standard deviation and the number of observations for selected landing parameters by aircraft model. Figures 4 shows a scatter plot of the relationship between the aircrafts approach speed and sink speed for the most numerous models of surveyed aircraft. As expected, the aircraft with the lowest approach speed had the lowest sink speeds, and the model with the highest approach speed had the highest sink speed.

TABLE 1. SURVEY PARAMETER COMPARISON BY AIRCRAFT MODEL, LCY

Parameters		Aircraft Model					
		Saab 2000	DeHavilland Canada DHC-8	Dornier 328	Fokker 50	Falcon	BAe 146
No. of events		5	23	5	72	5	143
Closure speed (knots)	Mean	116	104	105	93	99	109
	Std. Dev.	7.14	8.51	19.04	7.68	14.05	10.42
Approach speed (knots)	Mean	117	106	108	95	101	111
	Std. Dev.	6.56	8.85	20.53	7.25	14.75	10.58
Sink speed (ft/sec)	Mean	4.1	2.8	2.4	2.3	2.3	3.4
	Std. Dev.	3.12	2.03	1.21	1.45	1.15	1.83
Pitch angle (degrees)	Mean	2.2	6.2	2.9	2.5	6.2	3.2
	Std. Dev.	1.79	1.36	2.27	3.72	2.26	1.84
Roll angle (degrees)	Mean	-1.6	-0.8	-1.9	-1.1	-1	-1.5
	Std. Dev.	2.08	2.42	2.41	2.08	2.69	2.46
Yaw angle (degrees)	Mean	1.6	-3.0	-0.8	-2.5	-4.3	-2.9
	Std. Dev.	8.4	4.73	1.89	4.97	7.43	5.15
Runway off-center dist. (ft)	Mean	-4.1	-1.7	-1.4	-1.9	0.4	-0.8
	Std. Dev.	3.51	3.34	1.6	4.4	7.96	4.44

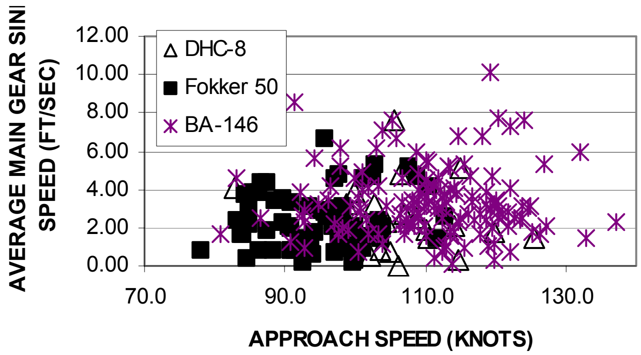


FIGURE 4. LONDON CITY SURVEY SINK SPEED VS APPROACH SPEED BY AIRCRAFT MODEL

Figure 5 presents a box-and-whisker plot of the three most recorded aircraft models at LCY: DeHavilland Canada DHC-8, Fokker 50, and the BAe 146. Box-and-whisker plots are a nonparametric tool for making quick visual comparisons showing the location and dispersion among multiple independent data sets, (see appendix A). The labels that are found on the plot correspond to the minimum of the data series, the maximum, the median, the 25th percentile, and the 75th percentile. The label "lower" refers to the lower quartile (25th percentile) and the label "upper" refers to the upper quartile (75th percentile). The median is the 50th percentile and the min and max labels represent the minimum and maximum values of the data series. The box is made up of the 25th, 50th, and 75th percentiles, and the whiskers extend from the box to the maximum and minimum values.

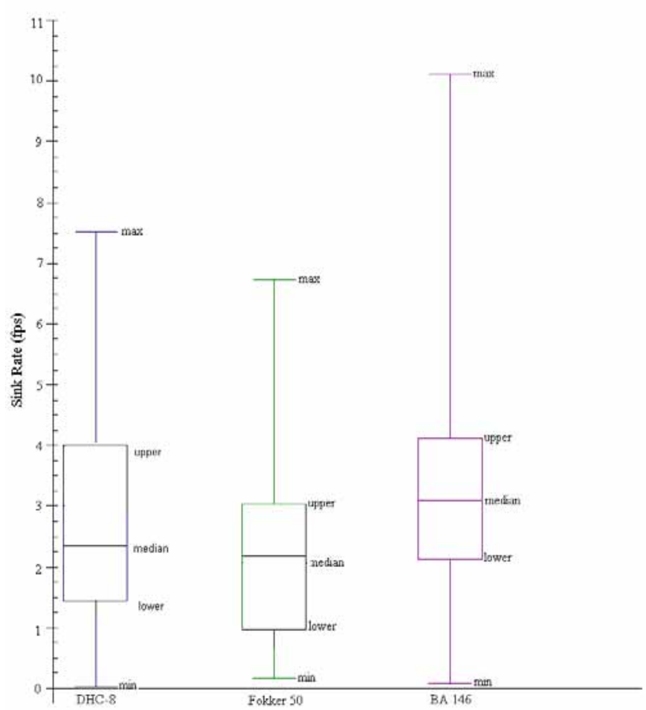


FIGURE 5. BOX-AND-WHISKER PLOT, LCY SINK RATE

More detailed statistical summaries for individual model types are provided in tables 2 through 4. The values of landing parameters determined for individual landings, sorted by airplane model type, are provided in appendix B. Landing parameter survey definitions in appendix C provide an explanation of the symbols and definition of the parameters used.

TABLE 2. STATISTICAL SUMMARY—DEHAVILLAND CANADA DHC-8, LCY

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	2.7	2.16	Ft/sec	23
	Starboard wheel	2.7	1.88	Ft/sec	23
Average of main wheels		2.8	2.04	Ft/sec	23
Closure speed (measured to camera)		104	8.51	Knots	23
Approach speed		106	8.85	Knots	23
Wind speed	Head wind	2.4	3.5	Knots	23
	Crosswind (absolute value)	5.3	3.45	Knots	23
Pitch angle at touchdown		6.2	1.36	Degrees	23
Roll angle at touchdown		-0.8	2.42	Degrees	23
Yaw angle at touchdown		-3.0	4.73	Degrees	23
Distance from touchdown to runway threshold		626	134	Feet	23
Off-center distance at touchdown		-1.7	3.34	Feet	23

TABLE 3. STATISTICAL SUMMARY—FOKKER 50

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	2.3	1.56	Ft/sec	72
	Starboard wheel	2.2	1.39	Ft/sec	72
Average of main wheels		2.3	1.45	Ft/sec	72
Closure speed (measured to camera)		93	7.68	Knots	72
Approach speed		95	7.25	Knots	72
Wind speed	Head wind	2.0	4.09	Knots	72
	Crosswind (absolute value)	5.4	3.68	Knots	72
Pitch angle at touchdown		2.5	3.72	Degrees	72
Roll angle at touchdown		-1.1	2.08	Degrees	72
Yaw angle at touchdown		-2.5	4.97	Degrees	72
Distance from touchdown to runway threshold		619	178.22	Feet	72
Off-center distance at touchdown		-1.9	4.4	Feet	72

TABLE 4. STATISTICAL SUMMARY—BAe 146

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	3.4	1.94	Ft/sec	143
	Starboard wheel	3.2	1.81	Ft/sec	143
Average of main wheels		3.4	1.83	Ft/sec	143
Closure speed (measured to camera)		109	10.42	Knots	143
Approach speed		111	10.58	Knots	143
Wind speed	Head wind	2.5	3.89	Knots	143
	Crosswind (absolute value)	5.5	3.90	Knots	143
Pitch angle at touchdown		3.2	1.84	Degrees	143
Roll angle at touchdown		-1.5	2.46	Degrees	143
Yaw angle at touchdown		-2.9	5.15	Degrees	143
Distance from touchdown to runway threshold		531	190	Feet	143
Off-center distance at touchdown		-0.8	4.44	Feet	143

Figures 6, 7, and 8 contain sink speed distributions for the DeHavilland Canada DHC-8, Fokker 50, and BAe 146 airplanes, respectively. These distributions vary somewhat in shape, but all three are positively skewed.

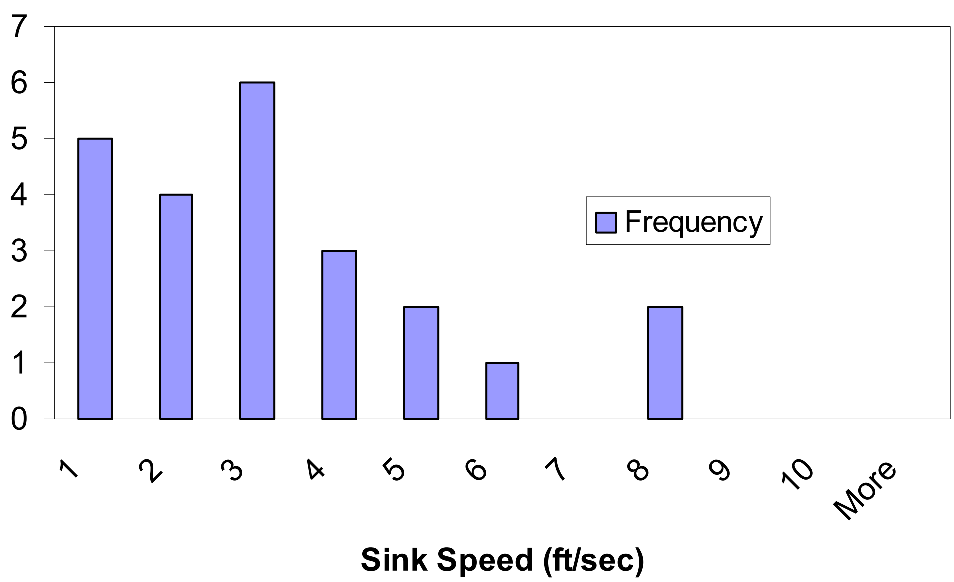


FIGURE 6. DEHAVILLAND CANADA DHC-8 SINK SPEED HISTOGRAM, LCY SURVEY

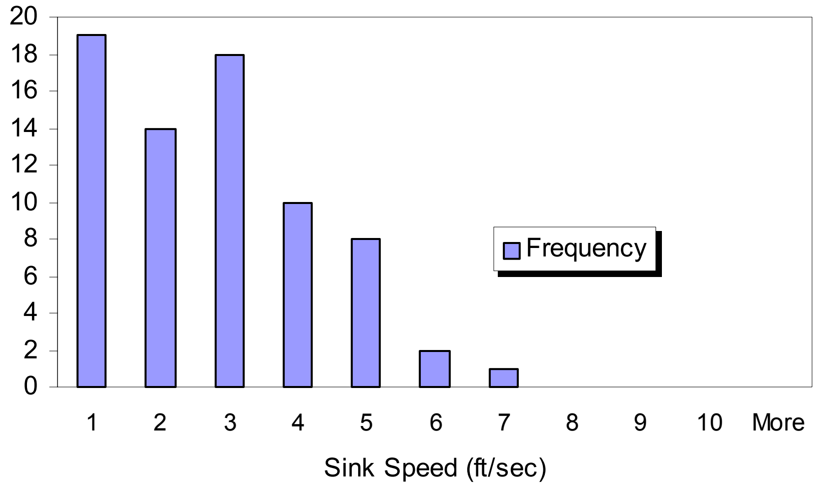


FIGURE 7. FOKKER 50 SINK SPEED HISTOGRAM, LCY SURVEY

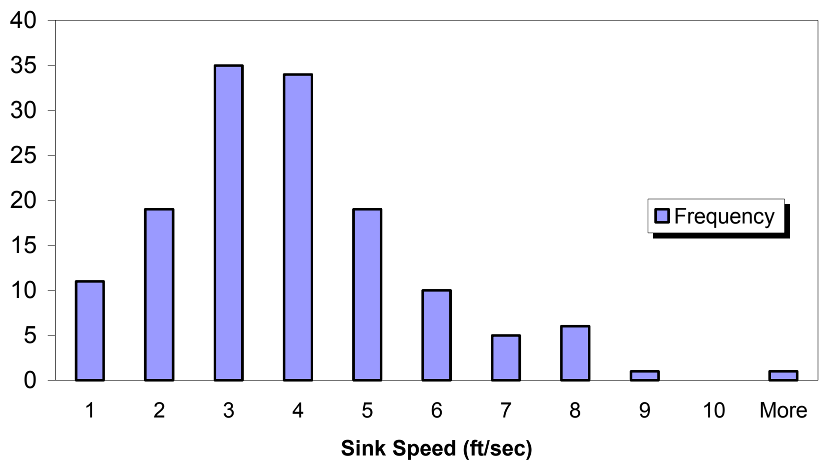


FIGURE 8. BAe 146 SINK SPEED HISTOGRAM, LCY SURVEY

The six aircraft models for which landings were analyzed in this survey had sink rates varying from 2.21 fps to 4.07 fps. Given the small sample sizes for the Saab 2000, Falcon Jet, and Dornier 328, more detailed analysis of these models was not pursued. The data for the individual landings of these three aircraft models are provided in appendix B. The aircraft with the high sink rates also had the higher closure speeds and were also the heavier of the commuter aircraft. In figure 9, the sink speed versus approach speed for all airplane models observed are plotted showing the trend between increased speed of approach and the result of increasing sink speed. For the same airplane model, higher approach velocities should translate into higher sink speed.

As listed in table B-6 in appendix B, landing event 333 indicates a 160.9-knot approach speed. This value was recorded under unusual circumstances. The aircraft did touchdown momentarily on the runway, allowing the collection of video images. The pilot then executed a missed approach procedure and made another attempt to land the aircraft. Given these unusual conditions, this event was excluded from the data summaries.

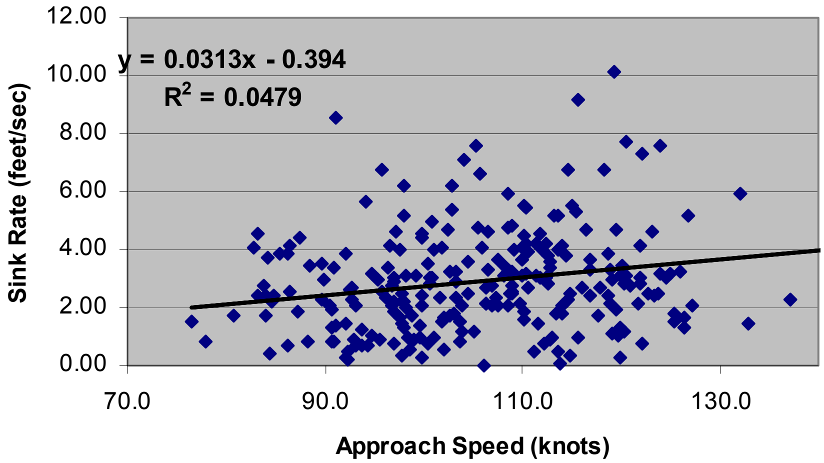


FIGURE 9. SINK SPEED VS APPROACH SPEED, LCY

Figure 10 shows a plot of sink speed versus touchdown distance from the runway threshold. The straight line (statistical trend line) indicates that the sink speed of the touchdown, occurring near the 300-foot threshold marks, are approximately twice those of the landings where touchdown was near the 800-foot mark. One observation that influenced this was the number of landings performed in crosswind conditions. Numerous landings were performed with the aircraft yawed to accommodate the crosswind, thus limiting the pilots opportunity to "flare" the aircraft prior to touchdown. Flared landings have lower sink rates, and the touchdown points are further from the runway threshold.

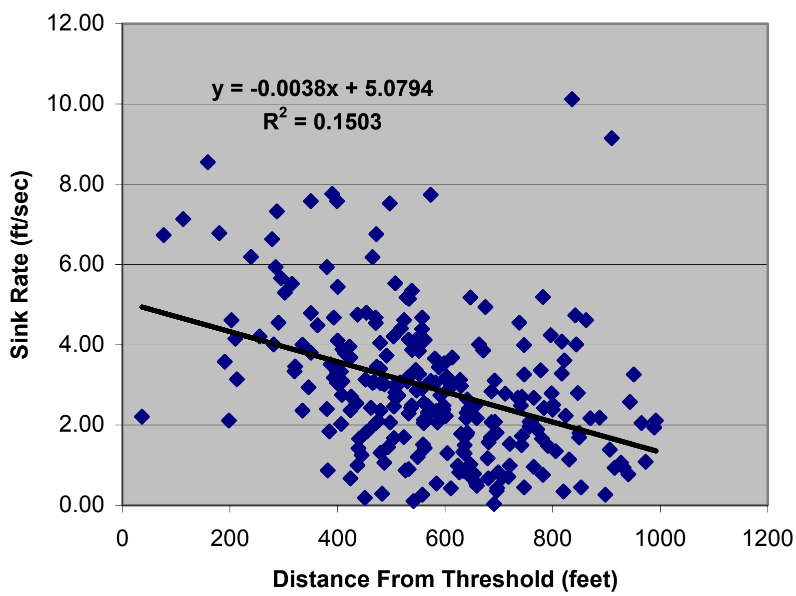


FIGURE 10. SINK SPEED VS DISTANCE FROM THRESHOLD, LCY

Figure 11 shows a plot of approach speed versus pitch angle, showing no correlation between these two parameters.

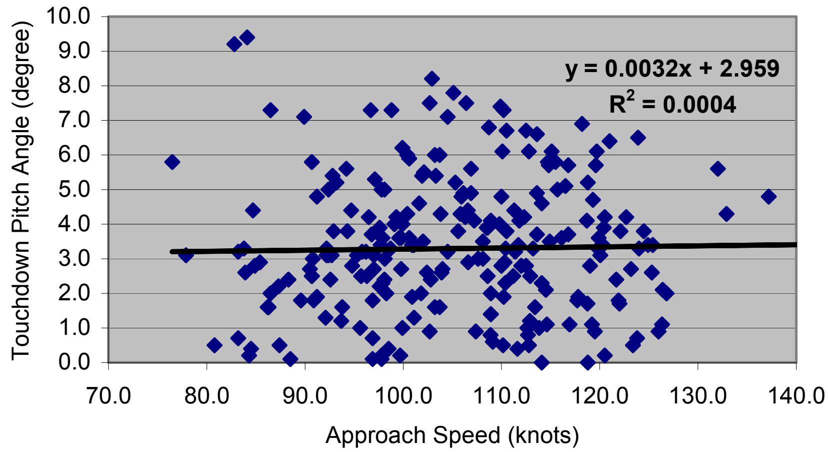


FIGURE 11. TOUCHDOWN PITCH ANGLE VS APPROACH SPEED, LCY

3.2 PHILADELPHIA INTERNATIONAL AIRPORT.

3.2.1 Philadelphia International Airport Operations.

Video images were recorded on the east side of runway 17 at PHL. For the most part, commercial jet operations are restricted to runways 9L-27R and 9R-27L. Runway 17 intersects with runway 9L-27R at the southern end of runway 17, see figure 12. At the time of the survey, runway 17/35 was the shortest runway at PHL, and the dominant runway used for commuter and general aviation flights in and out of the airport. The runway was constructed using asphalt and is grooved. Runway 17/35 is 5459 feet in length and 150 feet in width. The glide path angle into this runway is 3°. This survey was conducted prior to the opening of a new commuter runway (8/26), which was being constructed, and is shown in figure 12.

The PHL survey, like the survey done at LCY, was conducted to obtain a large quantity of commuter aircraft (Saab 340, Beech 1900D, BAe Jetstream 41, and DeHavilland Canada DHC-8) landings. The goal of the survey was to record 400 commuter landings. In a given day, about 105 commuters land at PHL. However, during the survey period from July 12-23, 1999, only 262 commuter airplane landings were recorded. Of the 262 landings recorded, 215 were analyzed. The quality of the others were too poor to analyze.

The camera location at PHL was monitoring aircraft landings from the north, onto runway 35, which is a 5449-ft-long runway. Runway 9L-27R crosses the southern end of runway 35 and during operations the pilots appeared to favor exiting the runway at taxiway K, see figure 12. It is operationally beneficial to turn off runway 35 at taxiway K to avoid the need to taxi back across an active runway on the way to the passenger terminals. This effectively shortens the runway length typically used for runway 17 landings. Review of the ramp to touchdown distance for Beech 1900 aircraft shows that the landings at PHL occur closer to the runway threshold than those at ACY.

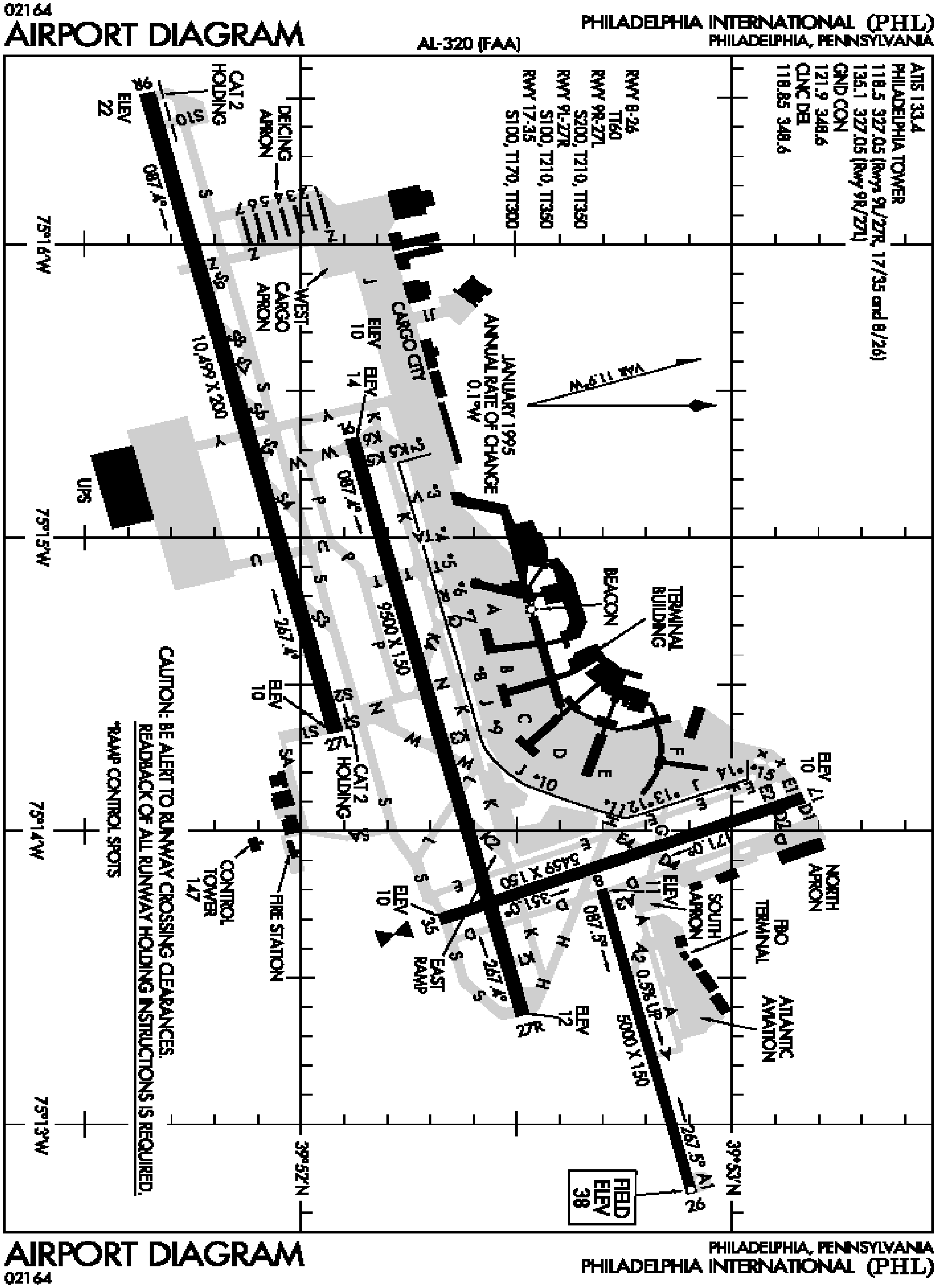


FIGURE 12. PHILADELPHIA INTERNATIONAL AIRPORT DIAGRAM

3.2.2 Philadelphia International Airport Survey Results.

Landing parameters for 215 commuter transport aircraft landings were calculated using the procedures described in references 1 and 4. Table 5 summarizes the primary landing parameters for most of the commuter airplane models covered in this survey. The table provides the mean and standard deviation and the number of observations for selected landing parameters by aircraft model. In addition to table 5, figure 13 is another box-and-whisker plot for each of the four commuter types analyzed at PHL, providing an easy look at the respective aircraft model sink speed data.

TABLE 5. SURVEY PARAMETER COMPARISON BY AIRCRAFT MODEL, PHL

Parameters		Aircraft Model			
		Saab 340	Beech 1900D	BAe Jetstream 41	DeHavilland Canada DHC-8
No. of Events		16	62	10	127
Closure speed (knots)	Mean	106	101	105	92
	Std. Dev.	6.06	7.18	4.22	7.3
Approach speed (knots)	Mean	109	104	107	96
	Std. Dev.	5.36	6.21	3.78	7.1
Sink speed (ft/sec)	Mean	1.7	1.3	2.1	1.8
	Std. Dev.	0.99	0.67	0.91	1.0
Pitch angle (degrees)	Mean	3.5	3.4	2.9	4.8
	Std. Dev.	1.24	1.28	0.64	1.19
Roll angle (degrees)	Mean	0.5	0.3	1.1	0.8
	Std. Dev.	1.47	1.93	1.47	1.47
Yaw angle (degrees)	Mean	-0.5	0.3	2.1	0.4
	Std. Dev.	2.19	1.77	1.76	1.31
Runway off-center dist. (feet)	Mean	1.4	-0.5	-0.3	0.9
	Std. Dev.	2.97	2.57	2.90	2.96

More detailed statistical summaries for individual model types are provided in tables 6 through 8. The values of landing parameters determined for individual landings, sorted by airplane model type, are provided in appendix B. Landing parameter survey definitions in appendix C provide an explanation of the symbols and parameters used.

Figures 14, 15, and 16 contain sink speed distributions for the Saab 340, Beech 1900D, and DeHavilland Canada DHC-8 airplanes, respectively. These distributions vary somewhat in shape, but all three are positively skewed.

The mean values for the sink speed of the main landing gear for the aircraft in the PHL survey are consistently lower than those found in earlier surveys of both wide- and narrow-body aircraft and significantly lower than the LCY results for the same type of aircraft.

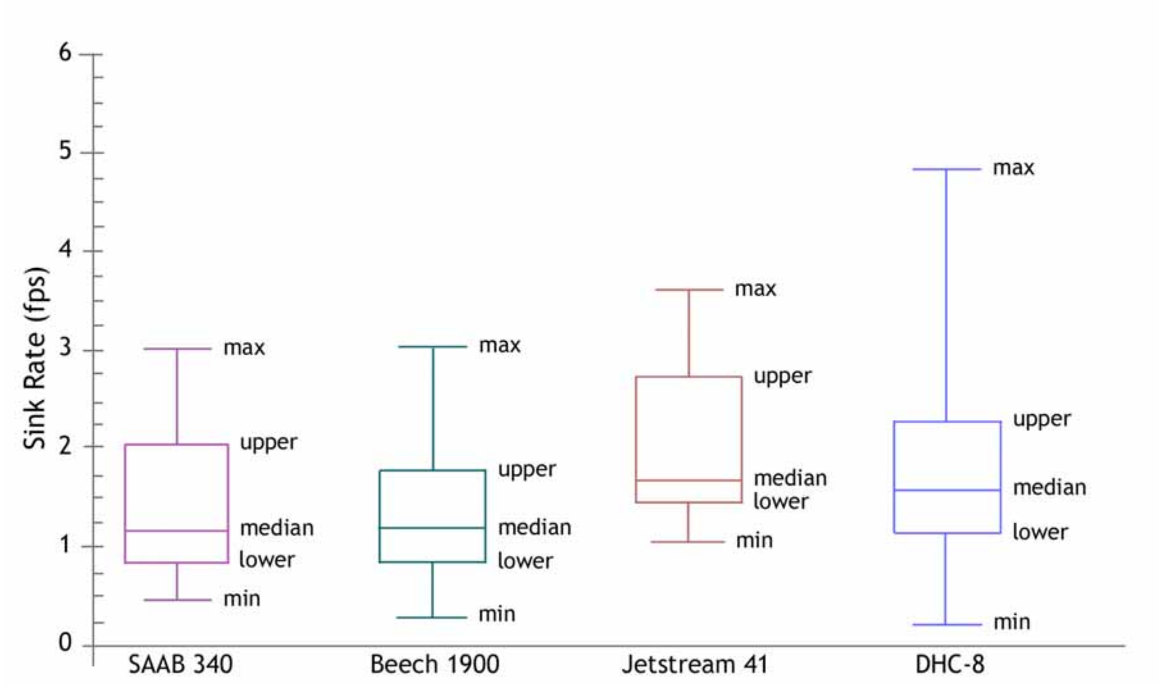


FIGURE 13. BOX-AND-WHISKER PLOT, PHL SINK SPEED

The four aircraft models for which landings were analyzed in this survey had sink rates varying from 1.32 fps to 2.1 fps. The aircraft (BAe Jetstream 41) with the highest sink rates also had one of the higher closure speeds. Given the small sample sizes for the BAe Jetstream 41, more detailed analysis of this models was not pursued. The data for the individual landings of the BAe Jetstream 41 are provided in appendix B.

TABLE 6. STATISTICAL SUMMARY—SAAB 340, PHL

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.7	0.73	Ft/sec	16
	Starboard wheel	1.7	0.99	Ft/sec	16
Average of main wheels		1.7	0.86	Ft/sec	16
Closure speed (measured to camera)		106	6.06	Knots	16
Approach speed		109	5.36	Knots	16
Wind speed	Head wind	3.3	3.34	Knots	16
	Crosswind (absolute value)	4.3	3.17	Knots	16
Pitch angle at touchdown		3.5	1.24	Degrees	16
Roll angle at touchdown		0.5	1.47	Degrees	16
Yaw angle at touchdown		-0.5	2.19	Degrees	16
Distance from touchdown to runway threshold		1098	343	Feet	16
Off-center distance at touchdown		1.4	2.97	Feet	16

TABLE 7. STATISTICAL SUMMARY—BEECH 1900D, PHL

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.4	0.73	Ft/sec	62
	Starboard wheel	1.3	0.77	Ft/sec	62
Average of main wheels		1.3	0.67	Ft/sec	62
Closure speed (measured to camera)		101	7.18	Knots	62
Approach speed		104	6.21	Knots	62
Wind speed	Head wind	3.4	3.74	Knots	62
	Crosswind (absolute value)	4.0	3.17	Knots	62
Pitch angle at touchdown		3.4	1.28	Degrees	62
Roll angle at touchdown		0.3	1.93	Degrees	62
Yaw angle at touchdown		0.0	1.77	Degrees	62
Distance from touchdown to runway threshold		1307	235	Feet	62
Off-center distance at touchdown		-0.5	2.57	Feet	62

TABLE 8. STATISTICAL SUMMARY—DEHAVILLAND CANADA DHC-8, PHL

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.5	0.87	Ft/sec	127
	Starboard wheel	1.9	1.17	Ft/sec	127
Average of main wheels		1.8	1.0	Ft/sec	127
Closure speed (measured to camera)		92	7.3	Knots	127
Approach speed		96	7.1	Knots	127
Wind speed	Head wind	3.8	3.67	Knots	127
	Crosswind (absolute value)	4.0	3.07	Knots	127
Pitch angle at touchdown		4.8	1.19	Degrees	127
Roll angle at touchdown		0.8	1.47	Degrees	127
Yaw angle at touchdown		0.4	1.31	Degrees	127
Distance from touchdown to runway threshold		1171	273	Feet	127
Off-center distance at touchdown		0.9	2.96	Feet	127

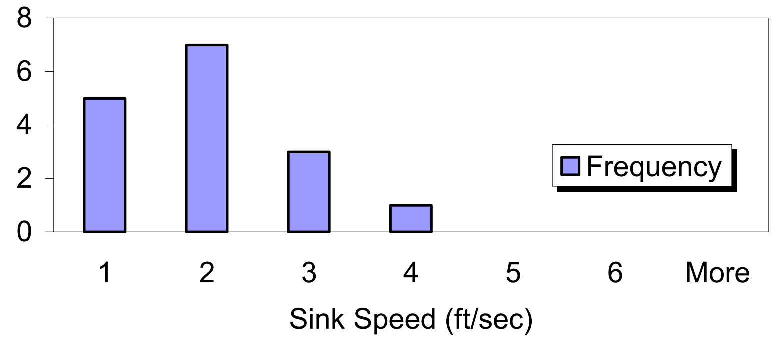


FIGURE 14. SAAB 340 SINK SPEED HISTOGRAM, PHL SURVEY

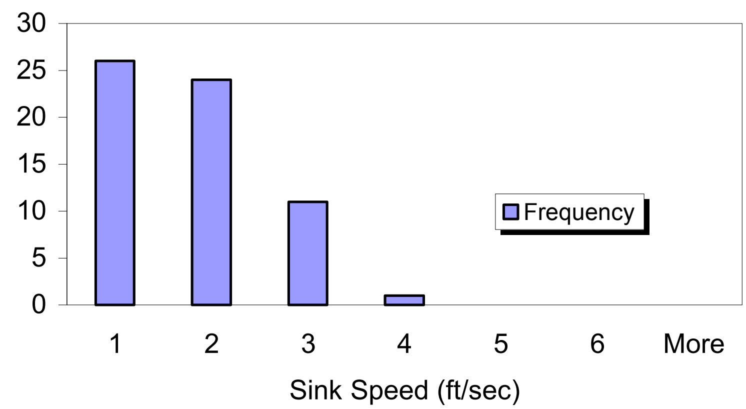


FIGURE 15. BEECH 1900D SINK SPEED HISTOGRAM, PHL SURVEY

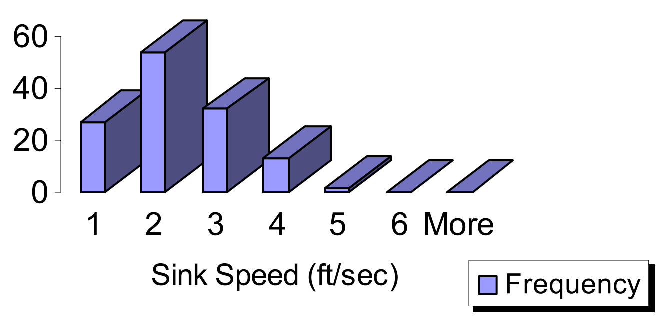


FIGURE 16. DEHAVILLAND CANADA DHC-8 SINK SPEED HISTOGRAM, PHL SURVEY

Figures 17 through 19 present some overall observations regarding the total 215 measured parameters of landing touchdown collected during the survey.

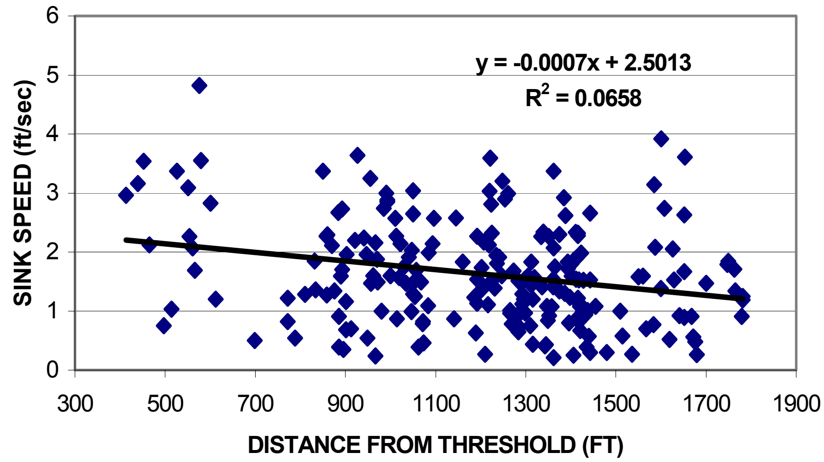


FIGURE 17. SINK SPEED VS DISTANCE FROM THRESHOLD, PHL

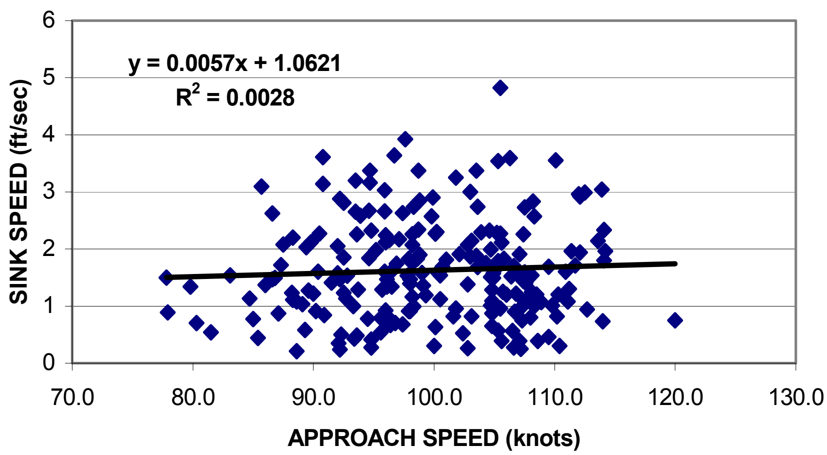


FIGURE 18. SINK SPEED VS APPROACH SPEED, PHL

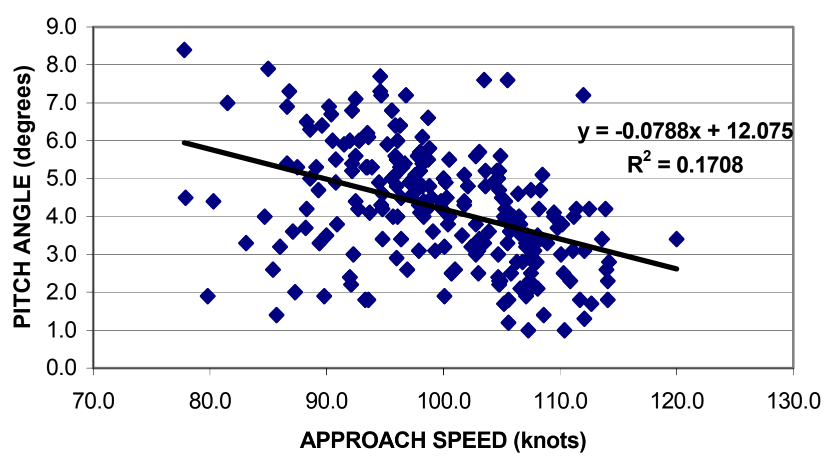


FIGURE 19. TOUCHDOWN PITCH ANGLE VS APPROACH SPEED, PHL

Figure 17 is a plot of sink speed versus touchdown distance from the runway threshold. The figure indicates that the span of camera coverage was approximately from 500 to 2000 feet from the threshold. The straight line (statistical trend line) indicates that the sink speed of the touchdown occurring near 500 feet from the threshold is about 1 foot per second more than landings where the touchdown is near the 1700-foot mark.

Figure 18 is a plot of sink speed versus approach speed. For the same airplane types, higher approach velocities should translate into higher sink speeds. From figure 18, one can quantify the contribution of approach velocity to sink speed, although, in this survey, the increase in approach speed has very little effect on sink speed. Figure 19 shows a significant correlation between approach speed and touchdown pitch angle. Statistical linear trend lines are provided on each figure.

3.3 ATLANTIC CITY INTERNATIONAL AIRPORT.

3.3.1 Atlantic City International Airport Operations.

Additional commuter data were collected at the FAA's permanent video landing survey facility, monitoring runway 13 at ACY. The FAA landing facility collects data on routine operations at ACY. The bulk of the landings observed are narrow-body jets in scheduled commercial service. In addition, a large number of military air refueling tankers and transport aircraft perform landing practice at ACY. These practice landings are normally touch and go landings. The majority of these operations are performed with KC-10 aircraft, the military version of the DC-10 wide-body aircraft. A significant number of commercial aircraft training landings of the Airbus A330 have also been recorded and analyzed. The presentation and analysis of the landing data from these aircraft are outside the scope of this report and are not included in the appendix. The one model of commuter aircraft that, until recently, provided service into ACY is the Beech 1900D. Landing data for the Beech 1900D, a commuter model that was also recorded at PHL, is included in this report to provide an additional source for direct comparison with the PHL results.

3.3.2 Atlantic City International Airport Results.

The results of the ACY Beech 1900D commuter landings are shown in table 9. A histogram of the Beech 1900D sink speeds recorded at ACY is provided in figure 20. In addition, crosswind data for the Beech 1900D at both ACY and PHL were measured and compared.

TABLE 9. STATISTICAL SUMMARY—BEECH 1900D, ACY

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.8	1.07	Ft/sec	77
	Starboard wheel	1.7	1.26	Ft/sec	77
Average of main wheels		1.7	1.06	Ft/sec	77
Closure speed (measured to camera)		98	10.68	Knots	77
Approach speed		104	11.46	Knots	77
Wind speed	Head wind	4.4	4.35	Knots	77
	Crosswind (absolute value)	5.2	3.19	Knots	77
Pitch angle at touchdown		1.7	2.63	Degrees	77
Roll angle at touchdown		0.1	2.48	Degrees	77
Yaw angle at touchdown		1.66	2.9	Degrees	77
Distance from touchdown to runway threshold		1825	339	Feet	77
Off-center distance at touchdown		1.0	5.1	Feet	77

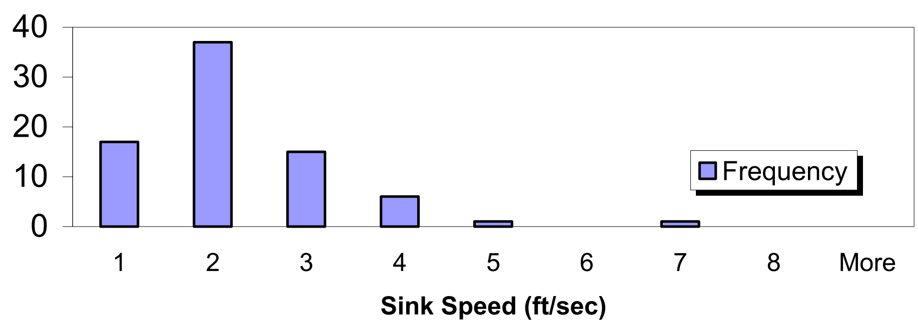


FIGURE 20. BEECH 1900D SINK SPEED HISTOGRAM, ACY SURVEY

The commuter data collected at ACY was recorded landings on runway 13, the only ILS-equipped runway currently at ACY. This is a 10,000-ft runway, see figure 21. Runway 4-22 crosses runway 13 at approximately mid length; thus, only one runway is operational at any time at ACY. Therefore, there is no incentive to land close to the threshold on runway 13. In addition, to taxi to the terminal at ACY, the pilots must cross runway 4-22. In fact, some aircraft touchdown so far down runway 31 that they leave the field of view of the cameras before touchdown occurs. These relatively benign conditions are reflected in the much wider variation in touchdown points from the runway threshold.

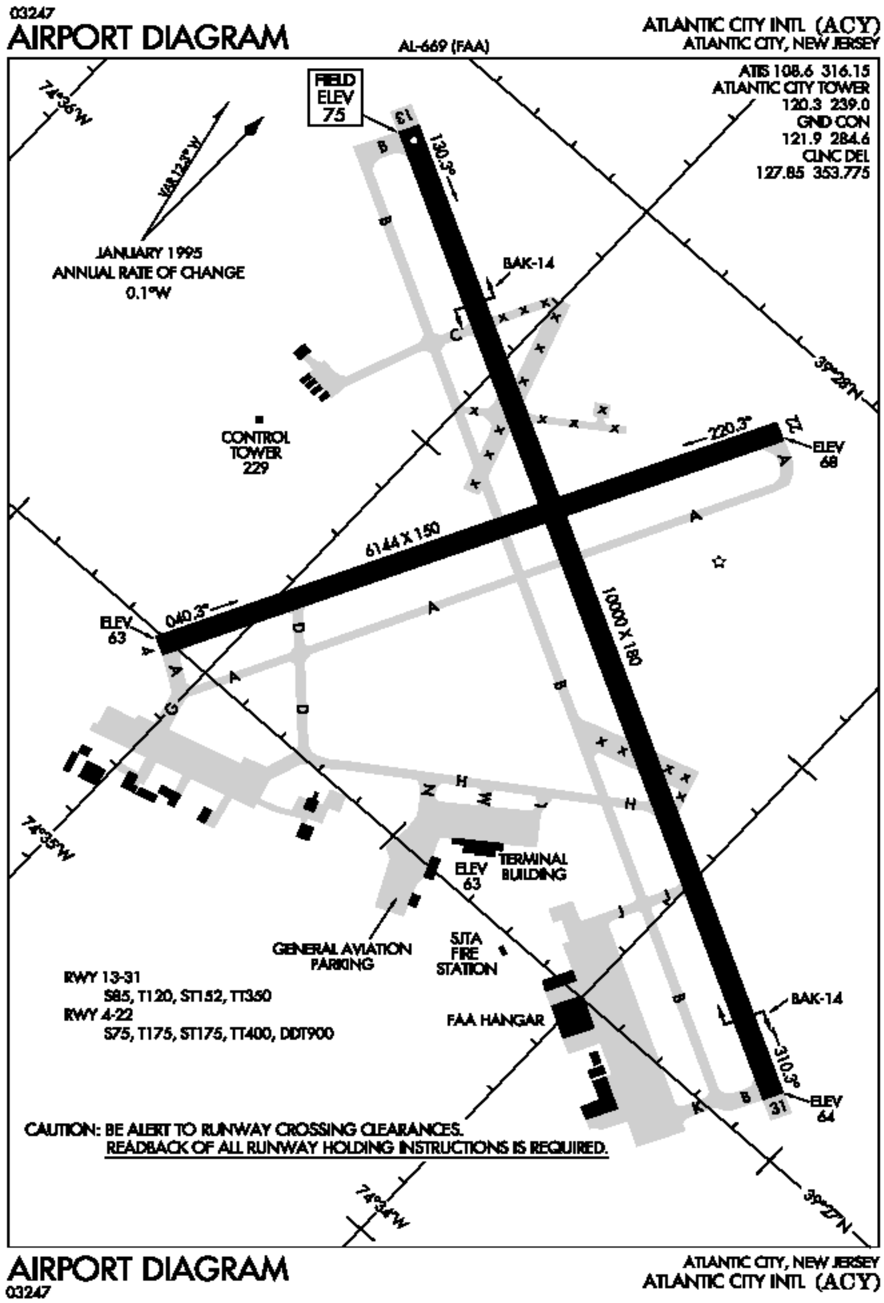


FIGURE 21. ATLANTIC CITY INTERNATIONAL AIRPORT DIAGRAM

4. AIRPORT COMPARISONS.

4.1 COMPARISON OF LCY RESULTS WITH PHL RESULTS.

The number of aircraft models available for direct comparison between LCY and PHL were limited since only aircraft certified to land at high glide slope angles operated into LCY. The DeHavilland Canada DHC-8 was the only aircraft observed at both the LCY and PHL surveys. Comparisons of the mean values of DeHavilland Canada DHC-8 approach speeds and sink rates are presented in table 10. An illustration of how the sink rates for the DeHavilland Canada DHC-8 matched up at each airport, is presented in a box-and-whisker plot, in figure 22. The observed difference in mean values and standard deviation in table 10 can be attributed to the different glide slope (5.5° at LCY, 3° at PHL) at the two airports. A statistical Students-t test for the significance of the difference between the mean values of two populations, shows that there is a 99% probability that the observed difference is real.

TABLE 10. DIRECT COMPARISON OF LANDING SURVEY RESULTS, DEHAVILLAND CANADA DHC-8

Aircraft Model		LCY Survey 1997		PHL Survey 1999	
		Approach Speed	Average Sink Speed	Approach Speed	Average Sink Speed
DeHavilland Canada DHC-8	Mean	106 (knots)	2.5 (fps)	96 (knots)	1.8 (fps)
	Standard Deviation	8.85	1.8	7.1	1.0
	No. of Landings	23	23	127	127

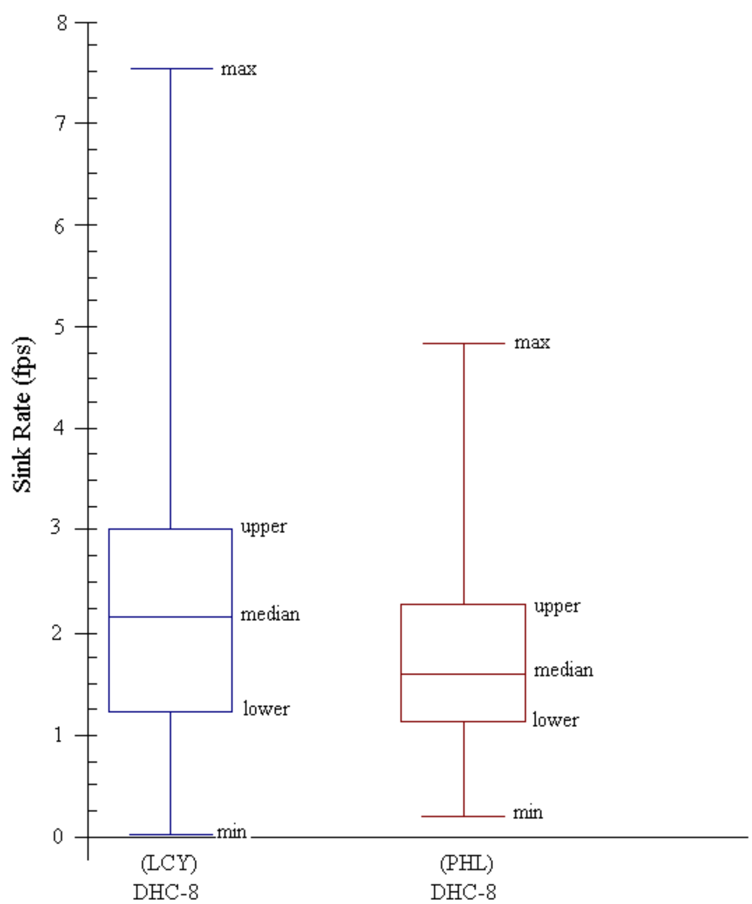


FIGURE 22. BOX-AND-WHISKER PLOT OF DEHAVILLAND CANADA DHC-8 SINK SPEED

4.2 COMPARISON OF PHL RESULTS WITH ACY RESULTS.

The effect that the crosswind had on the closure speed and sink rate at each airport can be seen in figures 23 through 26. In strong crosswind operations, the closure speed of the aircraft landing is increased to lessen the effect of the crosswind component on the airplane. As a result of increased closure speeds, sink rates are also increased as the crosswind magnitude is increased. Tables 11 and 12 compare the landing parameters along with the crosswind conditions at ACY and PHL for the Beech 1900D. The average crosswind for ACY landings were higher than those at PHL. Runway 13 at ACY is the only runway at ACY with an ILS; thus, in bad weather, landings must be performed on runway 13, contributing to the higher percentage of crosswind landings at ACY.

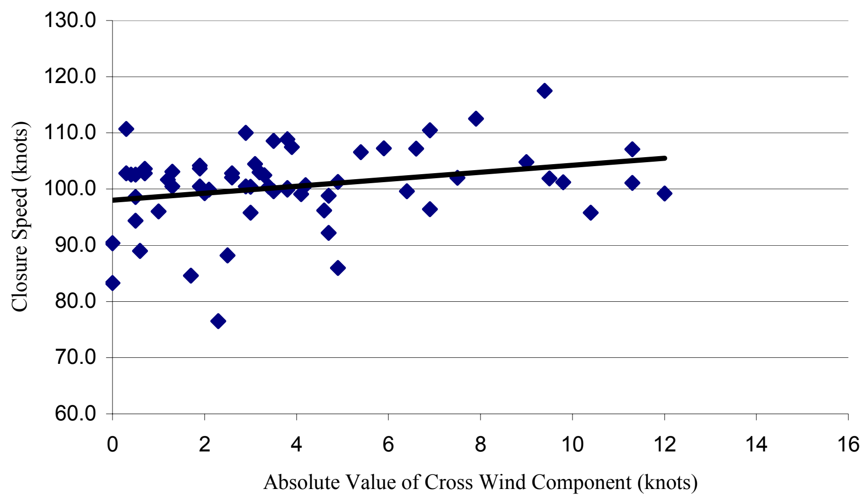


FIGURE 23. CLOSURE SPEED VS ABSOLUTE VALUE OF CROSSWIND, PHL

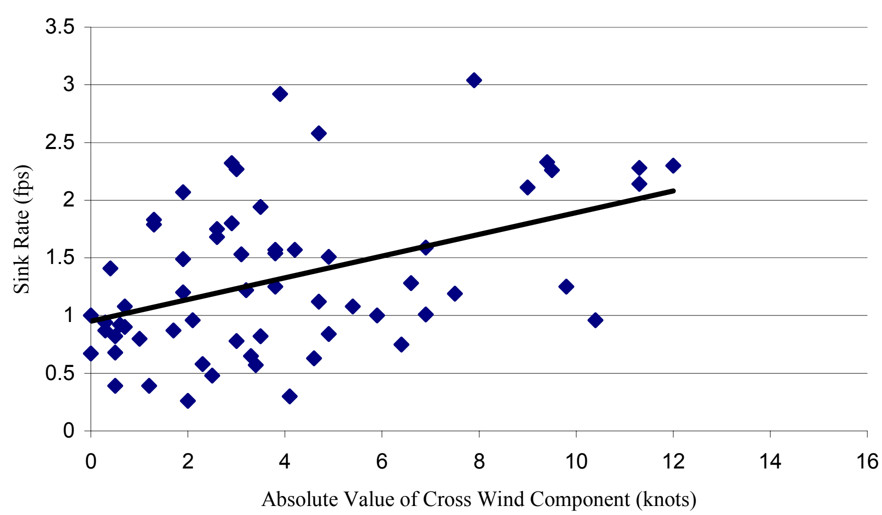


FIGURE 24. SINK RATE VS ABSOLUTE VALUE OF CROSSWIND, PHL

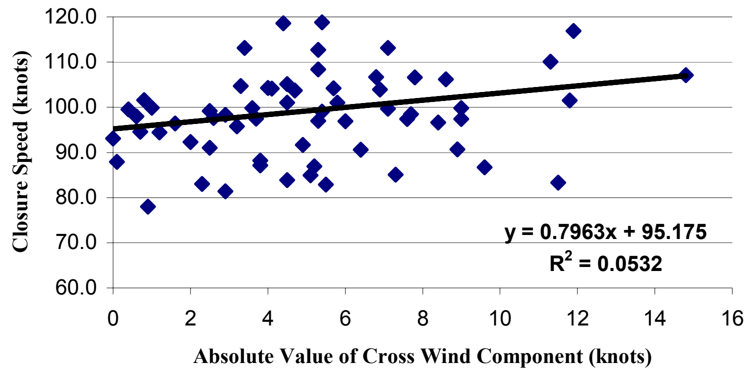


FIGURE 25. CLOSURE SPEED VS ABSOLUTE VALUE OF CROSSWIND, ACY

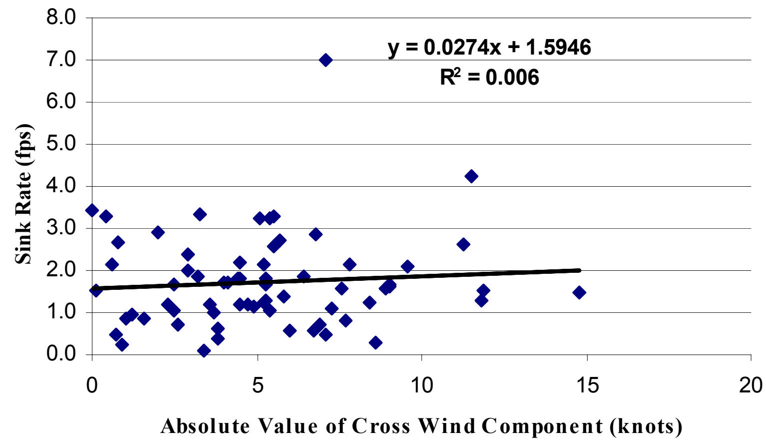


FIGURE 26. SINK RATE VS ABSOLUTE VALUE OF CROSSWIND, ACY

TABLE 11. DIRECT COMPARISON OF LANDING SURVEY RESULTS, BEECH 1900D

Aircraft Model		ACY Landing Data		PHL Survey 1999	
		Approach Speed	Average Sink Speed	Approach Speed	Average Sink Speed
Beech 1900D	Mean	104 (knots)	1.7 (fps)	104 (knots)	1.3 (fps)
	Standard Deviation	11.46	1.06	6.21	0.67
	No. of Landings	77	77	62	62

TABLE 12. CROSSWIND COMPARISON FOR BEECH 1900D LANDINGS

Absolute Value of Crosswind Components		
	Mean	Standard Deviation
ACY	5.2	3.19
PHL	4.0	3.16

At ACY, runway 13 is the only runway equipped with an ILS. In bad weather, pilots are required to perform more landings in adverse wind conditions at ACY than would be done at PHL, which has numerous options for ILS landings. Only runway 17, which is infrequently used, on the opposite end of the surveyed runway, does not have ILS in PHL. On the other hand, in good weather, the option to land commuters on crosswind runway 4-22 at ACY reduces the overall number of crosswind landings. During peak operating periods at PHL, the need to give preference to jet traffic on runways 9L-27R and 9R-27L may force commuter turboprop aircraft to do more good weather crosswind landings on runway 35.

During the survey period at PHL, there were no periods of poor visibility, and thus, weather did not appear to be a factor in survey results. At ACY, bad weather landings were included in the survey results.

Figure 27 is a box-and-whisker plot showing statistical data for the Beech 1900D at ACY and PHL.

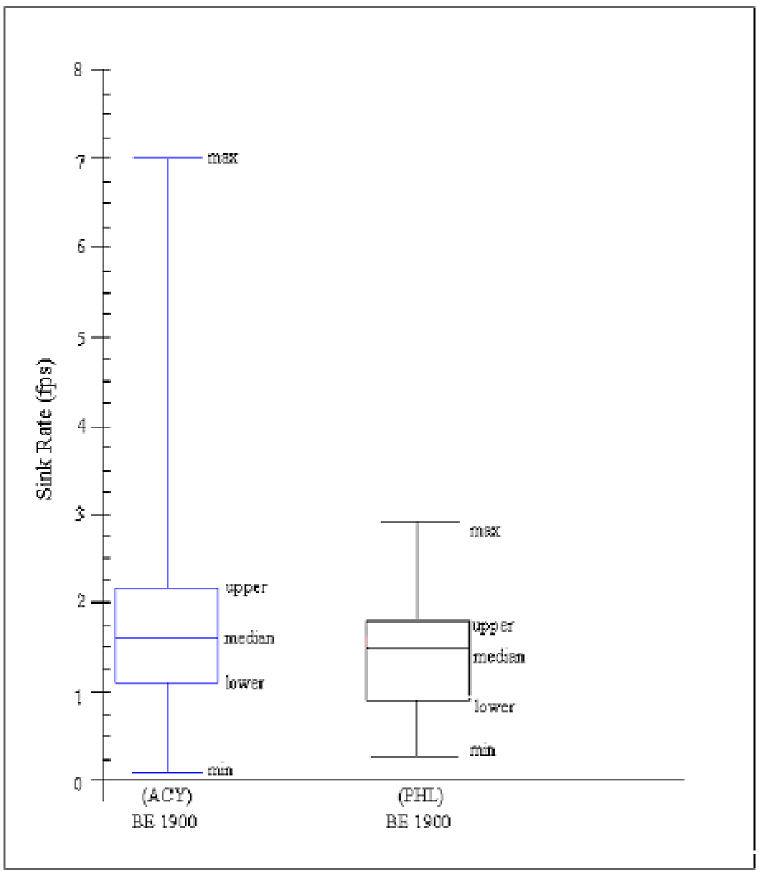


FIGURE 27. BOX-AND-WHISKER PLOT OF BEECH 1900D SINK SPEED

A number of high sink speed landings were observed during the LCY survey. This can be directly attributed to the higher 5.5° glide slope angle required to land at LCY. It was anticipated that landings in excess of 4 ft/sec would be rather rare in normal commercial operations. The results of the LCY survey have identified 60 landings (almost 24%) that had sink speeds of 4 ft/sec or more and 3 landings were in excess of 8 ft/sec. In previous surveys done on wide-body airplane models, 20% of the landings at HNL and 15% at JFK had landings at or above 4 ft/sec. The design limit descent velocity found in reference 5, Title 14 Code of Federal Regulations 25.473 for commercial transports, is 10 ft/sec. Reference 5 specifies a 10-ft/sec landing, a once per lifetime event, but does not require a sink speed frequency distribution. The military specification MIL-A-8866 for similar aircraft assumes a 10-ft/sec landing occurs once every 2000 landings and a 9-ft/sec landing once every 1000 landings. Figure 28 provides a histogram of the sink speed distribution recorded during the LCY survey.

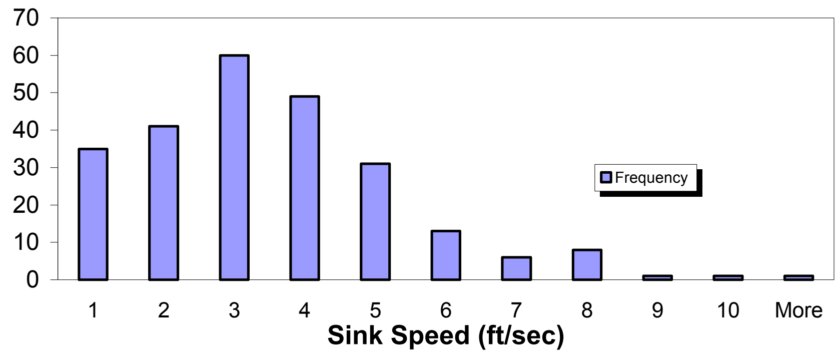


FIGURE 28. SINK SPEED HISTOGRAM, LCY SURVEY

The landing survey at PHL, which included turboprops only, produced data that was unlike that found in previous surveys. This was the low frequency of sink speeds that were over 4 ft/sec. In figure 29, a histogram of the sink speed for all landings captured at PHL is presented. During this survey only one of the 215 recorded landings had a sink speed over 4 ft/sec. In all prior surveys, the 4 ft/sec or over mark was encountered at the very least 15% of time.

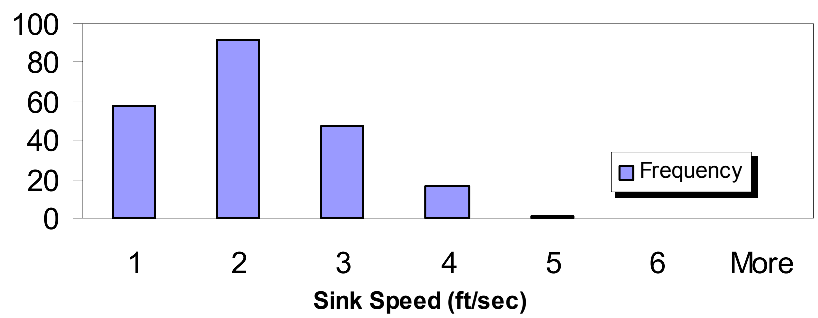


FIGURE 29. SINK SPEED HISTOGRAM, PHL SURVEY

Since there is no equivalent commercial specification, the observed sink speed distributions from the LCY and PHL surveys were compared with the distribution from MIL-A-8863. Commercial manufactures estimate the anticipated usage of the aircraft during the airplanes design phase. Figure 30 shows a plot of the probability that an aircraft's sink speed would reach a particular value. The military specifications for the sink speed distribution of transport aircraft is identified as the MIL-A-8866 curve. Also presented in figure 30 is a comparison of the sink speeds for three aircraft models captured in the LCY survey (BAe 146, DeHavilland Canada DHC-8, and Fokker 50) compared in a probability format with two aircraft models' sink speeds from the PHL survey (DeHavilland Canada DHC-8 and Beech 1900D). The MIL-A-8863 distribution indicates, that over a lifetime, a military transport fleet would be designed for the assumption that 4 percent of the sink speeds would be in excess of 6 ft/sec. During the LCY survey in June-July 1997, nearly 10 percent of the BAe 146 commuter transports exceeded 6 ft/sec, while about 3 percent of the Fokker 50 transports exceeded the same 6 ft/sec. In the PHL survey, none of the 215 landings analyzed exceeded the sink speed of 6 ft/sec.

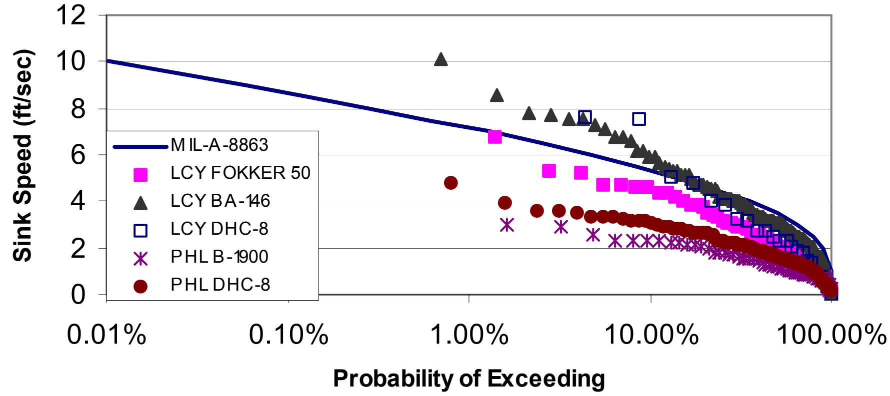


FIGURE 30. SINK SPEED PROBABILITY DISTRIBUTIONS, LCY VS PHL

The sink speed distributions for the two direct comparisons, the DeHavilland Canada DHC-8 at LCY and PHL and the Beech 1900D at PHL and ACY, have also been plotted in figures 31 and 32. In figure 31, the probability of exceeding the same sink speed at LCY is higher than at PHL. The likely reason for this could be the usually high glide slope at LCY. Figure 32 shows the plot comparing the PHL and ACY Beech 1900D landings. In this plot, the probability of exceeding a sink speed at ACY is higher than at PHL. Based on the crosswind data and its effect on landing parameters, this could be why the landings at ACY have a higher probability.

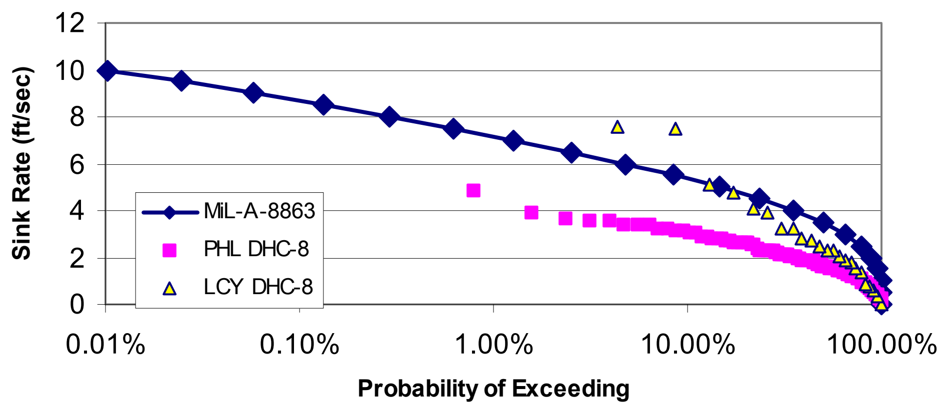


FIGURE 31. SINK SPEED PROBABILITY DISTRIBUTIONS FOR THE DEHAVILLAND CANADA DHC-8 AIRCRAFT

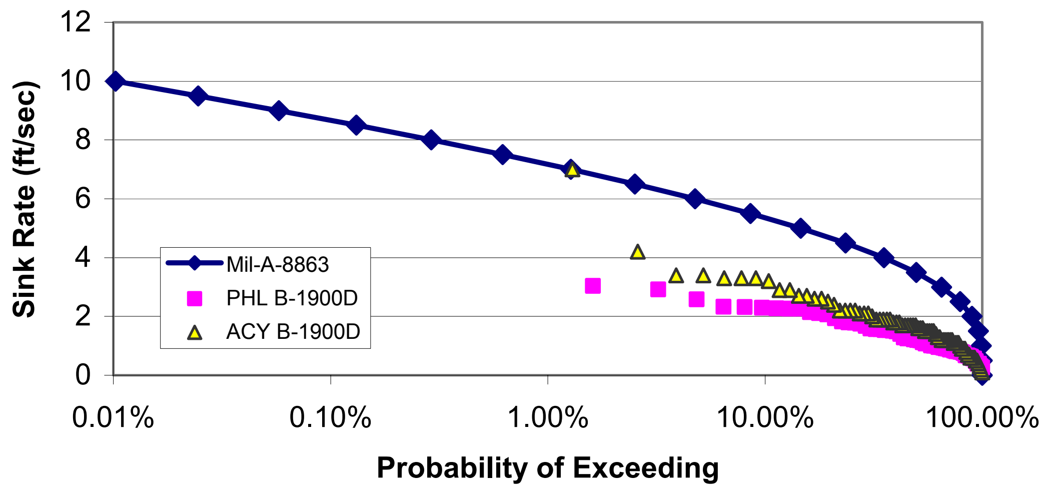


FIGURE 32. SINK SPEED PROBABILITY DISTRIBUTIONS FOR THE BEECH 1900D AIRCRAFT

As stated earlier, landing load surveys have been performed at other commercial airports. In particular, the survey at JFK did collect a limited number of commuter operations. However, given the relatively small sample sizes and the fact that the instrumented runway (13L at JFK) is 10,000 ft long, the data was only included as an appendix in the report cited in reference 6, no conclusions were presented for that data. The runway is equipped with ILS and has a 3.0° glide slope angle. Given the new commuter data provided in this report, it was considered reasonable to review the JFK data and compare it with the new results.

Summaries were generated from the JFK report data and are shown in tables 13 through 16. Comparing the data with the LCY and PHL data confirmed that the operations on the longer runway are less severe than on the shorter runway at PHL or the higher glide slope angle at LCY. Table 17 compares the data of high-wing commuter aircraft at all three airports. Table 18 compares the landing performance of the various Saab 340 commuter aircraft at all three airports. Figure 33 shows a plot of the sink rate versus approach speed for all turboprop-powered commuter aircraft observed during the surveys. The LCY data stands out as being the most demanding operating environment. The sink rates are lowest on the longer JFK runway even though the operations at JFK were performed in challenging crosswind conditions. The absolute value of the crosswind components at JFK had a mean value of 10 knots. The crosswind components were 5.0 knots for the PHL landings and 5.5 knots at LCY. These higher crosswind conditions contributed, in part, to the higher approach speeds reported at JFK. Another factor contributing to the higher JFK approach speeds was the higher volume of operations, whereby the commuters were mixed into the traffic flow with larger commercial jets, which may have resulted in higher approach speeds being flown by the commuter aircraft.

TABLE 13. STATISTICAL SUMMARY—ATR-42, JFK

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.1	0.98	Ft/sec	42
	Starboard wheel	1.3	1.04	Ft/sec	42
Average of main wheels		1.2	0.95	Ft/sec	42
Closure speed (measured to camera)		106	8.20	Knots	42
Approach speed		110	8.63	Knots	42
Wind speed	Head wind	4	4.36	Knots	42
	Crosswind (absolute value)	10	4.74	Knots	42
Pitch angle at touchdown		3.5	1.50	Degrees	42
Roll angle at touchdown		3.7	5.72	Degrees	42
Yaw angle at touchdown		-0.3	2.55	Degrees	42
Distance from touchdown to runway threshold		1894	1179	Feet	42
Off-center distance at touchdown		1.5	5.93	Feet	42

TABLE 14. STATISTICAL SUMMARY—DHC-7, JFK

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	2.0	1.21	Ft/sec	26
	Starboard wheel	1.9	1.39	Ft/sec	26
Average of main wheels		2.1	1.03	Ft/sec	26
Closure speed (measured to camera)		86	12.54	Knots	26
Approach speed		92	11.29	Knots	26
Wind speed	Head wind	6	2.83	Knots	26
	Crosswind (absolute value)	10	5.25	Knots	26
Pitch angle at touchdown		3.2	1.95	Degrees	26
Roll angle at touchdown		2.8	2.50	Degrees	26
Yaw angle at touchdown		0.5	1.93	Degrees	26
Distance from touchdown to runway threshold		1923	497	Feet	26
Off-center distance at touchdown		-1.1	4.62	Feet	26

TABLE 15. STATISTICAL SUMMARY—DHC-8, JFK

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	1.0	1.01	Ft/sec	10
	Starboard wheel	1.1	1.37	Ft/sec	10
Average of main wheels		1.1	1.24	Ft/sec	10
Closure speed (measured to camera)		95	14.72	Knots	10
Approach speed		99	13.99	Knots	10
Wind speed	Head wind	4	4.59	Knots	10
	Crosswind (absolute value)	10	3.55	Knots	10
Pitch angle at touchdown		5.8	2.29	Degrees	10
Roll angle at touchdown		2.7	2.81	Degrees	10
Yaw angle at touchdown		-1.7	1.30	Degrees	10
Distance from touchdown to runway threshold		1727	546	Feet	10
Off-center distance at touchdown		0.3	8.33	Feet	10

TABLE 16. STATISTICAL SUMMARY—SAAB 340, JFK

Parameters		Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sink Speed	Port wheel	0.9	1.05	Ft/sec	30
	Starboard wheel	1.0	1.12	Ft/sec	30
Average of main wheels		1.0	1.00	Ft/sec	30
Closure speed (measured to camera)		111	9.20	Knots	30
Approach speed		116	7.68	Knots	30
Wind speed	Head wind	5	4.72	Knots	30
	Crosswind (absolute value)	10	4.67	Knots	30
Pitch angle at touchdown		3.3	1.47	Degrees	30
Roll angle at touchdown		3.3	5.12	Degrees	30
Yaw angle at touchdown		-1.6	2.09	Degrees	30
Distance from touchdown to runway threshold		1636	563	Feet	30
Off-center distance at touchdown		1.9	5.83	Feet	30

TABLE 17. COMPARISON OF HIGH-WING COMMUTER AIRCRAFT, LCY, PHL, AND JFK LANDINGS

		Aircraft Model Location				
		DHC-8 LCY	DHC-8 PHL	DHC-8 JFK	DHC-7 JFK	ATR-42 JFK
Average sink speed (ft/sec)	Mean	2.8	1.8	1.1	2.1	1.2
	Standard Deviation	2.04	1.0	1.07	1.03	0.95
Approach speed (knots)	Mean	106	96	99	92	110
	Standard Deviation	8.85	7.1	13.99	11.29	8.63
Number of landings		23	127	10	26	42
Reference approach speed (knots)	See reference 7	90	90	90	83	NA

TABLE 18. COMPARISON OF SAAB COMMUTER AIRCRAFT, LCY, PHL, AND JFK LANDINGS

		Aircraft Model Location		
		Saab 2000 LCY	Saab SF-340 PHL	Saab SF-340 JFK
Average sink speed (ft/sec)	Mean	4.1	1.7	1.0
	Standard Deviation	3.12	0.99	1.00
Approach speed (knots)	Mean	117	109	116
	Standard Deviation	6.56	5.36	7.68
No. of landings		5	16	30
Reference approach speed (knots)*	Approach flaps Landing flaps	105 98	87 82	87 82

*Data from Jane's All the World Aircraft.

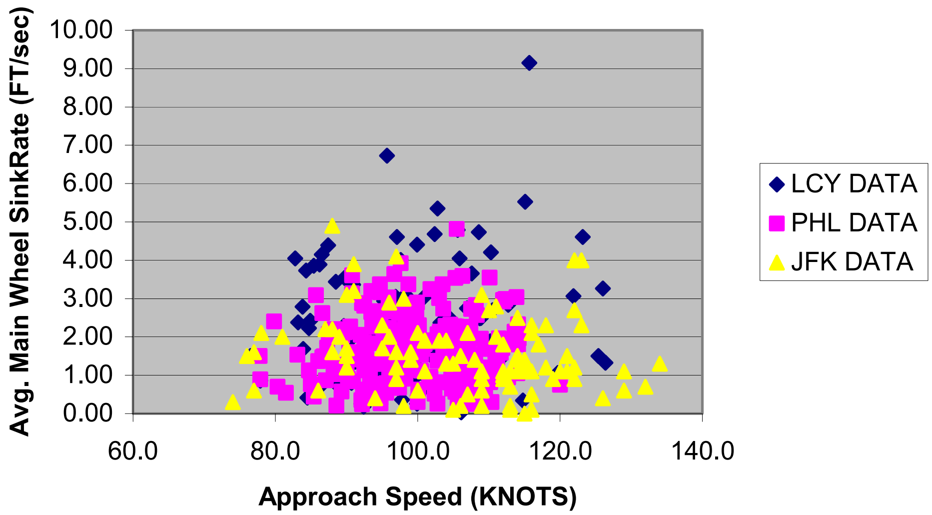


FIGURE 33. TURBOPROP COMMUTER AIRCRAFT COMPARISON BY SURVEY, SINK SPEED VS APPROACH SPEED

5. CONCLUDING REMARKS.

This research is part of a continuing series of landing parameter surveys intended to assess the continued suitability of current design and certification requirements for aircraft landing gear and support structure. The video landing data acquisition system has been shown to be a practical, cost-effective technique for collecting large quantities of typical landing parameter data on a noninterference basis at major commercial airports. This report summarized the commuter results from surveys conducted at London City Airport (LCY), Philadelphia International Airport (PHL), and Atlantic City International Airport (ACY). The LCY survey was performed in the summer of 1997, and the PHL survey was performed in the summer of 1999. The findings can be summarized as follows:

- Operations at higher glide slope angles result in significantly higher aircraft sink rates.
- Operations of commuter aircraft under typical operating conditions result in lower sink rates than those observed for narrow-body jet aircraft in previous landing surveys.
- Current design sink rate requirements appear to be adequate for commuter aircraft.
- A trend toward higher aircraft sink rates and approach speeds can be inferred from the results of landings performed during higher crosswind conditions.
- In general, the landing performance for aircraft appear to be effected by the runway configuration and terminal locations of the particular airports used.

6. REFERENCES.

1. Naval Air Development Center Technical Report, NADC-ST-6706, "The Standard ASD Photographic Method for Determining Airplane Behavior and Piloting Technique During Field or Carrier Landings," January 27, 1968.

2. Naval Air Warfare Center Aircraft Division, Warminster, PA, technical report 941034-60, "Naval Aircraft Approach and Landing Data Acquisition System (NAALDAS) Video Landing System Shipboard Performance Evaluation," 4 September 1994.

3. Naval Air Warfare Center Aircraft Division, Warminster, PA, technical report 93004-60, "Naval Aircraft Approach and Landing Data Acquisition System (NAALDAS) Video Landing System Land-Based Evaluation," 15 April 1993.

4. Micklos, R. and DeFiore, T., "Methods for Experimentally Determining Commercial Jet Aircraft Landing Parameters from Video Image Data," FAA report DOT/FAA/CT-93/7, August 1993.

5. Title 14 Code of Federal Regulations Part 25, Aeronautics and Space, Airworthiness Standards: Transportation Category Airplanes.

6. Barnes, T., DeFiore, T., and Micklos, R., "Video Landing Parameter Survey—John F. Kennedy International Airport," FAA report DOT/FAA/AR-96/125, July 1997.

APPENDIX A—BOX-AND-WHISKER PLOTS

A box-and-whisker plot can be useful for handling many data values. They allow people to explore data and to draw informal conclusions when two or more variables are present. Box and whisker plots are a contemporary tool, which provides pictorial representations for making informal comparisons of the range and location of multiple data sets. It shows only certain statistics rather than all the data. *Five-number summary* is another name for the visual representations of the box-and-whisker plot. The five-number summary consists of the median, the quartiles, and the smallest and greatest values in the distribution. Immediate visuals of a box-and-whisker plot are the center, the spread, and the overall range of distribution.

The first step in constructing a box-and-whisker plot is to first find the *median,* the *lower quartile* and the *upper quartile* of a given set of data. Example: The following set of numbers is the amount of marbles fifteen different boys own (they are arranged from least to greatest).

18 27 34 52 54 59 61 68 78 82 85 87 91 93 100

- First find the *median.* The *median* is the value exactly in the middle of an ordered set of numbers.

68 is the median

- Next, we consider only the values to the left of the median: 18 27 34 52 54 59 61. We now find the median of this set of numbers. Remember, the median is the value exactly in the middle of an ordered set of numbers. Thus 52 is the median of the scores, which are less than the median of all scores, and therefore is the *lower quartile.*

52 is the lower quartile

- Now consider only the values to the right of the median: 78 82 85 87 91 93 100. We now find the median of this set of numbers. The median 87 is therefore called the *upper quartile.*

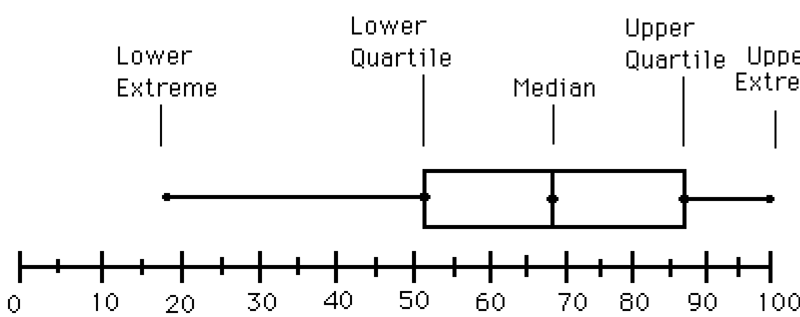
87 is the upper quartile

([*]If you're finding the median in an ordered set with an even number of values, you must take the average of the two middle numbers. For example: 3, 5, 7, and 10. Add the two middle numbers. 5 + 7 = 12. Divided 12 by 2 to get the average. 12 / 2 = 6. Therefore 6 is the median for the ordered set of 3, 5, 7, and 10.)

- One is now ready to find the *inter-quartile range (IQR).* The inter-quartile range is the difference between the upper quartile and the lower quartile. In our case the IQR = 87 - 52 = 35. The IQR is a very useful measurement. It is useful because it is less influenced by extreme values; it limits the range to the middle 50% of the values.

35 is the inter-quartile range

Now we begin to draw our graph:



[*] Article copied from: http://ellerbruch.nmu.edu/cs255/jnord/boxplot.html

APPENDIX B—FEDERAL AVIATION ADMINISTRATION VIDEO LANDING PARAMETER SURVEY—LANDING LISTINGS

TABLE B-1. LANDING DATA MODEL SAAB 2000 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
23	108.9	103.7	3.4	1.6	2.5	801	-10	1.4	-0.4	12.8	5.2
153		119.5	1.1	0.9	1.0	647	-3	0.2	0.0	3.7	0.0
194	121.9	120.3	2.3	3.8	3.1	583	-3	1.8	-2.7	4.4	1.6
239	123.2	119	3.6	5.1	4.6	524	0	2.7	0.0	-4.1	4.2
377	115.7	119.7	9.3	9.0	9.2	910	-5	5.0	-4.7	-9.0	-4.0

TABLE B-2. LANDING DATA MODEL DORNIER 328 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
46	126.4	120.4	1.7	0.9	1.3	634	2	2.1	0.2	-3.0	6.0
130	105.9	107.3	3.8	3.7	4.1	479	0	4.8	-4.8	0.4	-1.4
260	126.0	121.9	1.6	5.0	3.3	747	-3	0.9	0.9	-2.2	4.1
303	102.7	100.3	0.6	-0.8	1.8	640	-1	0.9	-3.5	-2.5	2.4
355	76.5	75.0	2.2	0.8	1.5	742	-18	5.8	-2.2	0.2	1.5

TABLE B-3. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
8	105.6	100.6	7.3	7.4	7.6	350	-4	3.8	-2.3	-0.2	5.0
19	106.9	106.9	2.5	3.0	2.8	408	0	5.6	0.7	-0.4	0.0
28	98.1	98.1	2.0	2.4	2.3	604	2	5.0	0.3	-9.5	0.0
56	115.1	108.1	5.2	4.9	5.1	507	-1	6.1	-4.2	-2.4	7.0
78		106.3	8.1	7.0	7.5	497	-4	5.6	-2.2	-5.8	
87	99.9	93.1	1.5	4.1	3.9	518	4	6.2	2.6	-13.3	6.8
111	106.1	109.6	0.3	1.2	0.0	691	-1	4.9	-2.1	-2.9	-3.5
124	106.4	100.6	4.2	4.8	4.8	659	6	7.5	4.4	-3.3	5.8
135	119.7	117.7	2.1	1.4	1.8	927	0	6.1	-1.3	-1.4	2.0
150	114.8	113.1	0.5	0.9	0.3	820	-3	5.7	-2.5	-1.6	1.7
156	103.7	101.4	1.2	0.5	0.8	626	0	6.0	0.4	2.1	2.3
165	110.5	108.4	0.8	1.9	1.4	743	-9	6.7	-0.6	6.4	2.1
189	110.2	110.2	0.9	3.0	1.9	771	-4	7.3	-2.4	2.9	0.0
242	96.7	93.2	2.2	3.3	2.8	712	1	7.3	0.8	-3.0	3.5
251	105.1	99.3	0.6	0.8	0.8	679	0	7.8	2.7	-1.8	5.8
278	104.5	100.6	2.6	1.5	2.3	538	-4	7.1	-2.4	2.0	3.9
298	82.8	79.0	5.7	3.2	4.1	548	-5	9.2	-3.3	-3.7	3.8
306	125.4	118.3	1.5	1.5	1.5	636	-5	3.4	-3.2	-14.2	7.1
331	98.8	101.5	3.8	1.5	3.2	523	0	7.3	-2.5	-4.1	-2.7
343	114.1	108.6	2.3	1.8	2.1	686	-2	4.6	3.2	-1.0	5.5
370	102.7	106.7	3.8	2.3	3.3	552	-2	7.5	-2.4	-4.9	-4.0
380	102.1	105.1	0.7	0.9	0.6	657	-6	5.5	-3.1	-3.2	-3.0
402	108.7	105.9	2.0	2.8	2.5	741	-1	6.8	1.7	-5.4	2.8

TABLE B-4. LANDING DATA MODEL FOKKER 50 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
1	103.0	99.0	1.9	1.7	1.8	630	-4	-0.1	-2.6	-7.6	4.0
6	88.5	83.5	3.1	3.8	3.4	588	1	0.1	-1.0	-10.4	5.0
16	100.9	89.9	3.8	5.1	4.6	480	3	3.4	-0.5	-2.3	11.0
33	96.9	96.9	2.1	4.0	3.1	465	4	1.8	1.2	-0.3	
37	86.2	82.7	2.5	4.0	3.9	409	4	1.6	1.1	-0.6	3.5
40	97.0	94.5	4.3	1.6	2.9	557	-3	2.7	0.3	-11.0	2.5
41	110.3	109.1	4.2	4.2	4.2	255	15	2.9	-1.5	-6.6	1.2
48	89.6	87.7	1.8	2.4	2.3	532	0	1.8	-0.8	-2.7	1.9
53	84.7	77.9	0.4	2.4	2.2	824	-3	4.4	1.0	-11.6	6.8
64	92.4	90.7	0.5	1.8	0.2	451	1	3.1	2.5	-11.7	1.7
65	77.9	76.9	0.8	1.7	0.9	633	-1	3.1	-0.9	-11.2	1.0
66	93.2	91.7	0.6	1.2	0.9	707	-3	-0.1	1.4	-10.3	1.5
84	86.3	84.2	0.8	1.0	0.9	718	-4	1.6	-0.4	-14.0	2.1
85	91.2	83.9	1.0	1.0	0.8	806	-4	1.9	-3.4	-9.0	7.3
86	88.3	79.6	0.6	1.2	0.8	699	-1	2.4	-1.2	-9.2	8.7
94	95.3	99.1	3.3	2.6	2.9	346	-4	3.1	-5.7	-1.1	-3.8
108	84.3	91.7	4.3	2.5	3.7	491	-4	0.2	-4.7	-4.8	-7.4
113	84.5	88.9	0.7	0.6	0.4	611	-5	0.4	1.4	-0.8	-4.4
123	103.2	94.0	3.2	2.3	2.4	424	-1	1.6	0.7	-0.2	9.2
129	97.8	96.2	1.5	1.4	1.4	562	-1	0.1	0.1	1.8	1.6
132	99.8	101.2	1.6	2.6	2.1	760	0	3.6	-0.3	-0.2	-1.4
133	98.5	95.1	1.4	0.4	1.0	624	0	0.4	-0.9	1.3	3.4
144	112.7	110.6	2.1	1.8	2.6	686	-11	0.8	-0.7	0.1	2.1

TABLE B-4. LANDING DATA MODEL FOKKER 50 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
147	98.1	96.0	2.4	2.0	2.2	601	-1	2.4	-0.4	1.8	2.1
157	93.7	90.8	1.3	1.2	1.3	445	2	1.2	-0.3	2.3	2.9
160	101.1	101.1	1.2	0.7	1.0	765	0	1.3	0.1	0.6	0.0
186	84.9	92.9	3.2	2.5	3.0	784	-4	2.8	-1.2	2.1	-8.0
187	89.7	101.0	3.4	3.7	3.5	598	-8	-1.1	-0.9	6.1	-11.3
191	102.8	102.8	6.2	4.5	5.4	538	-12	2.4	-5.2	5.4	0.0
199	95.7	95.7	6.8	4.9	6.7	77	-6	2.5	-2.4	3.3	0.0
204	107.6	111.0	4.1	5.5	5.2	581	-11	-0.1	0.0	2.0	-3.4
207	102.4	105.8	4.5	4.6	4.7	557	-1	2.6	-2.1	1.8	-3.4
208	97.6	98.5	3.9	3.2	4.0	844	-2	2.2	-2.1	3.1	-0.9
228	98.3	92.7	3.7	2.5	3.1	573	3	2.0	-0.3	2.8	5.6
229	97.0	94.1	1.4	0.1	0.8	941	-3	3.1	-1.2	-7.4	2.9
232	90.7	86.7	2.0	1.3	2.0	757	-5	5.8	-1.5	1.9	4.0
233	94.8	87.3	3.1	2.8	2.9	487	4	2.8	2.1	4.3	7.5
241	90.8	84.8	0.8	0.9	0.9	635	1	3.0	4.0	1.4	6.0
244	101.8	98.3	1.4	1.8	1.5	720	3	2.0	1.6	0.5	3.5
245	99.7	94.3	0.4	0.2	0.2	906	-1	0.2	-1.4	-5.4	5.4
252	99.9	92.9	0.4	0.3	0.3	898	-5	1.0	1.9	-7.4	7.0
262	90.7	85.1	0.8	0.7	0.8	648	-3	2.5	-1.2	0.0	5.6
274	83.9	84.2	0.5	2.1	1.7	685	-2	2.6	1.3	-2.7	-0.3
275	96.9	89.7	1.8	2.7	2.6	385	-1	0.7	-0.6	-0.7	7.2
276	92.1	88.1	1.4	0.6	1.0	558	-2	1.3	-3.1	4.2	4.0
279	97.1	92.1	4.8	4.2	4.6	862	-2	5.3	1.2	-7.8	5.0

TABLE B-4. LANDING DATA MODEL FOKKER 50 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
286	83.2	79.9	2.9	0.5	2.4	597	-1	0.7	-2.5	4.1	3.3
288	92.4	90.4	0.6	0.4	0.5	747	-4	5.0	-0.2	0.2	2.0
295	87.3	79.6	2.4	1.5	1.8	455	-8	2.2	-2.5	1.3	7.7
304	103.9	98.2	1.7	2.4	2.0	471	-4	2.6	-5.1	0.2	5.7
305	90.9	89.2	2.8	3.5	3.4	778	-2	1.8	-1.5	-4.0	1.7
313	85.4	83.0	4.4	3.2	3.9	671	-3	2.9	-1.0	-4.1	2.4
317	97.8	101.2	1.9	3.1	2.5	656	-8	0.2	-1.4	-6.0	-3.4
316	86.5	91.4	5.1	3.9	4.4	210	3	7.3	-3.2	1.1	-4.9
323	97.8	100.2	1.2	0.2	1.0	696	3	-4.5	2.9	-10.9	-2.4
327	108.6	106.0	5.0	5.3	4.7	842	-12	3.9	-2.4	-4.7	2.6
329	99.8	98.6	1.6	1.1	1.4	800	-4	2.7	-2.7	-5.3	1.2
334	93.2	93.8	3.8	2.6	3.2	498	-4	5.2	-3.3	2.3	-0.6
341	97.7	92.2	2.0	1.4	1.5	887	-2	3.4	-4.0	-1.8	5.5
342	103.7	99.1	1.4	1.5	1.5	559	4	1.6	-0.7	-1.6	4.6
351	90.5	91.7	2.3	1.9	2.1	560	-3	2.7	-2.2	1.9	-1.2
354	95.8	93.7	2.0	2.7	2.6	944	-6	3.2	-1.6	-11.4	2.1
366	111.6	107.4	1.4	1.4	1.4	439	2	0.4	-2.2	-5.4	4.2
368	83.8	84.6	1.5	1.6	1.7	798	-6	3.3	0.1	-4.0	-0.8
371	94.3	90.5	2.1	1.3	1.8	680	-1	3.8	-1.0	-2.7	3.8
378	99.6	100.9	0.8	1.2	0.9	932	-5	3.6	-1.5	-10.0	-1.3
379	93.8	90.7	0.1	0.8	0.7	424	4	1.6	-3.6	-3.5	3.1
383	96.8	93.3	1.6	2.6	2.1	475	5	3.7	-0.4	1.5	3.5
384	95.6	94.0	3.0	2.4	2.8	382	3	1.0	-2.7	-2.0	1.6
389	87.4	89.1	5.9	4.2	4.4	557	-2	0.5	-6.8	-6.5	-1.7
391	96.2	96.2	2.9	2.3	2.6	584	-4	3.2	-5.2	0.3	0.0
400	92.2	90.5	1.2	1.7	1.5	791	-6	3.3	0.1	-1.3	1.7

TABLE B-5. LANDING DATA MODEL FALCON AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
24	98.7	94.2	0.5	0.6	0.5	584	-5	3.3	0.4	-14.7	4.5
55	89.9	85.2	3.4	2.6	3.0	506	-4	7.1	-2.0	1.9	4.7
122	112.8	107.1	2.3	4.2	3.6	822	8	6.1	3.0	-9.1	5.7
201	118.8	118.8	1.6	1.8	2.1	992	10	5.2	-3.9	2.6	0.0
319	84.1	88.1	2.4	2.6	2.4	380	-7	9.4	-2.3	-2.4	-4.0

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
5	137.2	133.2	3.5	1.1	2.3	569	-2	4.8	-1.1	-13.2	4.0
7	112.5	106.5	2.6	3.4	3.0	610	-1	6.7	-2.8	-8.5	6.0
10	92.9	86.9	1.2	0.6	0.9	532	-1	3.8	1.1	-13.4	6.0
11	120.3	116.3	2.9	2.8	2.9	547	-4	3.4	-1.5	-2.1	4.0
12	120.4	113.4	2.4	2.5	2.5	549	1	3.9	-2.1	-5.9	7.0
13	92.6	84.6	2.7	2.3	2.6	641	-3	2.4	-1.6	-12.9	8.0
15	121.0	113.0	2.7	2.8	2.7	513	8	6.4	-0.7	-4.9	8.0
17	122.0	122.0	3.9	4.4	4.1	545	2	1.7	1.4	-10.7	0.0
18	96.9	88.2	2.2	2.2	2.2	36	2	0.1	-5.3	5.2	8.7
20	119.2	104.7	2.5	3.5	3.0	630	-2	1.1	1.0	-8.2	14.5
21	112.9	106.0	3.3	3.4	3.4	545	-2	1.2	-2.6	-9.2	6.9
22	106.6	100.3	4.6	4.6	4.6	203	4	4.4	-2.4	6.5	6.3
25	80.8	77.0	1.6	1.9	1.7	743	2	0.5	1.1	-5.6	3.8
26		109.2	0.3	0.6	0.4	697	-7	1.0	0.3	-11.7	
32	124.5	117.9	3.7	2.4	3.1	399	-4	3.8	0.7	-2.0	6.6
34	117.8	112.2	2.5	2.9	2.7	765	-3	1.9	0.1	-10.6	5.6
35	119.6	111.9	3.2	6.1	4.7	471	6	5.7	-1.7	-2.7	7.7
36		106.6	4.5	5.0	4.8	437	-1	1.3	-1.2	-8.6	
39	100.6	97.6	2.4	3.3	2.8	847	-2	3.6	1.1	-12.8	3.0
44	123.8	114.0	2.2	2.7	2.5	505	-2	0.7	0.3	-11.6	9.8
45	112.8	106.7	1.0	0.9	0.9	915	-2	0.5	-1.5	-8.0	6.1
57	122.1	117.2	0.3	1.2	0.8	644	-2	3.8	-2.5	-5.0	4.9
58	99.3	93.7	2.6	3.6	3.1	530	-1	4.2	1.1	-12.2	5.6

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
59	116.1	111.4	3.3	2.1	2.7	507	-2	3.6	-2.0	-1.5	4.7
63	101.1	96.8	2.6	4.8	4.0	747	-1	3.4	3.0	-10.1	4.3
69	119.3	116.2	9.9	10.4	10.1	836	11	4.7	-1.1	-7.1	3.1
72	119.9	120.1	3.0	3.3	3.2	468	-3	3.6	0.4	-11.2	-0.2
74	112.6	109.1	3.9	3.7	3.8	413	0	1.0	-4.0	-0.1	3.5
75	101.9	98.4	4.3	3.6	4.1	817	4	5.4	0.8	-11.5	3.5
81	113.6	106.7	1.6	1.4	1.5	659	3	6.6	-0.3	-11.5	6.9
82	113.6	105.9	4.7	5.6	5.2	533	-3	3.7	-1.1	-13.2	7.7
91	99.9	93.5	3.9	5.2	4.5	471	-1	4.0	0.3	-16.8	6.4
92	108.9	104.7	3.3	1.8	2.5	435	0	1.4	-5.3	-0.3	4.2
112	114.1	120.4	1.1	2.5	1.8	850	5	2.3	-0.4	-4.7	-6.3
114	104.5	99.7	3.5	5.1	3.1	190	-2	3.2	1.9	1.4	4.8
115	107.4	103.2	2.1	2.6	2.4	480	5	0.9	2.8	-3.2	4.2
139	112.9	110.6	1.8	0.2	1.0	437	1	2.5	-1.4	0.4	2.3
151	100.4	96.9	0.3	1.2	0.8	654	-3	4.3	-0.9	3.8	3.5
170	126.3	123.8	1.9	1.5	1.7	780	-2	1.1	0.2	1.1	2.5
180	110.2	105.8	4.4	4.6	4.5	363	2	0.5	0.1	1.2	4.4
182	123.9	125.3	3.2	3.2	3.2	393	8	6.5	0.3	-0.6	-1.4
183	108.5	109.3	2.7	1.4	2.1	586	5	-0.2	13.0	2.6	-0.8
184	124.0	124.0	8.0	6.3	7.6	399	-1	3.3	-3.3	8.7	0.0
185	110.4	117.2	5.8	1.4	5.4	400	-3	3.3	-2.7	9.6	-6.8
190	104.0	102.9	7.8	5.9	7.1	113	-13	2.7	-6.3	2.5	1.1
192	114.1	118.9	4.2	4.1	4.1	562	6	0.0	0.0	-2.7	-4.8

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
195	119.8	116.2	0.3	0.2	0.3	483	-1	3.3	-3.4	3.6	3.6
197	126.8	126.8	5.1	5.4	5.3	782	-2	2.0	-1.2	0.8	0.0
200	127.2	124.1	1.1	3.1	2.1	965	-5	-0.8	0.1	5.6	3.1
202	132.0	128.6	6.2	4.3	5.9	285	-10	5.6	-3.1	4.6	3.4
205	121.9	123.8	2.8	2.8	2.8	507	6	-1.6	1.9	5.4	-1.9
210	96.5	100.7	4.9	3.4	4.1	532	-6	4.2	-2.4	1.6	-4.2
211	110.1	106.7	0.9	2.2	1.6	681	0	6.1	1.1	2.8	3.4
213	120.5	126.0	5.3	7.9	7.7	573	-8	0.2	-0.2	2.0	-5.5
214	123.4	118.3	2.5	2.4	2.4	644	-12	0.5	-1.7	4.3	5.1
224	118.8	114.7	3.1	4.7	3.9	539	-2	1.7	-0.6	-1.1	4.1
227	122.7	114.9	2.6	0.6	2.5	597	-4	4.2	-2.9	-3.1	7.8
230	118.8	114.2	3.8	2.4	3.3	817	5	0.0	0.6	-2.6	4.6
235	116.8	113.8	3.4	4.0	3.7	613	4	5.7	-1.1	-6.9	3.0
236	113.2	110.0	5.1	4.5	5.2	528	-1	3.3	0.1	1.3	3.2
237	106.3	99.4	2.7	1.7	2.2	639	5	4.2	-0.5	-0.8	6.9
238	111.3	107.3	3.8	2.5	3.1	452	0	4.4	-0.9	1.9	4.0
240	112.0	109.9	3.1	4.3	4.0	335	6	2.8	-0.9	1.8	2.1
243	115.6	111.8	2.1	0.6	1.0	720	-1	-0.1	-0.4	1.3	3.8
246	114.5	112.0	4.0	3.6	3.8	350	9	2.1	-2.0	4.6	2.5
247	110.0	106.6	5.0	2.3	4.1	400	-5	4.8	-3.1	3.9	3.4
248	111.7	107.6	2.9	3.2	3.1	516	2	3.4	-2.6	-0.5	4.1
249	121.7	115.7	1.7	2.5	2.1	198	-1	2.4	-1.2	-5.6	6.0
253	107.6	100.8	0.8	2.0	2.1	693	2	3.0	1.9	-0.1	6.8

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
254	110.0	103.6	3.7	3.7	3.7	424	-1	2.8	0.1	4.0	6.4
255	119.0	113.3	0.8	1.4	1.1	973	-5	2.8	1.2	-9.4	5.7
256	118.7	112.8	2.5	2.0	2.4	462	9	4.1	-1.3	-3.3	5.9
257	116.9	112.7	2.2	2.7	2.4	537	0	1.1	-2.7	-2.4	4.2
265	120.5	118.0	3.0	3.1	3.2	628	-1	4.2	-2.2	-8.5	2.5
270	110.4	109.1	3.1	3.3	3.2	531	1	2.3	-2.6	-4.9	1.3
271	111.8	107.7	4.1	4.6	4.6	290	3	4.1	-1.5	-0.7	4.1
272	101.6	99.9	2.3	3.5	2.4	335	-5	4.6	-6.1	0.1	1.7
273	119.9	116.0	1.3	1.1	1.1	480	0	3.3	-0.6	-4.0	3.9
277	97.9	93.6	6.1	6.5	6.2	465	-2	3.6	0.9	0.6	4.3
280	110.2	105.4	6.1	5.0	5.5	315	0	1.9	-2.1	-0.1	4.8
281	97.6	93.0	2.8	0.6	1.7	440	6	3.9	0.2	-3.9	4.6
282	108.5	103.3	2.4	3.9	3.3	320	8	3.9	-2.7	-0.8	5.2
283	108.9	105.4	5.6	3.9	4.8	454	-3	0.8	-3.8	-1.8	3.5
284	119.5	116.0	2.0	1.9	1.9	989	-8	0.9	-0.9	-14.5	3.5
290	132.9	125.8	2.1	0.7	1.5	494	-3	4.3	-2.1	-1.7	7.1
292	108.9	100.5	3.5	2.7	2.7	591	-3	2.0	-1.2	1.3	8.4
293	109.1	105.3	4.5	3.5	4.0	281	1	0.6	-2.2	-3.9	3.8
297	103.2	96.3	2.0	1.5	1.6	608	-10	6.0	-0.6	-6.2	6.9
299	100.4	97.9	4.3	3.0	3.5	387	1	6.0	-4.3	0.1	2.5
300	114.6	112.2	1.8	3.2	2.3	640	-3	1.1	-0.5	-4.1	2.4
301	116.5	115.7	4.1	5.2	4.7	393	2	5.1	-1.0	-4.9	0.8
307	115.5	113.4	6.0	4.7	5.3	302	9	5.8	-0.8	-2.0	2.1

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)						
308	94.7	98.2	3.68	1.98	3.20	603	-11	4.4	-1.8	-2.6	-3.5
309	106.9	109.2	0.42	1.24	2.08	757	-10	4.9	-2.4	-3.4	-2.3
310	112.3	109.8	0.66	2.58	0.76	782	-7	4.2	-2.3	-7.5	2.5
311	120.1	114.7	5.14	1.78	3.46	321	-1	3.1	-5.1	0.3	5.4
312	91.2	87.8	9.28	8.00	8.55	159	4	4.8	-4.8	1.1	3.4
314	92.8	92.1	3.05	2.77	2.68	735	-2	5.4	-2.0	-1.3	0.7
315	110.5	108.9	4.26	1.91	3.95	422	-4	3.8	-4.0	-0.6	1.6
318	100.9	104.9	5.98	4.64	4.94	675	2	1.9	-1.6	-5.0	-4.0
321	108.1	111.2	4.18	2.72	3.45	473	2	3.0	-2.3	-5.9	-3.1
322	97.9	105.0	6.37	3.73	5.18	647	-3	2.3	-4.2	-3.2	-7.1
324	109.9	111.5	4.28	1.17	3.09	409	-4	7.4	-4.7	-3.3	-1.6
326	98.1	104.2	2.25	1.62	2.02	407	0	3.0	-7.1	0.5	-6.1
333	160.9	164.9	7.52	7.78	7.76	390	-5	6.5	-2.0	-5.1	-4.0
335	92.2	96.7	4.20	1.91	3.85	551	-2	3.1	-4.1	-1.8	-4.5
336	102.9	108.4	5.98	6.40	6.19	239	-1	8.2	-1.5	-3.5	-5.5
337	108.6	112.1	6.23	5.54	5.94	380	0	2.5	-6.1	-1.2	-3.5
338	105.3	106.9	8.39	7.21	7.58	350	0	5.2	-5.1	-6.6	-1.6
344	125.3	123.0	0.11	2.23	1.81	696	-4	2.6	2.5	-2.1	2.3
345	118.2	121.3	7.10	4.19	6.76	472	-2	6.9	-6.8	-4.6	-3.1
346	103.3	103.3	3.53	3.55	3.26	399	-4	5.4	-3.6	-5.7	0.0
348	94.2	97.2	6.52	4.79	5.66	295	-2	5.6	-6.1	-2.6	-3.0
349	114.9	113.9	2.58	2.02	2.48	567	-2	3.5	-2.4	-5.8	1.0
356	116.8	116.8	3.60	2.86	3.33	406	0	3.7	-2.5	-3.1	0.0

TABLE B-6. LANDING DATA MODEL BAe 146 AIRCRAFT
FAA SURVEY—LONDON CITY AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)
358	109.8	106.0	2.85	2.04	2.13	560	-9	4.0	-3.4	0.0	3.8
359	112.5	110.9	3.97	1.49	4.24	796	-4	2.8	-2.3	-2.6	1.6
360	106.6	113.5	3.74	2.67	3.33	399	6	2.9	-4.8	-1.9	-6.9
361	113.8	113.8	0.00	0.30	0.10	541	0	1.0	-1.7	-3.8	0.0
363	102.0	104.6	2.38	0.84	1.67	505	2	3.5	-2.1	-1.3	-2.6
369	111.4	113.0	4.82	2.39	4.2	504	0	3.2	-5.5	-7.5	-1.6
372	86.5	88.1	3.37	1.46	2.55	561	-3	2.0	-4.7	-3.3	-1.6
373	105.8	106.4	6.96	5.30	6.63	278	5	4.3	-4.9	-3.2	-0.6
375	92.7	94.4	2.56	1.93	2.31	568	-8	3.1	-4.0	0.9	-1.7
376	83.2	79.4	3.20	6.51	4.55	738	-2	3.2	3.3	0.3	3.8
381	117.7	119.6	1.51	2.26	1.69	849	-3	1.8	1.8	-10.8	-1.9
382	114.7	113.1	7.19	5.23	6.78	180	4	5.8	-3.1	-5.1	1.6
385	113.4	109.5	1.64	2.23	1.81	641	-6	1.6	-1.1	-3.0	3.9
387	106.4	104.3	2.76	1.78	2.71	425	-6	4.3	-0.7	1.7	2.1
392	107.2	107.2	2.35	1.48	2.17	870	-1	4.1	-0.3	-9.0	0.0
398	103.8	101.9	1.04	1.23	1.14	831	-6	4.3	0.1	-5.4	1.9
403	113.6	109.7	4.12	4.14	4.01	663	-2	4.9	-2.3	-1.4	3.9
404	99.1	96.5	1.70	1.82	0.87	526	-7	4.0	-2.8	2.3	2.6
405	108.1	105.4	2.49	3.48	3.11	692	-2	3.5	-1.0	1.4	2.7
406	90.7	90.2	0.37	1.28	1.29	636	0	2.5	-0.8	3.0	0.5
407	124.9	121.9	3.20	3.08	3.14	213	6	3.4	-1.6	1.5	3.0
408	108.9	105.1	3.27	3.55	3.26	951	-3	4.1	-1.2	-9.5	3.8
409	96.3	92.5	3.69	2.54	3.40	479	-3	2.5	0.9	2.1	3.8
414	122.1	116.1	7.40	7.31	7.32	287	1	-0.1	-1.5	1.9	6.0
416	111.2	106.3	0.50	1.16	0.45	853	1	2.5	-1.6	-3.7	4.9
429	100.6	106.5	2.07	3.94	3.01	487	-3	5.9	-0.9	-0.7	-5.9

TABLE B-7. LANDING DATA MODEL SAAB 340 AIRCRAFT
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Stbd. (fps)	Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. knots)	Wind Perp. (knots)
23	103.5	95.5	1.9	1.9	1.9	970	0	3.3	0.5	1.3	8.0	-0.7
41	98.3	94.8	0.9	1.1	1.0	1046	0	4.4	-1.1	4.0	3.5	-3.5
54	110.9	108.0	1.2	2.6	1.6	1247	1	2.3	0.8	0.9	2.9	-4.1
55	120.0	115.5	2.0	1.1	0.8	497	0	3.4	-3.2	-1.5	4.5	-5.4
68	112.3	109.7	3.2	2.6	3.0	1261	-1	4.2	0.6	1.2	2.6	
94	111.9	109.1	2.9	0.2	1.7	1763	1	1.8	0.5	0.9	2.8	-2.8
114	109.8	107.2	1.6	1.4	1.0	1265	1	3.7	-1.2	-2.2	2.6	-3.1
120	103.0	104.8	2.5	2.9	3.0	991	1	2.5	0.7	-1.1	-1.8	-6.8
141	111.7	109.0	1.6	1.6	1.6	1305	-2	2.5	0.9	-1.2	2.7	7.5
151	109.5	112.3	0.8	0.2	0.5	1073	4	4.1	2.4	-1.3	-2.8	10.6
200	105.5	97.0	2.1	1.9	2.3	1192	3	3.3	2.2	-2.2	8.5	3.1
214	102.4	101.0	1.1	0.5	0.5	1619	-2	3.2	0.8	3.0	1.4	-3.8
235	111.4	103.9	1.6	2.4	2.0	947	-2	4.2	1.4	-2.1	7.5	2.7
236	114.2	106.5	1.8	1.8	2.0	903	7	2.8	0.0	-4.1	7.7	6.4
240	110.2	109.2	0.6	1.0	0.8	1072	5	3.8	0.3	-2.2	1.0	5.9
254	112.0	111.1	2.2	3.6	3.0	413	7	7.2	2.8	-2.1	0.9	0.4

TABLE B-8. LANDING DATA MODEL BEECH 1900D AIRCRAFT
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. knots)	Wind Perp. (knots)
1	112.1	108.6	1.5	2.4	1.9	1235	-2	1.3	-2.4	0.8	3.5	-3.5
6	104.9	100.7	1.7	1.5	1.6	1319	-9	5.6	-3.1	0.1	4.2	-4.2
7	96.4	90.4	0.7	0.5	0.7	1421	1	4.5	-0.7	0.8	6.0	0.0
19	105.5	99.9	1.2	0.5	1.0	1287	-1	3.9	-0.3	0.1	5.6	-2.1
20	106.0	103.7	1.0	1.4	1.2	1296	-3	4.0	-0.4	0.9	2.3	-1.9
22	107.6	102.6	1.8	1.1	1.4	1361	1	3.2	-3.2	-2.1	5.0	0.4
25	105.3	100.5	1.5	1.3	1.8	1747	1	4.2	-0.1	-1.2	4.8	-1.3
29	102.8	99.3	0.3	0.2	0.3	1680	1	3.8	0.3	1.6	3.5	-2.0
39	105.3	100.4	1.0	0.1	0.6	1440	-5	3.9	-0.4	2.0	4.9	-3.4
40	104.3	102.8	1.5	1.8	1.8	1030	-4	4.9	-1.1	2.9	1.5	-2.6
45	96.0	89.0	0.6	0.2	0.9	1641	-2	2.9	-2.9	1.8	7.0	0.6
60	104.9	104.2	1.2	1.8	1.5	1068	0	2.3	0.6	2.3	0.7	-1.9
62	96.3	95.8	1.3	0.2	0.8	1269	-3	5.3	-0.8	2.4	0.5	-3.0
64	103.6	102.1	1.4	1.6	1.7	1273	-1	4.8	-0.1	-0.3	1.5	-2.6
73	103.1	99.6	0.7	1.0	0.8	1418	0	3.4	-0.3	1.4	3.5	-3.5
74	112.1	107.5	3.6	2.2	2.9	1385	-5	3.1	-1.0	2.7	4.6	-3.9
82	104.7	101.3	1.2	1.9	1.5	1284	-2	5.0	-1.5	2.4	3.4	-4.9
85	111.1	106.6	1.0	1.1	1.1	1455	1	3.1	-0.6	1.7	4.5	-5.4
90	100.1	96.2	1.1	0.9	0.6	1189	-3	3.2	-1.1	4.3	3.9	-4.6
91	100.4	96.4	1.7	1.2	1.6	1560	-1	3.8	0.5	3.0	4.0	-6.9
93	100.1	100.4	1.8	1.7	2.3	858	-3	1.9	-0.6	1.2	-0.3	-3.0
98	114.1	110.0	2.6	1.0	1.8	1402	-2	1.8	-2.7	1.7	4.1	-2.9
103	102.8	100.5	1.6	2.5	2.1	1362	-3	5.6	0.1	2.5	2.3	-1.9

TABLE B-8. LANDING DATA MODEL BEECH 1900D AIRCRAFT
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
110	105.8	103.1	1.9	2.3	1.8	1312	-1	2.5	-0.4	2.5	2.7	-1.3
111	104.6	100.5	2.1	2.6	2.3	1416	-1	5.2	-0.8	1.6	4.1	-2.9
113	93.9	92.2	3.5	3.0	2.6	1145	-3	5.3	-2.5	1.1	1.7	-4.7
116	100.5	98.8	1.0	1.2	1.1	1292	0	4.0	-0.2	-0.5	1.7	-4.7
117	106.8	103.0	1.1	1.3	1.2	1416	0	2.8	-2.5	-0.9	3.8	-3.2
119	104.8	102.5	0.8	0.5	0.7	1284	0	4.7	-2.0	0.4	2.3	-3.3
128	107.3	99.6	1.9	0.5	0.8	1310	-2	1.0	1.9	0.7	7.7	6.4
139	101.8	95.8	0.5	1.6	1.0	1265	2	4.4	5.0	-1.7	6.0	10.4
142	113.6	107.1	2.5	1.8	2.1	1093	3	3.4	0.4	-1.5	6.5	11.3
143	105.2	101.1	3.6	2.3	2.3	1416	2	4.0	3.6	-2.9	4.1	11.3
150	108.3	107.3	0.9	1.1	1.0	980	7	4.7	2.5	0.3	1.0	5.9
159	100.2	99.2	1.3	2.7	2.3	1375	0	4.9	4.6	-1.3	1.0	12.0
163	108.1	101.2	1.9	0.6	1.3	1781	-1	3.5	2.6	-1.7	6.9	9.8
166	107.4	101.9	2.2	2.6	2.3	1351	0	2.3	1.9	-2.0	5.5	9.5
171	105.6	104.8	2.5	1.7	2.1	870	1	1.2	3.4	-4.3	0.8	9.0
176	104.7	110.5	0.9	1.2	1.0	1437	3	2.4	0.8	-3.5	-5.8	6.9
178	114.1	117.5	2.1	2.6	2.3	1411	6	2.3	3.0	-3.4	-3.4	9.4
180	97.4	94.4	0.9	0.6	0.7	901	1	4.6	-0.2	0.3	3.0	-0.5
181	104.8	102.8	0.6	0.9	0.9	1014	-1	2.3	0.8	1.6	2.0	-0.3
183	107.5	103.6	1.0	1.2	1.1	1420	-1	4.7	0.6	2.0	3.9	0.7
184	105.6	102.6	0.5	0.3	0.4	1435	-1	1.8	-0.7	-0.7	3.0	0.5
186	101.6	98.6	0.8	1.1	0.8	772	1	3.5	-0.6	0.2	3.0	-0.5
190	92.0	100.2	1.7	1.4	1.6	1019	3	2.4	2.0	-2.5	-8.2	-3.8

TABLE B-8. LANDING DATA MODEL BEECH 1900D AIRCRAFT
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
197	108.0	96.0	0.7	0.7	0.8	1396	-1	2.8	-0.3	-0.8	12.0	1.0
203	89.3	76.5	1.2	1.2	0.6	1515	0	4.7	1.8	-1.6	12.8	2.3
206	93.3	83.3	1.1	0.8	1.0	1510	-1	1.8	1.0	-0.6	10.0	0.0
207	110.4	99.1	0.6	0.0	0.3	1443	-1	1.0	2.1	0.3	11.3	4.1
210	106.7	102.8	1.2	0.6	0.9	1417	-4	3.5	-2.4	-0.3	3.9	0.7
211	87.1	84.6	0.9	1.3	0.9	1141	-1	3.6	-0.4	0.0	2.5	-1.7
213	112.7	110.7	1.0	0.9	0.9	1432	0	1.7	-1.0	0.7	2.0	-0.3
218	107.1	104.5	2.2	0.9	1.5	1443	3	3.3	1.4	-0.8	2.6	3.1
220	108.6	101.7	1.2	0.2	0.4	886	1	1.4	1.6	0.0	6.9	1.2
226	108.1	99.9	1.7	1.4	1.5	1412	-2	2.1	3.4	1.9	8.2	3.8
228	90.9	86.0	1.6	0.8	0.8	1349	2	3.8	3.1	1.0	4.9	4.9
234	93.6	88.2	0.7	0.3	0.5	1676	-4	6.1	-0.9	0.0	5.4	2.5
238	113.9	112.5	2.5	2.9	3.0	1050	1	4.2	0.9	0.2	1.4	7.9
246	99.3	102.0	1.3	1.1	1.2	1781	0	3.1	3.0	-0.6	-2.7	7.5
251	104.8	107.2	0.8	2.2	1.3	810	1	2.2	2.1	1.7	-2.4	6.6
260	105.7	108.9	1.1	1.4	1.3	1054	2	3.6	0.9	-0.4	-3.2	3.8

TABLE B-9. LANDING DATA MODEL JETSTREAM 41 AIRCRAFT
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
21	105.2	99.8	1.8	1.6	1.7	1652	-2	1.7	0.4	1.9	5.4	-2.5
26	110.1	107.1	3.1	4.0	3.6	579	1	3.0	0.7	1.9	3.0	0.5
71	107.4	107.2	1.6	1.2	1.4	1312	-2	2.9	0.4	2.1	0.2	-1.0
97	114.0	110.0	0.8	0.6	1.1	1285	2	2.6	1.3	4.1	4.0	-5.7
118	99.1	99.6	1.3	1.8	1.4	834	2	3.6	1.1	4.2	-0.5	-6.0
158	107.5	105.4	1.0	2.9	2.7	893	-2	2.1	-0.1	2.3	2.1	7.7
174	106.6	108.5	0.8	1.6	1.7	893	-4	3.8	3.6	1.5	-1.9	10.8
189	106.3	99.5	2.4	4.7	3.6	1221	5	2.8	0.9	-2.1	6.8	1.8
242	107.8	103.3	1.5	1.6	1.5	1192	-3	3.1	-0.7	2.0	4.5	2.1
258	108.9	109.9	1.8	2.2	2.0	1358	0	3.3	3.8	3.2	-1.0	3.9

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
4	98.7	94.7	0.3	2.7	2.3	1339	0	6.6	2.2	1.5	4.0	-0.3
5	84.7	79.1	0.4	0.2	1.1	1192	-2	4.0	1.6	1.5	5.6	-2.1
8	102.8	95.3	1.0	1.8	1.4	1600	4	3.0	-1.1	1.4	7.5	-2.7
9	89.4	82.4	2.0	2.0	2.0	1047	1	3.3	1.8	0.5	7.0	0.0
10	98.8	96.5	2.0	1.8	1.9	1413	-4	4.8	-0.6	0.8	2.3	-1.9
11	86.8	83.9	0.7	2.3	1.5	972	-2	7.3	-1.8	2.8	2.9	-4.1
12	98.7	93.8	3.0	2.7	3.4	1362	-2	5.5	-0.4	1.3	4.9	-0.9
13	86.6	82.8	1.3	1.7	1.5	1700	0	6.9	0.5	0.2	3.8	-1.4
14	97.4	91.8	1.3	3.5	2.6	1652	5	5.0	3.0	1.1	5.6	-2.1
15	77.8	73.8	0.3	2.7	1.5	1223	1	8.4	1.0	-1.2	4.0	0.3
16	99.9	96.0	2.1	2.6	2.9	1254	-3	4.2	0.0	-0.4	3.9	-0.7
17	99.0	94.5	1.2	1.8	1.6	1550	1	4.5	2.0	2.8	4.5	-2.1
18	101.8	99.8	0.8	1.5	1.0	1284	-2	4.3	0.9	-1.0	2.0	-0.3
24	98.2	92.2	1.7	1.1	1.2	901	-1	4.8	-0.2	0.9	6.0	-0.5
27	81.5	74.5	1.0	1.1	0.5	788	1	7.0	-1.0	2.0	7.0	-0.6
30	89.1	87.0	1.4	0.7	1.0	514	-1	5.3	-3.8	-1.9	2.1	-2.1
31	97.9	95.8	1.7	0.2	0.9	1779	3	4.3	-0.5	0.3	2.1	-2.1
34	95.9	87.9	1.2	2.1	1.6	962	1	6.4	-0.1	1.5	8.0	0.7
36	93.4	85.9	1.1	0.9	0.4	1345	1	5.3	-0.7	-0.2	7.5	-2.7
37	87.3	85.6	1.3	1.5	1.7	1394	3	2.0	-1.2	0.2	1.7	-1.0
38	95.6	88.3	0.5	1.1	0.8	1071	4	5.0	1.0	1.7	7.3	-3.4
42	106.6	103.1	1.2	1.2	0.3	1210	1	2.1	1.9	0.7	3.5	-2.0
43	96.4	93.7	2.2	1.0	1.6	890	-2	3.4	0.5	3.0	2.7	-1.3

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
47	92.8	90.0	1.6	1.5	1.5	1629	-1	6.0	0.4	1.5	2.8	-2.8
48	90.2	84.4	1.3	0.9	0.9	886	0	6.9	-1.5	0.5	5.8	-6.9
49	94.7	87.6	3.3	3.5	3.4	526	-1	7.2	-4.1	1.8	7.1	-7.1
50	92.7	90.7	1.1	1.1	1.1	1419	-6	4.2	-1.5	2.1	2.0	0.2
51	86.0	82.2	0.6	1.2	1.4	1203	0	3.2	0.8	2.9	3.8	-3.2
52	95.9	93.0	2.3	3.8	3.0	1220	1	5.6	-0.3	1.1	2.9	-4.1
53	86.6	83.3	2.8	1.3	2.6	1388	-2	5.4	-1.2	1.7	3.3	-2.3
57	85.0	82.2	0.6	0.4	0.8	1584	1	7.9	3.0	3.7	2.8	-2.8
59	93.5	94.5	2.6	2.7	2.7	1050	1	6.2	0.0	0.7	-1.0	0.0
65	108.5	106.5	1.1	1.3	1.2	612	2	5.1	-1.3	0.9	2.0	-3.5
66	92.2	93.6	1.5	1.4	1.5	1049	-4	5.2	-0.4	3.4	-1.4	-3.8
67	90.0	85.7	1.3	0.5	1.2	772	-6	3.5	-1.3	1.7	4.3	-2.5
69	94.8	93.7	0.3	0.5	0.4	1343	1	4.6	-0.1	2.1	1.1	-1.6
70	85.4	85.4	0.3	0.6	0.4	1316	-2	2.6	0.2	1.9	0.0	-4.0
72	88.3	84.4	1.1	0.3	1.1	1216	5	6.5	-2.8	-2.9	3.9	-0.7
77	98.3	95.0	2.5	3.3	2.7	985	-3	4.0	-0.4	2.0	3.3	-2.3
79	94.8	91.3	0.2	0.6	0.3	1536	-2	3.4	1.1	1.7	3.5	-3.5
80	92.5	91.8	2.0	1.9	2.8	1223	1	4.4	-0.2	1.4	0.7	-1.9
81	96.5	95.1	1.4	1.3	1.3	1765	5	5.3	0.5	0.9	1.4	-1.4
83	90.4	87.2	1.8	1.4	1.6	1000	0	6.7	-1.2	0.4	3.2	-3.8
84	176.2	92.2	0.6	2.4	0.8	1275	-3	4.9	-3.1	1.0	2.3	-1.9
86	80.3	76.4	1.1	0.3	0.7	1567	1	4.4	0.1	0.7	3.9	-1.0
87	77.9	78.1	1.0	0.9	0.9	1652	1	4.5	-2.7	-0.2	-0.2	-2.0

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
88	93.6	91.0	0.9	3.6	2.3	554	1	1.8	0.0	1.0	2.6	-3.1
89	95.2	92.9	2.1	1.9	2.0	1423	-4	5.9	-1.3	1.7	2.3	-3.3
92	111.2	109.1	0.8	1.8	1.3	1387	-5	4.0	-0.9	0.1	2.1	-2.1
95	98.0	99.4	1.0	0.1	0.9	1668	0	4.1	0.0	0.4	-1.4	-3.8
96	96.9	96.1	2.0	3.1	1.7	1202	-2	2.6	-1.3	2.8	0.8	-2.9
99	96.1	99.6	1.7	0.9	1.5	1034	0	4.0	-1.5	2.9	-3.5	-6.1
100	96.0	95.2	1.9	1.6	2.1	1218	-3	5.5	-3.0	1.4	0.8	-1.8
101	103.5	99.0	2.9	3.8	3.4	850	-6	7.6	-5.8	-1.2	4.5	-5.4
104	96.8	93.9	0.9	0.5	0.7	913	-1	7.2	-0.6	1.3	2.9	-0.8
106	98.2	95.4	1.5	2.0	1.8	1365	-2	6.1	-0.4	3.5	2.8	-1.0
107	103.0	99.7	2.3	1.5	1.9	1408	1	3.1	-0.4	0.9	3.3	-2.3
108	87.5	84.5	2.2	0.0	2.1	1587	1	5.3	2.6	1.5	3.0	-0.3
109	97.9	94.4	2.6	1.1	1.8	1160	-2	3.1	-1.2	2.4	3.5	-6.1
112	98.0	94.0	2.2	0.6	1.4	1231	-6	5.7	-0.5	3.0	4.0	-6.9
115	100.3	94.2	1.2	1.9	1.6	1402	1	4.5	-0.9	0.9	6.1	-3.5
121	95.6	93.9	0.2	0.9	0.5	949	-3	6.8	-4.1	-1.1	1.7	-2.5
123	98.6	95.3	1.5	1.8	1.8	1393	-1	4.2	-1.5	-0.3	3.3	-2.3
124	92.2	89.0	3.3	2.0	2.9	993	-3	5.4	-2.9	-1.3	3.2	-3.8
125	88.6	85.1	0.2	0.2	0.2	1362	0	5.0	-2.2	3.2	3.5	-6.1
126	92.3	87.2	0.4	1.3	0.6	698	-9	3.0	0.9	1.8	5.1	-6.1
127	93.5	87.7	2.0	4.1	3.2	1248	1	5.3	2.2	-1.8	5.8	6.9
134	107.2	97.2	0.8	0.0	0.3	1406	3	3.2	1.4	-2.8	10.0	8.4
135	105.5	99.4	3.3	4.4	4.8	576	9	7.6	5.3	0.2	6.1	5.1

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
136	103.9	95.5	1.7	2.8	2.3	860	6	3.6	4.2	-3.7	8.4	7.1
138	98.8	96.7	2.3	3.4	2.9	993	4	5.8	5.4	-3.2	2.1	11.8
145	90.8	87.4	1.5	4.8	3.1	1585	2	5.5	2.5	-2.6	3.4	9.4
146	99.8	95.7	1.9	3.3	2.6	1011	8	4.4	3.4	0.8	4.1	11.3
147	94.6	92.5	0.5	3.1	1.8	1749	1	7.7	4.5	-2.5	2.1	11.8
148	103.6	94.4	0.5	3.7	2.7	1608	3	5.2	4.4	0.7	9.2	7.7
152	108.3	105.2	3.2	2.0	2.6	1096	11	3.4	2.3	-2.5	3.1	8.5
154	92.5	87.9	1.3	2.4	1.9	832	6	5.6	2.9	-1.0	4.6	10.0
155	105.0	101.6	1.5	0.8	0.9	1352	1	4.5	1.7	-2.3	3.4	7.3
156	89.8	87.9	1.0	2.8	2.1	465	0	1.9	3.3	2.5	1.9	10.8
157	94.7	97.8	1.6	3.4	3.2	439	8	4.3	2.8	-1.5	-3.1	8.5
164	97.6	91.3	3.7	4.0	3.9	1601	3	5.1	4.2	-0.3	6.3	13.6
165	103.1	95.6	0.9	2.8	2.1	1022	0	5.7	3.5	-0.7	7.5	10.6
170	104.8	101.0	0.2	2.0	1.1	1083	2	5.2	4.4	0.7	3.8	10.3
172	106.4	100.4	2.2	0.9	1.5	1428	5	4.6	0.1	-1.3	6.0	10.4
173	100.0	104.5	0.5	0.1	0.3	1480	10	5.0	2.2	-4.1	-4.5	7.8
175	94.6	100.4	3.0	2.3	2.7	884	1	7.3	1.2	-1.6	-5.8	6.9
177	92.2	94.0	0.2	0.7	0.2	967	7	6.8	4.3	0.8	-1.8	6.8
179	92.0	90.6	1.4	3.0	2.1	1626	3	6.0	2.5	-1.9	1.4	7.9
182	105.3	101.4	3.4	3.3	3.5	452	-2	4.4	-0.3	0.7	3.9	-0.7
187	107.1	102.2	1.7	2.5	1.9	1241	5	1.9	3.9	2.7	4.9	4.9
188	98.2	86.4	1.7	2.5	2.1	561	-1	4.3	1.1	-1.4	11.8	2.1
191	109.5	101.3	1.4	1.9	1.7	566	1	4.0	2.4	-1.0	8.2	5.7

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
192	93.7	81.9	0.7	2.2	1.3	1292	1	4.1	2.8	-1.8	11.8	5.5
193	91.5	81.5	1.3	1.3	1.4	1336	-1	5.9	2.3	-4.2	10.0	4.6
194	96.3	83.1	2.1	2.0	2.2	967	3	6.4	1.3	1.8	13.2	4.8
195	97.8	87.8	2.3	0.8	1.5	1418	3	5.6	1.3	-1.3	10.0	4.6
196	100.7	88.1	1.2	2.2	1.7	1057	2	2.5	1.7	0.9	12.6	3.4
198	110.3	97.3	0.6	1.7	1.2	1316	3	2.5	2.3	2.6	13.0	0.0
199	107.2	96.3	1.0	1.0	1.0	1299	0	3.5	0.6	0.4	10.9	5.1
202	89.6	80.1	1.7	0.5	1.3	859	1	6.4	0.1	-1.6	9.5	5.5
205	90.5	78.7	1.3	3.7	2.3	1013	7	6.0	2.0	0.4	11.8	2.1
209	106.5	94.9	0.1	1.2	0.6	1672	3	4.0	3.8	1.7	11.6	3.1
212	83.1	81.1	2.0	1.1	1.5	1298	0	3.3	0.4	0.6	2.0	-0.2
215	88.2	83.2	0.4	2.1	1.2	1186	2	3.7	2.2	0.7	5.0	-0.4
216	85.7	82.7	3.0	3.2	3.1	551	0	1.4	2.9	2.3	3.0	0.0
217	94.8	91.8	1.2	3.3	2.3	1225	-1	4.2	1.6	2.2	3.0	0.0
219	102.1	98.5	1.0	2.8	1.9	1041	5	4.8	1.9	0.1	3.6	1.7
221	98.0	93.4	1.7	1.0	1.5	957	0	5.2	-1.3	-0.5	4.6	3.9
224	101.8	94.9	2.9	2.7	3.3	955	3	5.1	0.9	0.3	6.9	4.0
225	92.5	84.3	1.2	1.2	1.2	1398	2	7.1	0.4	-2.1	8.2	3.8
230	79.8	74.1	2.2	2.6	2.4	875	1	1.9	2.0	1.6	5.7	4.0
231	104.7	100.1	1.8	2.2	2.0	1085	4	3.0	4.8	1.1	4.6	3.9
233	88.3	84.2	1.2	2.6	2.2	921	0	4.2	1.3	1.0	4.1	2.9
237	101.0	98.5	1.7	1.2	1.8	1236	1	2.6	-0.9	0.4	2.5	5.4
239	88.6	87.6	1.0	1.2	1.1	1347	2	6.3	1.5	0.1	1.0	3.9

TABLE B-10. LANDING DATA MODEL DEHAVILLAND CANADA DHC-8
FAA SURVEY—PHILADELPHIA INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
241	92.1	88.2	0.1	0.6	0.4	896	-3	2.2	2.8	0.2	3.9	4.6
243	100.5	100.2	1.3	1.8	1.5	1361	-3	5.5	0.2	-1.6	0.3	1.0
244	90.8	88.4	3.0	4.2	3.6	1653	3	4.9	4.5	-1.0	2.4	6.6
245	98.2	97.5	1.8	2.5	2.3	1334	2	5.4	2.5	1.8	0.7	3.9
247	96.1	94.0	2.5	1.1	1.3	1375	4	6.0	2.2	-1.9	2.1	5.6
248	97.1	97.1	2.2	3.1	2.2	1207	0	4.9	2.6	-1.2	0.0	6.0
249	95.7	99.1	1.6	1.0	1.3	1050	3	4.0	0.2	0.4	-3.4	9.4
250	96.7	98.7	2.9	3.7	3.6	927	5	5.4	3.7	0.8	-2.0	3.5
255	96.0	95.3	2.0	2.1	2.2	941	-2	4.8	1.7	0.3	0.7	1.9
256	95.9	96.4	2.6	2.7	2.7	1443	7	5.1	0.2	-2.3	-0.5	6.0
262	107.1	108.5	0.6	0.2	0.4	1062	4	3.2	0.4	-0.7	-1.4	3.8
263	108.2	110.6	2.7	3.0	2.8	601	4	4.2	1.6	-2.6	-2.4	6.6

TABLE B-11. LANDING DATA MODEL BEECH 1900D
FAA SURVEY—ATLANTIC CITY INTERNATIONAL AIRPORT

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
228	109.6	101.6	2.3	3.0	2.7	2374	1	2.0	0.6	1.6	8.0	0.8
243	91.4	88.2	0.4	0.9	0.6	1413	-8	4.1	0.3	2.0	3.2	3.8
245	109.3	96.4	1.1	0.7	0.9	1466	-7	2.7	-0.1	1.7	12.9	1.6
269	92.4	82.9	2.6	2.6	2.6	1584	-3	5.5	-0.5	1.5	9.5	5.5
300	84.9	78.0	1.3	-0.8	0.2	1748	-1	3.3	-2.9	1.5	6.9	0.9
303	97.3	96.9	0.2	1.0	0.6	1719	0	5.8	0.6	1.8	0.4	6.0
309	93.4	90.6	2.0	1.8	1.9	2245	10	3.5	0.6	1.8	2.8	6.4
317	103.6	101.5	1.5	1.1	1.3	1288	-12	4.5	-6.5	1.3	2.1	-11.8
323	109.4	107.1	1.6	1.4	1.5	2319	-2	3.2	-3.1	1.5	2.3	-14.8
337	104.7	104.3	2.2	1.2	1.7	1465	-6	1.2	-2.3	1.4	0.4	-4.0
344	114.5	106.2	0.1	0.5	0.3	2410	-8	2.2	-1.5	1.4	8.3	-8.6
345	104.9	98.5	1.2	0.5	0.8	1812	-6	3.9	-4.0	1.5	6.4	-7.7
360	99.1	97.6	1.0	0.5	0.7	2357	11	2.7	-1.8	1.6	1.5	-2.6
362	125.0	120.3	1.8	2.5	2.1	1262	-6	4.1	1.0	1.7	4.7	-5.2
367	85.7	87.1	0.7	0.1	0.4	1650	-4	2.2	-1.1	1.6	-1.4	3.8
369	105.2	103.9	1.1	0.3	0.7	1956	-6	6.1	1.4	2.0	1.3	6.9
378	107.9	101.0	0.5	2.2	1.4	2141	4	2.8	5.1	1.8	6.9	5.8
432	99.4	85.1	1.1	1.1	1.1	2427	6	2.0	-0.4	2.1	14.3	7.3
433	115.4	99.8	1.8	1.4	1.6	1794	1	7.5	2.4	1.9	15.6	9.0
441	114.4	106.6	1.4	2.9	2.2	1193	-3	1.4	3.5	1.6	7.8	7.8
454	90.7	94.6	0.5	0.5	0.5	2230	-3	0.6	0.3	1.9	-3.9	0.7
464	98.3	95.8	1.7	2.0	1.9	1916	-1	0.6	-1.4	1.6	2.5	-3.2
465	96.0	94.4	1.2	0.6	0.9	1692	1	1.6	0.1	1.5	1.6	-1.2
471	92.9	86.9	1.3	1.1	1.2	2328	-1	2.6	-2.0	1.5	6.0	-5.2
501	98.0	97.4	1.8	1.5	1.7	1980	1	2.4	1.1	1.8	0.6	9.0
515	86.8	83.3	2.7	5.8	4.2	1773	4	4.4	5.4	1.8	3.5	11.5

TABLE B-11. LANDING DATA MODEL BEECH 1900D
FAA SURVEY—ATLANTIC CITY INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown Port (fps)	Sinking Speed at Touchdown Stbd. (fps)	Sinking Speed at Touchdown Avg. (fps)	Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
519	93.9	86.7	2.4	1.8	2.1	1803	-4	2.3	-3.2	1.3	7.2	-9.6
521	105.3	97.4	1.9	1.3	1.6	1888	-8	2.2	-2.4	1.3	7.9	-7.6
535	92.7	92.4	3.3	2.5	2.9	1871	0	3.6	-1.9	1.8	0.4	-2
545	116.7	113.1	0.6	0.3	0.5	2178	2	5.9	1.2	1.8	3.6	7.1
548	116.9	108.4	1.7	1.7	1.7	2081	12	1.2	2.0	1.8	8.5	5.3
550	114.2	104.7	4.4	2.2	3.4	1087	-4	3.6	.6	1.7	9.5	3.3
555	101.6	97.0	1.4	1.2	1.3	1718	-1	0.5	0.1	1.6	4.6	-5.3
556	98.7	90.7	1.4	1.8	1.6	1733	-9	2.7	-1.8	1.3	8.0	-8.9
567	88.9	81.4	1.0	3.0	2.0	1586	1	3.7	6.0	1.7	7.5	-2.9
573	107.0	98.0	0.6	3.8	2.2	1933	-1	0.8	-0.6	1.3	9.0	0.6
583	106.5	99.5	3.6	3.0	3.3	1330	3	3.0	0.9	1.6	7.0	0.4
599	124.3	116.9	1.6	1.5	1.5	2141	-1	2.3	-5.5	1.4	7.4	-11.9
614	135.0	118.6	2.4	1.1	1.8	2255	0	2.2	0.1	1.1	16.4	4.4
617	108.1	99.7	7.2	6.8	7.0	1778	15	1.2	3.0	1.74	8.4	7.1
631		91.1	2.9	1.4	1.9	1560	2	5.6	0	1.7		
638		83.6	2.0	1.7	1.9	1560	2	5.6	0	2.0		
652		94.2	1.9	1.1	1.5	2302	3	4.5	-0.5	1.7		
656		99.6	2.3	1.9	2.1	2204	1	4.4	-0.7	1.6		
659		93.7	0.8	0.3	0.6	1136	-7	4.2	2.0	1.42		
666		84.4	1.3	1.6	1.5	2324	6	4.4	0.2	1.53		
676		89.1	1.4	0.8	1.1	2132	0	5.5	-0.3	1.5		
685		91.2	2.6	2.5	2.5	1398	2	2.4	0.8	1.8		
686		89.3	1.8	1.7	1.7	1779	1	2.9	1.7	1.5		
698		103.1	1.6	2.1	1.9	1636	3	3.0	3.3	2.0		
707		98.1	2.3	2.1	2.2	1510	1	0.9	6.5	1.6		
775	89.3	84.9	3.3	3.2	3.2	1556	5	2.6	1.5	1.7	4.4	5.1

TABLE B-11. LANDING DATA MODEL BEECH 1900D
FAA SURVEY—ATLANTIC CITY INTERNATIONAL AIRPORT (Continued)

Landing No.	Power Approach Airspeed (knots)	Closure Speed	Sinking Speed at Touchdown			Ramp to TD Dist. (ft)	Runway Off-Center (ft)	Pitch Angle TD (degrees)	Roll Angle TD (degrees)	Yaw Angle TD (degrees)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)							
783	113.8	118.8	3.0	3.6	3.3	1451	5	2.8	4.5	1.6	-5.0	5.4
834	96.9	104.1	1.7	1.9	1.7	1877	0	2.9	-1.4	1.6	-7.2	-4.1
846	96.6	91.7	1.5	0.7	1.2	1972	1	2.0	-2.0	1.4	4.9	-4.9
847	89.0	83.0	1.4	1.0	1.2	1453	4	3.6	-0.3	1.5	6.0	-2.3
850	110.1	104.2	3.1	2.3	2.7	1500	3	3.0	-2.5	2.0	5.9	-5.7
853	107.7	103.7	1.8	0.4	1.2	2253	5	1.5	-3.2	1.7	4.0	4.7
854	101.5	101.0	1.3	2.4	1.8	1585	8	3.3	1.0	1.8	0.5	4.5
867	114.0	110.1	2.0	3.2	2.6	1875	6	3.3	3.8	1.8	3.9	11.3
875	115.7	113.1	0.0	0.7	0.1	2115	2	2.6	0	1.5	2.6	-3.4
877	88.4	83.9	1.9	2.5	2.2	1543	4	3.4	0.7	1.7	4.5	-4.5
878	102.6	99.0	1.6	0.5	1.1	1698	7	2.5	-2.6	1.36	3.6	-5.4
884	101.7	97.5	1.0	0.1	1.0	2073	5	5.0	-1.3	1.8	4.2	-3.7
886	100.8	99.8	1.0	1.4	1.2	1581	2	3.0	0.1	1.4	1.0	-3.6
887	100.0	99.9	0.9	0.7	0.9	2276	3	5.3	-1.4	1.6	0.1	-1.0
892	100.0	98.3	2.4	2.3	2.4	1632	10	9.9	1.0	3.0	1.7	2.9
897	128.2	126.8	2.5	4.1	3.3	1760	5	6.0	2.0	.9	1.4	5.5
911	110.3	106.7	2.6	3.1	2.9	1744	2	1.9	2.2	1.7	3.6	6.8
912	136.8	131.6	1.4	0.0	0.6	1399	5	1.7	3.9	1.8	5.2	6.7
919	100.7	96.6	0.8	1.6	1.2	1647	3	1.9	3.9	1.6	4.1	8.4
942	114.3	112.7	1.8	1.8	1.8	1824	2	3.9	-0.3	1.6	1.6	-5.3
947	92.5	91.0	2.1	1.3	1.7	2046	2	5.0	-3.1	1.3	1.5	-2.5
949	105.8	105.1	1.6	0.8	1.2	2133	2	3.3	-1.0	1.63	0.7	-4.5
985	101.2	99.2	1.1	1.1	1.1	2284	5	3.2	0.2	1.8	2.0	2.5
993	93.1	93.1	3.1	3.8	3.4	1507	5	5.0	1.1	1.8	0.0	0.0
997	95.2	87.9	2.1	0.9	1.5	1871	-4	4.9	-2.0	1.52	7.3	0.1

APPENDIX C—LANDING PARAMETER SURVEY DEFINITIONS

SINK SPEED V_V

Sink speed is the sink speed of the aircraft landing gear wheel just prior to touchdown. Sink speed is reported for each landing gear individually: that is for the port, starboard, and nose wheels just prior to individual runway contact. In addition the average sink speed of the aircraft main landing gear is calculated just prior to touchdown of the first main landing gear wheel. Sink speed is determined from image data. The symbols used to identify aircraft sink speed are as follows:

V_{V_A} - average sink speed
V_{V_S} - sink speed of the starboard main wheel
V_{V_P} - sink speed of the port main wheel

The values of aircraft sink speed are reported in feet per second

WIND SPEED V_W

Wind speed is the wind velocity measured by the survey team's instrumentation. A head wind is defined as the positive direction for the parallel component of wind speed. The perpendicular component of wind speed, the crosswind, is also reported.

The symbol for wind speed is V_W and is reported in knots.

CLOSURE SPEED V_C

The closure speed is the speed determined by the change in the aircraft's range from the camera. It is reported parallel to the runway center line. Closure speed is reported with respect to the ground. Closure speed is calculated from image measurements.

The symbol for closure speed is V_c and is reported in knots.

APPROACH SPEED $V_{P'AF}$

The value of approach speed reported is the algebraic sum of closure speed and component of wind speed parallel to the runway centerline. The value of approach speed is the aircraft forward velocity with respect to the air mass.

The symbol for approach speed is $V_{P'AF}$ and is reported in knots.

AIRCRAFT PITCH ANGLE θ_P

The aircraft pitch angle is measured between the aircraft reference line and a line parallel to the runway. Positive values of pitch angle are reported for an aircraft with a noseup attitude. Pitch angle is determined from image data.

The symbol for pitch angle is θ_P and is reported in degrees.

AIRCRAFT ROLL ANGLE θ_r

The aircraft roll angle is measured between the aircraft reference line and a line parallel to the runway. Positive values of roll angle are reported for an aircraft whose starboard wing is down. Roll angle is determined from image data.

The symbol used for roll angle is θ_r and is reported in degrees.

AIRCRAFT OFF-CENTER LINE DISTANCE Y

This is the distance measured perpendicularly between the aircraft center line and the center line of the runway. This value is calculated from image data just prior to first main wheel touch-down. Positive values of this quantify indicate that the aircraft landed on the port side of the runway center line.

The symbol for this quantity is Y and is reported in feet.

DISTANCE FROM RUNWAY THRESHOLD TO FIRST MAIN WHEEL TOUCHDOWN X_W

The distance between the runway threshold and the point of first main wheel touchdown is determined from image data.

The symbol for this quantity is X_W and is reported in feet.

AIRCRAFT YAW ANGLE YAW_{td}

The yaw angle is the angle between the aircraft center line and the aircraft flight path at the point of first main wheel touchdown. Positive yaw angle is defined to be that orientation where a clockwise rotation of the flight path vector causes the vector to coincide with the aircraft center line using a minimum angular rotation. Yaw angle is determined from image data.

The symbol for this quantity is YAW_{td} and is reported in degrees.

LIST OF SUBSCRIPTS

P - Port
S - Starboard
N - Nose wheel
A - Average
r - Roll
p - Pitch